12th National Nutrient Databank Conference

April 12-15, 1987

Houston, Texas

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ZINC: ITS COMPOSITION IN FOOD AND ROLE IN HUMAN NUTRITION

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The essentiality of zinc for humans we suggested more than four decades ago by findings of Eggleton in patients with severe malnutrition (Eggleton, 1980). About 30 years ago, Vallee et al. (Vallee, et al., 1956) described conditioned zinc deficiency in alcoholic-cirrhotic patients. Zinc deficiency related primarily to diet was described more than 20 years ago by Prasad et al. (Prasad, et al., 1963a; Prasad, et al., 1963b; Sandstead, et al., 1967) and Halsted et al. (Halsted, et al., 1972) in patients from Egypt and Iran. Since then, our understanding of the importance of zinc in human nutrition and recognition of the association of zinc deficiency with a variety of clinical circumstances has progressively accelerated (Sandstead, et al., 1976). About 15 years ago, Hambidge et al. (Hambidge, et al., 1972) described zinc responsive failure to thrive in infants and children from Denver. Subsequently, Jameson reported the decline in serum zinc that is associated with pregnancy, and provided the first evidence that pregnant women are at risk of zinc deficiency; women with low plasma zinc levels early in pregnancy had a higher incidence of some complications of pregnancy (Jameson, 1976). Others also found decreases in plasma zinc during pregnancy (Crosby et al., 1979; Mukerjee et al., 1984; Meadows et al., 1981; Cherry et al., 1987; Cherry et al., 1981; Hunt et al., 1983) and some found association between low indices of maternal zinc nutriture and pregnancy complications including fetal distress (Mukerjee et al., 1984), and pregnancy induced hypertension (Cherry et al., 1981). Associations between low maternal tissue zinc and fetal growth retardation were reported (Meadows et al., 1981; Patrick et al., 1982; Simmer and Thompson, 1985). Evidence that zinc deficiency was in part responsible for the observed abnormalities was provided from therapeutic trials with zinc in which outcomes were improved in mothers treated with zinc (Cherry et al., 1987; Jameson, 1982). Improved growth of growth retarded preschool Hispanic children from Denver who were treated with zinc provided further evidence of zinc deficiency in the U.S., among a population at potential risk (Walravens et al., 1986). The elderly were another group found at risk of zinc deficiency, in part on the basis of the relation between economic resources and food choices and also from the effects of underlying diseases on nutrition (Sandstead et al., 1982).

These various reports and other associated research findings suggest that with the exception of patients with underlying diseases that impair zinc metabolism or homeostasis, zinc deficiency is, to a significant degree, related to food availability and food choice.

Intake of zinc may vary widely depending on foods selected (Table I). For example, the zinc content of institutional diets reported to be consumed by children ages 8-12 in the continental United States ranged from 3.2 to 16.2 mg per day with a mean of about 4.5 mg daily (Murthy et al., 1971). White et al. (White, 1976) reported that self-selected cafeteria diets of 14-16 year old girls ranged from 0.8 to 19 mg zinc daily while older women selected foods that provided 4.8 to 47.0 mg zinc daily. Higher levels of intakes in these subjects were associated with the selection of zinc rich foods. In Scotland, Lyon (Lyon et al., 1979) found zinc intakes of 7.3 to 9.7 mg daily in children ages 8-12 and 7,6 to 10.1 mg daily in adults. Working in Maryland, Holden et al. (Holden et al., 1979) chemically analyzed 132 self-selected, 3-day diet composites that were obtained on 22 persons ages 14-64 years and found a range of zinc intakes from 5.9 to 12.4 mg daily. The mean zinc intake for the group was 8.6 mg. Abdulla (Abdulla et al., 1977) analyzed 37 self-selected diet composites from 67-year old Swedish persons and found mean intakes of 8.3 and 7.2 mg daily in men and women, with a range of intake of 3.7 to 20.4 mg. Calculated zinc intakes of various population groups provided by others have generally been similar to levels

Table I. Zinc Contents of Diets

Group	Mg Zinc	Reference
Institutional - Children, 8-12 y	3.2-16.2	Murthy et al., 1971
Cafeteria - Girls, 14-16 y	0.8-19.0	White, 1976
Cafeteria - Women	4.8-47.0	White, 1976
Home - Children, 8-12 y	7.3-9.7	Lyon et al., 1979
Home - Adults	7.6-10.1	Lyon et al., 1979
Home - Person, 14-64 y	5.9-12.4 ($\bar{X}$ 8.6)	Holden et al., 1979
Home - Elderly, 67 y	3.7-20.4 ($\bar{X}$ 8.0)	Abdulla et al., 1977

measured by chemical analysis.

The importance of economics and food choice for zinc nutriture has been illustrated by calculations of possible zinc intakes from USDA Thrifty Food Plan diets that might be selected by elderly persons (Sandstead et al., 1982). These calculations indicated a range of zinc intake from 8.1 to 14.8 mg daily depending on the foods selected at a cost of $1.59 to $1.82 at the time of the study. From these calculations and findings of the Ten State Nutrition Survey (DHEW, 1972) it was evident that cost of a diet is not necessarily closely related to zinc content. It seems that food choice is the major determinate of dietary zinc content, and that income becomes important in circumstances of severe economic deprivation.

The zinc content of common household portions of selected foods was published by Murphy (Table II) (Murphy et al., 1975). The findings suggest that beef and beef liver are particularly rich sources of zinc for Americans. It was estimated by an expert committee that about 43% of dietary zinc is provided by meat, poultry and fish while 25% is provided by milk, cheese, ice-cream and eggs (National Research Council, 1979). According to Welch and Marston, the major dietary source of zinc for Americans is beef (Welch and Marston, 1982). Variety meats such as liver and beef heart are also very rich in bioavailable zinc and may be important sources of zinc for persons with restricted incomes.

Bioavailability appears to be a major issue affecting zinc nutriture (Sandstead, 1985). Selection of diets low in red meat may substantially reduce the amount of readily bioavailable zinc consumed. Experimental studies have shown that mild zinc deficiency can be induced in humans by limiting animal protein sources to white poultry meat and white fresh water fish (Milne et al., 1983; Kykaski et al., 1984).

Substances in food derived from plants such as phytate, certain hemicelluloses, lignin, and products of Maillard browning can form insoluble complexes with zinc and prevent its absorption (Sandstead, 1985). Experiments in animals established the adverse effects of phytate on zinc bioavailability (Oberleas, 1973; Erdman, 1979; and Davies and Nightingale, 1975). Findings in humans fed whole meal bread were consistent with this work (Reinhold et al., 1973). It has been suggested that the ratio of dietary phytate to zinc may be an important determinant affecting zinc bioavailability (Oberleas and Prasad, 1976).

Studies of Reinhold et al. (Reinhold et al., 1973; Reinhold et al., 1976a; Reinhold et al., 1976b) and others (Sandstead et al., 1987) suggest that high intakes of whole meal bread prepared from high extraction wheat flour might be an important contributing factor to the occurrence of zinc deficiency among populations that subsist on diets based on cereals and who rarely have meat. In Vitro observations by Ismail-Beigi et al. (Ismail-Beigi et al., 1977) have shown the binding of

Table II. Content of Common Household Portions of Selected Foods

Fish, light poultry meat, shellfish (except crab & oyster)	3 oz	<2.0
Poultry liver, dark chicken meat	3 oz	2.0/3.0
Pork, veal, crab, dark turkey meat, ground beef (77% lean)	3 oz	3.0/4.0
Beef liver, beef	3 oz	4.0/5.0
Oyster	3 oz	>5.0
Egg (whole)	1	0.5
Peanut butter	2 Tbsp	0.9
Mature dried beans, lentils, chickpeas, split peas (boiled, drained)	1/2 cup	0.9/1.0
Cow peas, black eyed peas (boiled, drained)	1/2 cup	1.5
Milk: Whole fluid	1 cup	0.9
Canned, evaporated	1/2 cup	1.0
Dried nonfat, instant	1/3 cup	1.0
Ice cream	1 1/2 cup	1.0
Cheddar cheese	3 slices (1 1/2 oz)	1.6
Cooked oatmeal	1 cup	1.2
Cooked whole wheat cereal	1 cup	1.2
Wheat flakes	1 oz	0.6
Bran flakes (40%)	1 oz	1.0
Wheat germ (toasted)	1 Tbsp	0.9
Corn flakes	1 oz	0.08
Cooked corn meal	1 cup	0.3
White wheat bread	1 slice	0.2
Whole wheat bread	1 slice	0.5
Cooked brown rice (hot)	1 cup	1.2
Cooked white rice (hot)	1 cup	0.8
Precooked white rice (hot)	1 cup	0.4

zinc by whole meal wheat bread. More recent studies showed that as little as 26 grams dry weight of wheat bran added to bread will inhibit zinc retention from a mixed American diet (Figure 1) (Sandstead et al., 1987).

Other research has shown that toasting of corn flakes to produce Maillard browning will impair the bioavailability of zinc that has been incorporated into the corn during the growing process (Figure 2) (Lykken et al., 1986). Consistent with these observations, foods such as tortilla and frijoles (beans) were shown to impair zinc absorption from a zinc rich animal protein source (oyster) (Solomons et al., 1979b). In these experiments, phytate, lignins and Maillard browning products were presumably the inhibitors of zinc retention.

Certain animal proteins appear to facilitate zinc retention. When subjects were fed whole meal wheat bread with or without animal protein in the form of meat, absorption of a 65-zinc tracer from meals that provided 3.1 to 3.6 mg zinc was about 15% when the meal provided 27

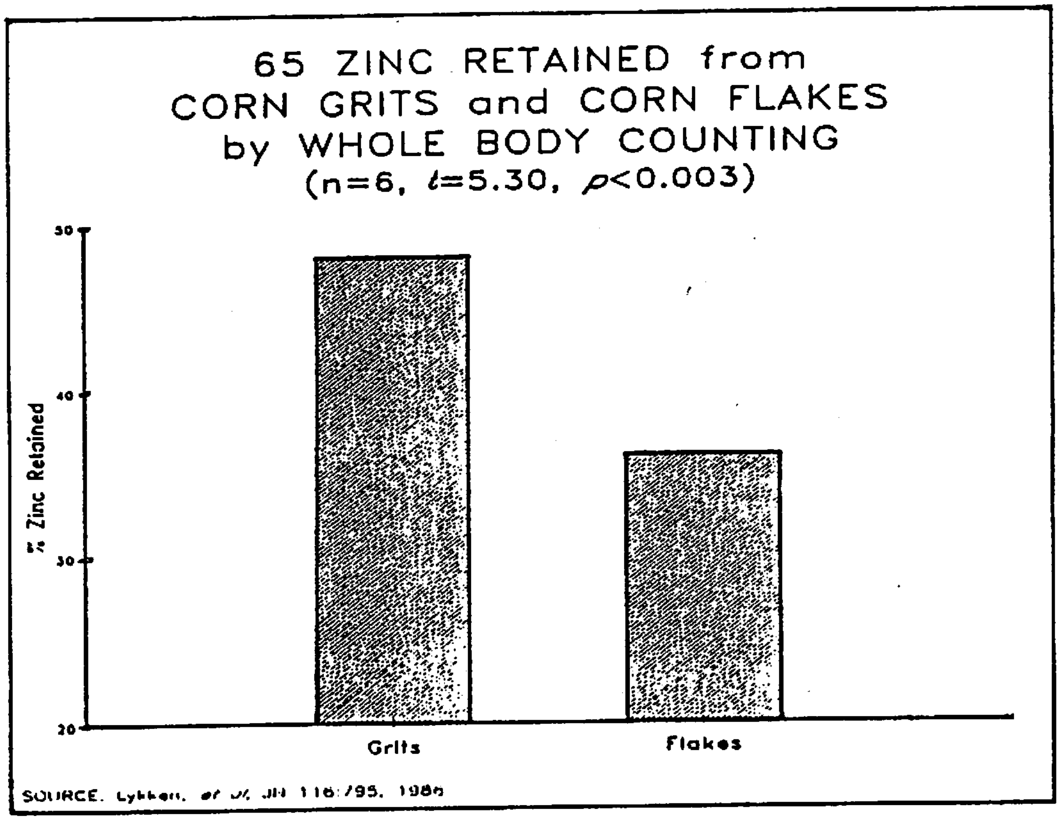

Figure 1.

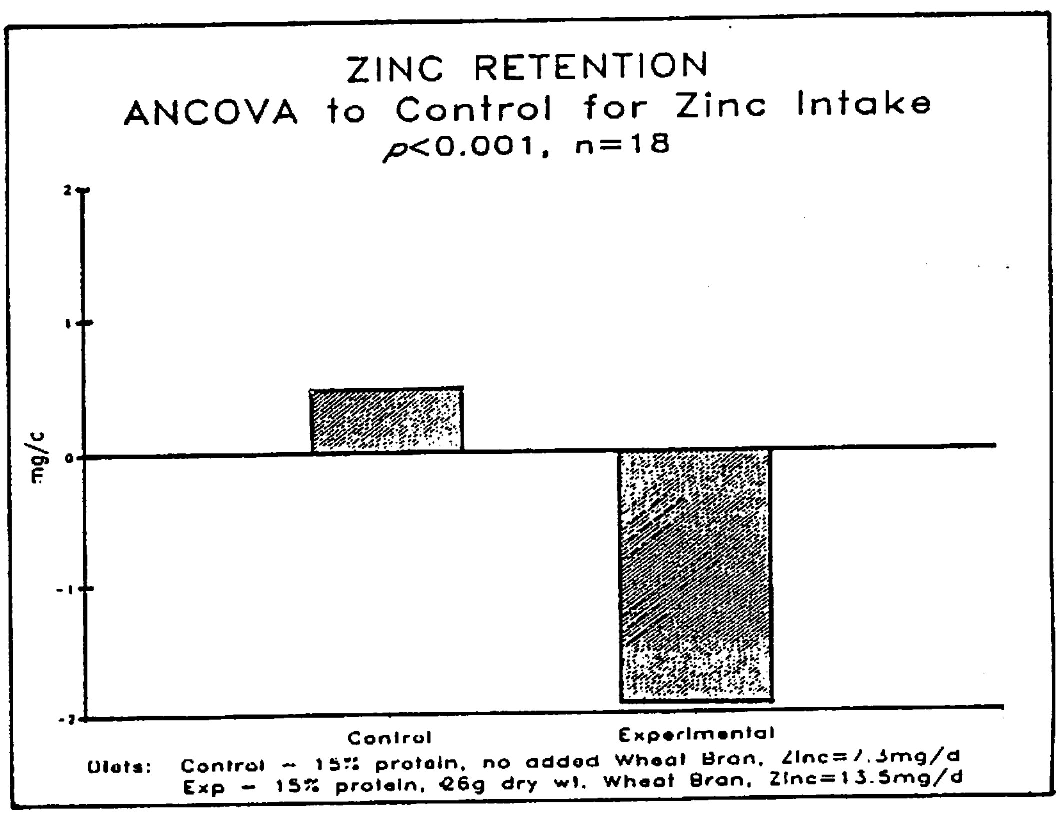

Figure 2.

grams of animal protein but only 8% when animal protein was substantially reduced (Sandstrom et al., 1980). The type of protein appears to be important. For example, it has been suggested by Lonnerdahl that casein may form insoluble complexes with phosphate and zinc that impair zinc utilization (Lonnerdahl, 1987). This phenomenon might account in part for the poorer bioavailability of zinc from cow milk than from human milk (Lonnerdahl et al., 1981) and may explain the lower zinc retention from dairy products than from other animal sources (Pecoud et al., 1975).

Calcium and phosphorus are among the minerals in food that influence zinc bioavailability. In experimental animals, high calcium intakes suppressed zinc absorption (Davies and Nightingale, 1975; Becker and Hoekstra, 1971). On the other hand, substantial intakes of calcium salts added to human metabolic diets by Spencer et al. (Spencer et al., 1965) did not reduce zinc retention. Perhaps this discrepancy is related to the dose of calcium administered. Studies in animals have shown that an interaction between calcium and phytate facilitates the binding of the zinc and impairment of zinc retention (Forbes, 1964; and Franz et al., 1980). Occurrence of this phenomenon in some humans seems possible where the calcium content of diets is very high (Franz et al., 1980). Evaluation of potential predictors of zinc requirement by regression analysis of balance data from more than one hundred 26-30 day balance studies in men who were fed conventional diets suggested that both dietary calcium and phytate are significant predictors of amount of zinc required for homeostatic equilibrium (Sandstead et al., 1985). The prediction formula was: Requirement = 0.19+0.37(zinc balance)+9.75(diet calcium)+42.69(diet phytate)-18.97(diet calcium x phytate).

An inhibitory effect of high phosphate intake on zinc retention was reported by Greger and Snedeker (Greger and Snedeker, 1980). We found a similar relationship through regression analysis of balance data from the above experiment (Sandstead, 1985). Our findings suggested that both dietary protein and phosphate content influenced zinc retention. Analysis of 157 man months of balance diet show that zinc balance, dietary phosphorus and dietary nitrogen predicted 83% of the variance in the amount of zinc required for homeostatic equilibrium. The prediction equation was: Requirement = - 1.466+0.23 (zinc balance)+5.19(diet phosphorus) +0.40 (diet nitrogen)-0.30 (diet phosphorus-1.389)(diet nitrogen-14.646).

Using the equation, the theoretical requirements for zinc at various levels of dietary protein and phosphorus intake were calculated (Table III). The calculations showed that increases in either dietary phosphorus or protein resulted in an increase in the amount of zinc necessary for homeostasis equilibrium. Thus, a diet that provided 60 grams of protein and 1500 mg of phosphorus required a mean of 10.27 mg of zinc daily for equilibrium. The 95% confidence interval was 9.47-13.06 mg. However, if protein intake was 100 grams daily while the phosphorus intake was 1500 mg, the calculated zinc requirement for equilibrium was 12.57 mg daily, with a 95% confidence interval of 9.78-15.36 mg. These estimates of zinc requirement were exclusive of the loss of zinc in sweat that occurred in the air-conditioned environment of the metabolic unit. Other studies from the unit showed that 0.50 +/- 0.38 mg of zinc was lost daily in eighty-eight 24-hour "whole body" collections of sweat loss from 13 men (Jacob et al., 1979).

Other substances taken as medications or diet supplements that can impair zinc retention include ferrous iron and folic acid. Apparent adverse effects of both on zinc nutriture have been observed in humans. Solomons et al. (Solomons et al., 1979a) showed an inhibition of zinc absorption by ferrous iron when the ferrous salt was administered simultaneously with a zinc salt. Hambidge et al. (Hambidge et al., 1983) found evidence in pregnant women that suggested iron salts might affect zinc nutriture. Impairment of zinc retention by folate was first observed in men who were fed a diet limited in zinc, and given 400 mcg of folate every other day (Milne et al., 1983). Subsequently, a dose of 350 ug folate was shown to inhibit absorption of zinc during

Table III. Predicted Relationship of Adult Male Daily Dietary Zinc Requirements (mg) as Affected by Dietary Phosphorus and Protein in Mixed American Diets*+

Protein (g)	40	60	80	100
Phosphorus (mg)				
1,000	5.27 (2.48-8.07)[a]	6.91 (4.11-9.70)	8.54 (5.74-11.33)	10.17 (7.38-12.96)
1,500	9.11 (6.32-11.91)	10.27 7.47-13.06)	11.42 (8.62-14.21)	12.57 (9.78-15.36)
2,000	12.95 (10.16-15.75)	13.63 (10.83-16.42)	14.30 (11.50-17.09)	14.97 (12.18-17.76)
2,500	16.79 (14.00-19.59)	16.99 (14.19-19.78)	17.18 (14.38-19.97)	17.37 (14.53-20.16)

* Requirement = -1.466 + 0.23 (zinc balance) + 5.19 (diet phosphorus) + 0.40 (diet nitrogen) - 0.30 (diet phosphorus - 1.389) (diet nitrogen - 14.646)

\+ These data are exclusive of the zinc lost in sweat, which was 0.50 ± 0.38 mg for 88 24-hr collections on 13 men under temperate conditions

a 95% Confidence interval

an oral zinc tolerance test (Figure 3) (Simmer et al., 1987). In other studies of pregnant women who were given prenatal folate supplements of 800-1000 ug daily, it appeared that high serum levels of folate adversely influenced pregnancy outcome (Figure 4) (Mukerjee et al., 1984; and Cherry et al., 1987). While the mechanism of this finding was not elucidated, it seems possible that the high levels of serum folate impaired cellular mechanisms that are dependent on zinc.

Other dietary inhibitors of zinc retention include tin (Greger and Johnson, 1981) and very high intakes of polyunsaturated fat (Lukaski et al., 1983). The practical importance of these two phenomena for everyday living is unknown.

Clay is an important, non-dietary substance that can inhibit zinc retention. In Iran, high intakes of clay were implicated by Prasad and Halsted as major contributing factors to the occurrence of dwarfism in village boys (Halsted et al., 1972). Reasons for their high clay intake appear to be sociocultural. Pica of other sorts has also been associated with low zinc nutriture (Danford, 1982). In these instances it is unclear whether the behavior is primary or secondary to the low zinc status.

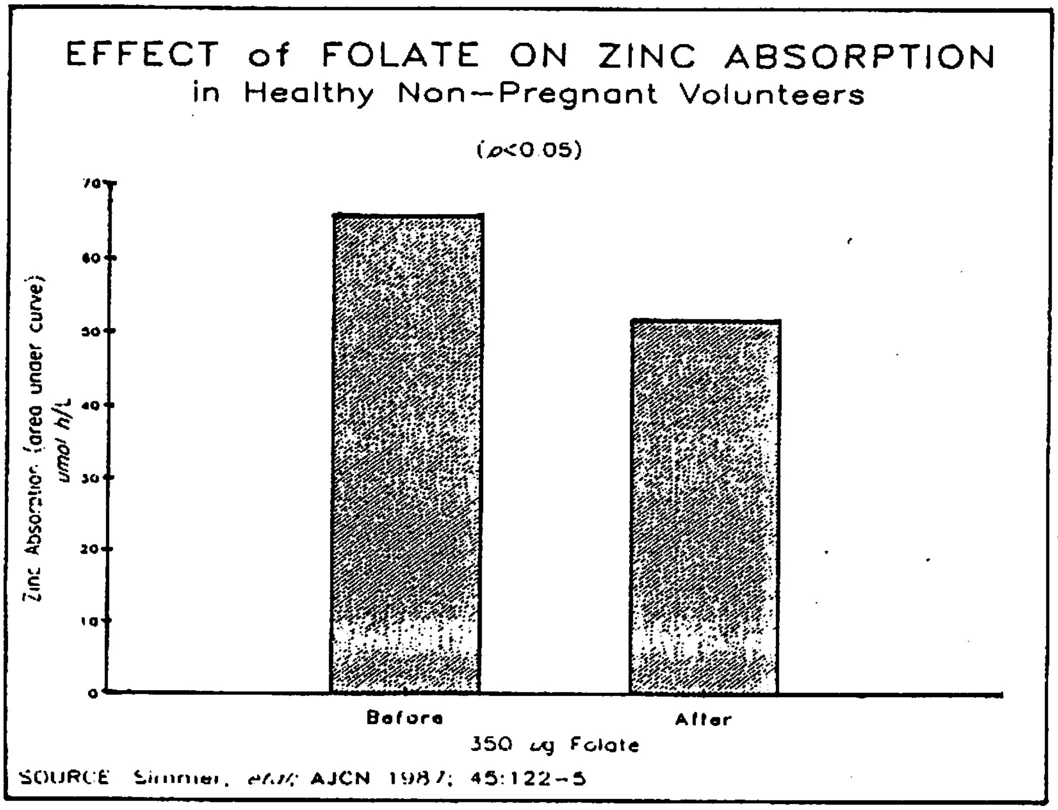

Figure 3.

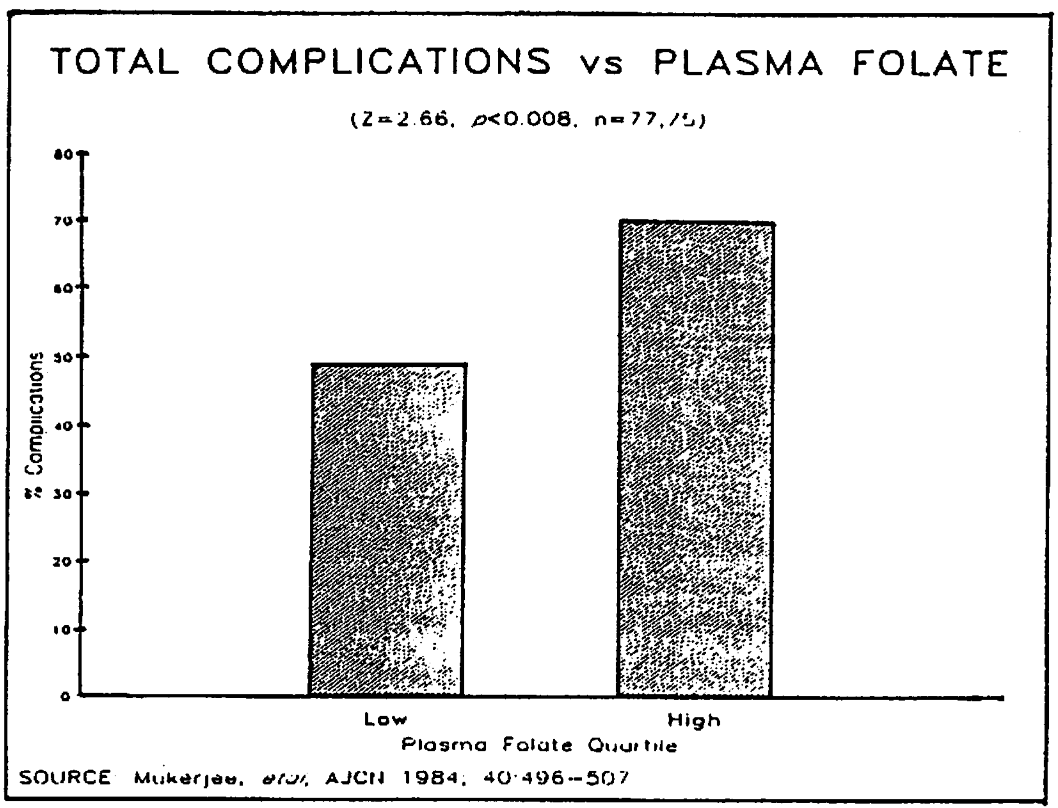

Figure 4.

Zinc homeostasis is not only influenced by substances that impair absorption from the intestine but also by substances that influence its excretion in urine. Dietary protein was shown by Greger and Snedeker (Greger and Snedeker, 1980) to increase urinary zinc loss. Similarly, Mahalko found that an increase in dietary protein from 65-95 grams daily was associated with increased urinary zinc (Mahalko et al., 1983). Balance studies from the same laboratory showed that dietary phosphate and nitrogen predicted urinary zinc excretion ($R^2=0.16, P<0.001$) (Sandstead, 1982).

Other studies suggest that the level and type of protein in the diet influences intestinal absorption of zinc. Spencer et al. (Spencer et al., 1965) reported that roughly 3% of zinc was retained in balance studies when dietary protein was 27 grams compared to 15% when dietary protein was 90 grams (Figure 5). The cause of the lower zinc retention from the lower protein diet is unknown. Apparently in contrast to the findings of Spencer et al. (Spencer et al., 1965), analysis of balance data from studies in which men were fed about 60 grams protein or 100-120 grams protein in a mixed diet suggested that zinc retention was better when dietary protein was 60 grams daily than when the high levels were consumed, i.e. more zinc was required in the diet for equilibrium when the protein level was higher (Figure 6) (Sandstead, 1985).

Alcohol is another important nutritional factor that influences zinc nutriture. High intakes can induce substantial zincuria (Sullivan, 1962a). High intakes of alcohol with diets that are marginal in bioavailable zinc increase the risk of zinc deficiency (Spencer et al., 1965). The public health significance of this phenomenon seems high in view of the fact that many Americans consume substantial amounts of alcohol on a daily basis and the estimate of some authorities that 10% of elderly persons are heavy drinkers (Iber et al., 1982).

The possibility that low molecular zinc binding ligands in food facilitate zinc retention has received considerable study. In addition to amino acids such as histidine and cysteine, substances such as citrate and picolinic acid which coordinate with zinc in vitro have been shown in some experiments, but not in others, to facilitate zinc absorption. Their importance for zinc homeostasis under usual circumstances is therefore unresolved, and indeed much remains to be done to fully elucidate the mechanism of zinc absorption across the intestinal cell. Current hypothesis and supporting research have been reviewed in detail by Cousins (Cousins, 1985).

Factorial estimates of human requirements for zinc in relation to bioavailability illustrate the importance of bioavailability and homeostatic adaptation for zinc nutriture (Sandstead, 1973). For example, when reported mean zinc intakes of children living in institutions in the United States (Murthy et al., 1971), and the zinc content of self-selected cafeteria diets of young women (White, 1976) were evaluated in terms of the factorial estimates of their respective zinc requirements and zinc bioavailability, it became apparent that many of these individuals were at risk of zinc deficiency, if the factorial estimates of their zinc requirements were correct, and if homeostatic mechanisms for maintenance of zinc nutriture were unable to adjust sufficiently to assure adequate zinc absorption and retention when their zinc intakes were below the calculated need. Because information on the homeostatic capacity to adjust to low intakes is limited, it seems prudent to assume that many individuals in these groups were at risk. Clearly, research is needed to test this hypothesis.

Severe zinc deficiency has been induced in humans by feeding formula diets or diets in which meat was replaced by soy substitutes (Hess et al., 1977; and Prasad et al., 1978b). Biochemical and metabolic consequences of severe experimental zinc deficiency in humans have thus been documented. In contrast, our observations on men who were fed 3.5-4.0 mg zinc in diets based on white poultry meat or fresh water white fish meat indicate that it is possible to become mildly zinc deficient from selection of a diet of conventional foods that does not include red meat or other good sources of readily bioavailable zinc (Milne et al., 1983; and Lukaski et al., 1984). While individuals so deprived of zinc display substantial homeostatic adjustments to reduce zinc losses for many days, some of them eventually lose the ability to adjust and go into

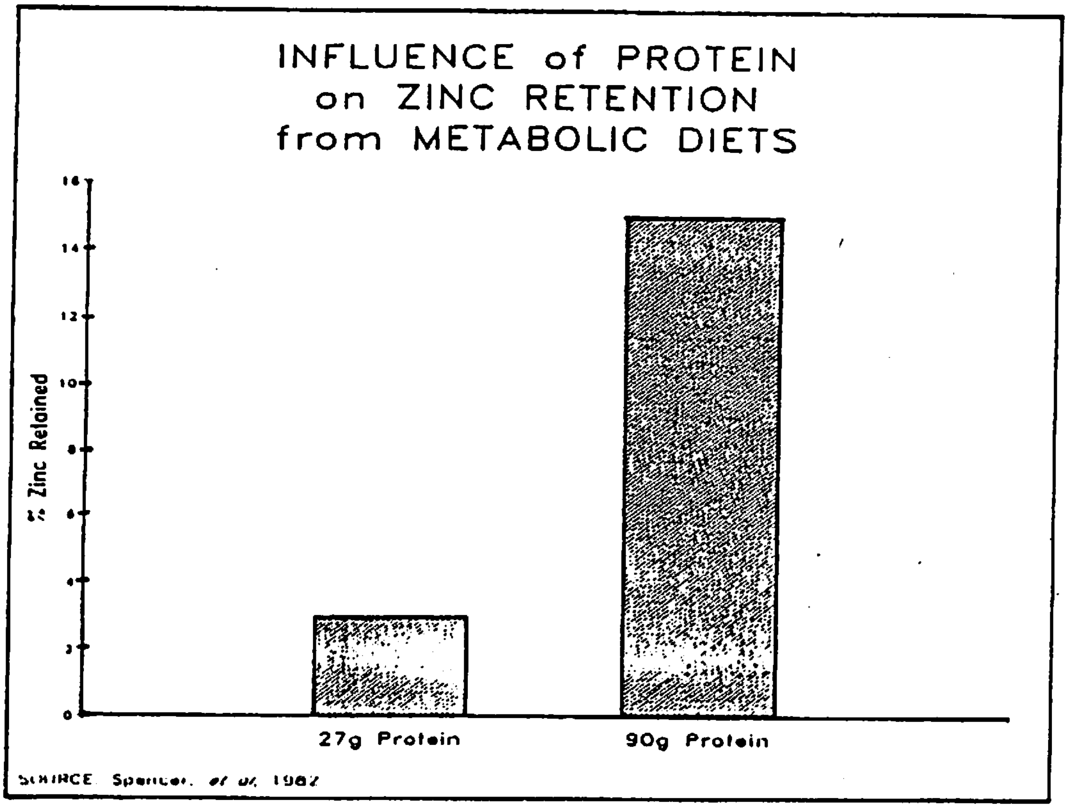

Figure 5.

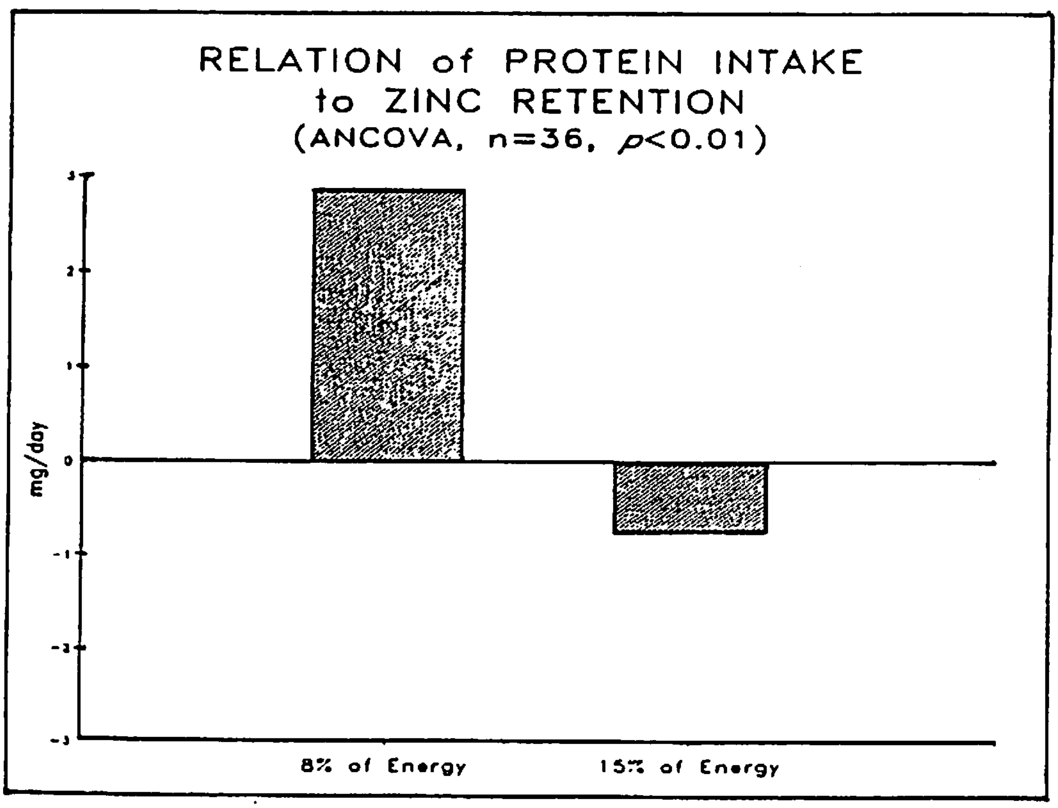

Figure 6.

negative balance, with increased zinc loss both in urine and feces. These studies suggest that the zinc requirement of adult men might be between 4 and 5 mg daily when the dietary zinc is readily bioavailable. One might presume that the addition of dietary fiber and phytate to such diet would impair zinc bioavailability and precipitate deficiency.

Estimates of provisional of human zinc requirements by an expert committee of the World Health Organization documented the influence of bioavailability on zinc requirements of various age groups (Table IV) (World Health Organization, 1973). According to calculations of the committee, a pregnant woman at 20-30 week gestation who was consuming a diet from which zinc is 10% bioavailable, would need 29 mg zinc in the diet to meet the minimal requirement for growth of the fetus and homeostatic maintenance. On the other hand, if the dietary zinc was 20% bioavailable, the amount of zinc required would be 14.5 mg daily, and if the zinc was 40% bioavailable, only 7.3 mg zinc would be required in the diet to meet requirements. These provisional requirements do not include allowance for variability in individual response or allow for adaptation that might occur in colonic fermentation when the diet habitually includes substances that can bind zinc and prevent its absorption by the upper small intestine. Increased colonic fermentation of dietary fiber and phytate might release zinc for absorption by the colon. A recent study indicates that zinc and calcium installed into the colon from below can be absorbed by the colon (Sandstrom et al., 1987). It seems possible that some adaptation occurs to habitual high intakes of dietary fiber and phytate. This question needs exploration to define the limits of adaptation. Colonic fermentation of dietary fiber and phytate may be very important for the homeostasis of zinc and other metals in populations that subsist on diets high in cereals and vegetables.

Review of available information suggests that the zinc content of diets, its bioavailability, adjustments in homeostatic mechanisms that regulate zinc absorption and excretion, and adaptations in colonic fermentation that may occur are the major nutritional factors that influence zinc nutriture. Further understanding is needed of adaptive mechanisms that maintain zinc homeostasis. In particular, the limits of adaptation need clarification. Methods for improving adaptation, or for improving the bioavailability of presently poorly bioavailable forms of zinc need exploration. Novel approaches such as "bio-engineering" human colonic flora to increase fermentation of dietary fiber and phytate should be explored. If successful, it might be possible to increase the bioavailability of zinc and other essential minerals from diets that are based on cereals and vegetables. Such bio-engineering might also increase the availability of dietary energy, a need in many Third World countries. Another more conventional approach to improving nutrition of vitamins and some minerals is enrichment of common foods. The efficacy of this approach for zinc has not received sufficient investigation. In the meantime, as recent findings of Prasad et al. of the critical role of zinc in the function of thymulin and immune function (Prasad et al., 1987), and our own calculations from 1973 (Sandstead, 1973) suggest, it seems likely that zinc deficiency will continue to emerge as a much more common problem for human health, and indeed public health than has previously been suspected.

Table IV. Provisional Dietary Requirements for Zinc in Relation to Estimates of Retention, Losses, and Availability*

Age	Peak daily retention (mg)	Urinary excretion (mg)	Sweat excretion (mg)	Total required (mg)	Necessary mg in daily diet if content of available zn is 10%	20%	40%
Infants							
0-4 months	0.35	0.4	0.5	1.25	12.5	6.3	3.1
5-12 months	0.2	0.4	0.5	1.1	11.0	5.5	2.8
Males							
1-20 years	0.2	0.4	1.0	1.6	16.0	8.0	4.0
11-17 years	0.8	0.5	1.5	2.8	28.0	14.0	7.0
18+ years	0.3	0.5	1.5	2.2	22.0	11.0	5.5
Females							
1-9 years	0.15	0.4	1.0	1.55	15.5	7.8	3.9
10-13 years	0.65	0.5	1.5	2.65	26.5	13.3	6.6
14-16 years	0.2	0.5	1.5	2.2	22.0	11.0	5.5
17+ years	0.2	0.5	1.5	2.2	22.0	11.0	5.5
Pregnant women							
0-20 weeks	0.55	0.5	1.5	2.55	25.5	12.8	6.4
20-30 weeks	0.9	0.5	1.5	2.9	29.0	14.5	7.3
30-40 weeks	1.0	0.5	1.5	3.0	30.0	15.0	7.5
Lactating women	3.45	0.5	1.5	5.45	54.5	27.3	13.7

* The above estimates were based on the assumption that the fat-free tissue concentration of zinc in man is approximately 30 µg/g. This figure is equivalent to 2.0 g of zinc in the soft tissues of an adult male and 1.2 g in the soft tissues of an adult female, as determined from lean body mass with age. Bone zinc was not included in these calculations, because zinc in bone is relatively sequestered from the metabolically active pool of body zinc. The zinc content of sweat was based on an assumed zinc surface loss of 1 mg/liter. The estimated requirement for lactation was based on a zinc content in milk of 5 mg/liter and a daily milk secretion of 650 ml. The urinary excretion of zinc was based on reported levels.

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USDA SURVEYS: PAST AND PRESENT

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The 1980's ushered in a new era in USDA's food consumption surveys. The Continuing Survey of Food Intakes by Individuals (CSFII), initiated in 1985, was the first nationwide dietary intake survey in this country to be conducted on a year-by-year basis. This innovative survey was designed to provide continuous data on the adequacy of diets of selected population groups and early indications of changes in food consumption practices.

April 1 marks the completion of data collection for the second year of the CSFII and it also marks the beginning of the USDA's next decennial survey--the Nationwide Food Consumption Survey of 1987 (NFCS 1987). It is timely, therefore, to talk about our experiences with the CSFII and our plans for future surveys.

THE CSFII EXPERIENCE

Methodology. The core of the CSFII was a sample of women 19 to 50 years of age and their children 1 to 5 years. These age groups were selected because previous surveys have shown that they are more likely than other population groups to have diets low in certain nutrients. In each of the first 2 years of the survey, data were collected from approximately 1,500 women and 500 of their children. In addition, the CSFII included separate samples of low-income women and children in 1985 and 1986 and of men in 1985.

Backed by 3 years of preliminary studies and investigations, several new methodological approaches were instituted in the CSFII:

1. The use of a panel of respondents who were asked to provide 6 individual days of dietary data over a 1-year period. Each day's data were collected with a 1-day dietary recall at intervals of approximately 2 months. The use of the panel differs from previous surveys in which individuals were asked to provide either 1 day of data or 3 consecutive days of data. The panel approach assumes that surveying days spaced over the year provides a better measure of usual intake for an individual than surveying adjacent days.
2. The use of the telephone to collect dietary data. The first day of data in the CSFII was collected in a personal interview; subsequent days of data were collected by telephone. The personal interview in the first wave built rapport with the respondent prior to telephone interviews in later waves. The telephone interviews were cost-effective, requiring less time for data collection and processing since the calls were made from the main office. However, the capability to conduct personal interviews in the field was important because of the relatively large percentage of households that did not have phones. For example, in 1985, 9 percent of the core sample and 30 percent of the low-income sample did not have telephones. In addition, a significant number of telephones were "disconnected" during the 2 years of the CSFII.
3. The collection of information on the use of fat in the preparation of the food and, if used, the type. Information was also obtained on use of salt in food preparation. These questions were asked of the main meal planner/preparer--not of all individuals.
4. The use of a computer-assisted system for coding foods reported by survey respondents. In previous surveys, foods had been coded on the questionnaire before being entered into the data processing system. The new system reduced coding to one operation, reducing processing time substantially and improving the quality of the data because of the reduction in coding errors.

The better measure of usual intake available with the panel approach was accompanied by several drawbacks. Response rates dropped substantially between the first and sixth days. The number of respondents in the first wave was 1,459, compared with 902 in the sixth wave. The largest drops occurred after the first and second waves. Only 692 women provided all 6 days of intake data.

Part of the decline in response rates was built into the survey design. Because funds were limited, respondents were not followed if they moved out of their original area. During the survey year, 145 respondents (10 percent of the women) moved. Analysis of the data, as well as interviewer debriefing, indicates that a number of socioeconomic characteristics are associated with the likelihood of dropping out. Factors associated with being less likely to participate in four or more waves included: being younger, having a low income, having poor health, being on a special diet, having one or more children, being suburban, being black, or working. For the most part, the opposite characteristics were associated with the women who participated for four or more waves.

Prior to the initiation of the CSFII, several exploratory studies were conducted to determine the best method for collecting information from a panel of respondents. In a study of individuals of all incomes, the response rates obtained with the telephone were as good as those obtained by in-person interviews. Actual experience with telephones in the CSFII was not as good as the preliminary studies had predicted.

A second drawback of the panel approach was the apparent conditioning effect that occurred between day 1 and subsequent days. Food energy intake declined by 10 percent between day 1 and day 2. There were further declines following day 2, but the decline was greatest between the first two waves. Analysis of both the core sample and the low-income sample indicated that the switch from personal to telephone interview method was not responsible for the drop in food energy. Those households who were interviewed in wave 2 by personal interview reported a drop in calories similar to those interviewed by telephone.

In addition to food energy, the number of food items consumed each day declined. We are in the process of investigating which foods declined. Nutrient intakes also declined between day 1 and 2 and, to a lesser degree, after day 2. On a nutrient density basis, however, the intakes of many nutrients per 1,000 kilocalories remained fairly consistent or increased slightly on a wave-by-wave basis.

Results. The CSFII demonstrated that frequent surveys can provide timely indications of dietary changes. For example, between 1977 and 1985 the percentage of individuals drinking whole milk declined, while the percentage drinking lowfat/skim milk increased. Data from the 1986 CSFII indicate a continuation of this trend.

The CSFII results also indicate a drop in meat intakes between 1977 and 1985. Previous surveys, including the 1977 survey, have shown the consumption of meat to be higher at successively higher income levels. In 1977, high-income women--those from households with incomes over 300 percent of the poverty level--reported 20 percent more meat than women from households under 131 percent of the poverty level. In 1985, however, high-income women reported 25 percent less meat than low-income women. Although meat intake by all three income groups was lower in 1985 than in 1977, the decline was greatest for the high-income group.

The CSFII confirmed findings of the 1977-78 NFCS that multiple days of data are necessary to explain the variability of intakes among individuals and the day-to-day variability for a specific individual. A single 1-day recall provides adequate information for deriving population means. However, it can be misleading for showing the distribution of intakes or the percentage of intakes that meet a defined level, such as the Recommended Dietary Allowance (RDA).

For example, we looked at 1-day intakes and 4-day intakes at the 5th and 95th percentiles for food energy and selected nutrients. For all nutrients, the spread of nutrient intakes is wider for 1-day intakes than for 4-day intakes. For example, for food energy, the 4-day intake at the 5th percentile is 47 percent below the intake at the median, but the 1-day intake is 60 percent below.

The difference between the 1-day and 4-day intakes at the 5th and 95th percentiles differs among food components. Food energy intakes have the smallest difference; vitamin A intakes have the greatest. For some food components--in particular, vitamins A, C, and B-12, cholesterol, vitamin E, calcium, polyunsaturated fat, and folacin--the difference in 1-day and 4-day ranges at the 95th percentile is very large. These are generally food components that are provided in large amounts by certain food types that some people eat and others do not. For example, several vegetables, especially dark-green and deep-yellow ones, are rich in vitamin A and citrus fruits in vitamin C. People who eat these vegetables and fruits, even in reasonable amounts, consume well above the median intakes of vitamins A and C. Over 4 days, their selections of some items less rich in these nutrients tend to reduce the average vitamin A and C intakes.

We have used the average intake for 4 days of CSFII 1985 to take a first look at the proportions of women who achieved specified fat and cholesterol levels. These preliminary averages indicate how many women might meet the goals recommended by some groups.

Fat: Of the women reporting 4 days of food intake, only 12 percent ate fat furnishing the less than 30 percent of calories suggested by some authorities, such as the National Cancer Institute and the American Heart Association (AHA). But these low-fat diets were not all good. The mean levels of calcium, iron, and zinc in these lower fat diets were below levels for women who had higher fat diets. Only 10 percent of the women reported 4-day diets with saturated fat below 10 percent of calories, as AHA suggests. These women also had mean intakes of iron and zinc that were especially low. From these findings, it appears that women need food selection guidance to help them to improve nutrient levels while controlling fat in their diets. Studies are under way to illustrate dietary changes that might be required to meet various goals suggested.

Cholesterol: The 300 milligrams or less of cholesterol suggested by AHA in 1978 was achieved in 62 percent of the women's 4-day diets. However, the more recent recommendation of less than 100 milligrams of cholesterol per 1,000 calories was achieved by only 9 percent of the women. We question the soundness and the practicality of this recommendation.

The last point I want to make on the CSFII experience relates to the timely release of results. In previous dietary surveys, the data had been published several years following the completion of data collection. With the CSFII, however, the first report from each of the 2 years of data collection was available about 6 months after the completion of data collection. This is a commitment HNIS made before the CSFII, and we are proud to be one of the first agencies to provide data of this complexity on such a timely basis.

SURVEY PLANS

The NFCS 1987. The contract for the Nationwide Food Consumption Survey 1987 (NFCS 1987) was signed in September 1986. Data collection started April 1, 1987, and will run for a year. The NFCS 1987 is the seventh in a series of surveys conducted at approximately 10-year intervals. NFCS 1987 consists of two samples--a basic sample of 6,000 households of all incomes and a sample of 3,600 low-income households.

As in 1977, NFCS 1987 includes two parts: a household food use phase and an individual intake phase. In the household phase, respondents are asked to provide information on the food used by the household for a 1-week period and on the prices paid for purchased foods used. The household phase of the NFCS 1987 will differ from that of NFCS 1977-78 in that the interviewer will ask questions as presented on a computer screen and enter responses directly into the computer. This procedure will reduce data-processing time, making survey results available on a more timely basis than for previous surveys.

In the individual intake phase, household members are asked to provide 3 days of food intake information. This information is collected by asking individuals to recall the food they have eaten in the previous 24 hours and then to keep a diary of food eaten for 2 additional days. This method is similar to that used in the 1977-78 survey but differs from the 6-day panel approach used in the CSFII. In other aspects, the individual intake phase of the NFCS 1987 will be similar to the CSFII. However, the NFCS includes individuals of all ages rather than the specific age groups surveyed in the CSFII.

In addition to the household and individual intake information, the NFCS 1987 will obtain socioeconomic information such as income, education, employment, and participation in food assistance programs. Also, individuals are being asked to evaluate their health status and household food managers are asked to assess the sufficiency of their food.

In preparation for the NFCS 1987 and in response to requests from the Congress, the National Academy of Sciences, and others that the NFCS surveys be better linked to the National Health and Nutrition Examination Surveys (NHANES), several working groups were formed to investigate comparability and to make recommendations for linkage. One working group reviewed variables to be used in NFCS 1987 and planned for NHANES III. Thirty-eight variables were studied. One set of variables was found to be conceptually so similar that only minor changes were suggested if any--urbanization, sex, age, education, pregnancy status, reported height, and self-evaluation of general health status. Another set had similar intent, and suggestions were made for attaining closer linkage through inclusion of one or more common questions, alterations in reference time periods, or other dimensional change--race, employment status, farm, lactating female, breastfed child, reported weight, cigarette-smoking, and surrogate respondent. A third set of variables had major conceptual differences which precluded comparability through modification of questions or definitions--income, five household-versus-family variables, and physical activity. Some of these differences are necessary because the purposes of the surveys differ. Staff developing the NFCS also reviewed variables from the Current Population Survey and the Survey of Income and Program Participation and reworded questions as appropriate.

A total of 19 reports are planned for NFCS 1987; the first two, covering the first quarter of data, are planned for release late this year or early in 1988. Initial in-depth analytical studies to be conducted extramurally have been planned, and the Requests For Proposals will be issued shortly.

The CSFII. Plans to reinstate a modified CSFII in 1989 are now nearing completion. The two CSFII surveys in 1985 and 1986 demonstrated that continuous monitoring of population groups in the years between the large decennial surveys can provide timely notice of changes in foods eaten by individuals and in their dietary status. Also, continuous monitoring of dietary status of the general population and of low-income Americans has been called for by the Congress. The CSFII proposed for 1989 and beyond will provide this continuous monitoring using a cost-effective "moving-average" approach recommended by two committees established by the Food and Nutrition Board of the National Academy of Sciences.

The CSFII that is to be initiated in 1989 and continued in following years will provide a 2-to-5-year moving average of the dietary status for all sex-age groups. Annual estimates for both men and women 19 to 50 years old will be provided after 2 years, while estimates for other sex-age groups will be provided after 3 to 5 years. The new CSFII will include two samples--a sample of all individuals in 1,500 households of all incomes and a sample of all individuals in 750 low-income households. Low-income households are defined as those with incomes of 130 percent of the poverty level or less. The survey will be designed so that low-income households in the general sample can be combined with households in the low-income sample. This will increase the number of low-income individuals for whom we have dietary data. Several other changes have been made for CSFII 1989. First, all individuals from a household will be included in the sample, rather than the specific age groups that were included in the 1985 and 1986 surveys.

Second, dietary intakes will be taken for three consecutive days by the recall/record method, as in the decennial survey, rather than for six 1-day recalls, as in the CSFII 1985/86. This approach is less costly and, we believe, will improve the response rates. Finally, at least part of the interview process will be computerized--in particular, the sociodemographic household data and the initial 24-hour recall.

The Human Nutrition Information Service has undertaken an ambitious program to meet the nutrition monitoring needs of the nation. In addition to conducting the two surveys, HNIS has committed its resources to maintaining and improving other research areas that either support or complement the survey activities. These include improvements in the Nutrient Data Bank, a continuation of the methodological research aimed at improving survey efficiency and data quality, and the release of survey results on a timely basis.

DEVELOPMENT OF THE CONTINUING SURVEY OF FOOD INTAKES BY INDIVIDUALS (CSFII) DATA BASE

Betty P. Perloff

The USDA Nutrient Data Bases for Individual Food Intake Surveys are a series of nutrient data bases developed for use in the USDA Nationwide Food Consumption Surveys. The first release (1) of this series was used to process data for the Nationwide Food Consumption Survey conducted in 1977-78. The second release (2) was prepared for the Continuing Survey of Food Intakes by Individuals (CSFII). Many differences in food descriptions and food codes exist between the two releases. Also, Release 2 contains updated nutrient values as well as data for several additional nutrients.

The Continuing Survey of Food Intake by Individuals is a nationwide survey in which 24-hour interviewer-assisted recalls are taken from survey respondents approximately every two months. CSFII 85 was conducted between April 1985 and April 1986. CSFII 86 began in April 1986 and ends in April 1987. For each year, national samples were drawn for women 19 to 50 years of age and their children 1 to 5. A low income sample was included for the women and children. CSFII 85 also included a sample of men 19 to 50 years of age.

Before CSFII 85 began, a nutrient data base containing data for approximately 4,500 items was prepared. As the survey progressed, data for new foods were added as needed. This nutrient data base was released to the public in May 1986 as Release 2 of the nutrient data base series for individual food intake surveys. Approximately 3 months of CSFII dietary records had been coded. The nutrient data base was released again as Release 2.1 (3) of the series after coding was completed for CSFII 85. Release 2.1 is identical to Release 2 except that it contains data for about 500 additional food items.

Release 2 was also used by the National Center for Health Statistics, U.S. Department of Health and Human Services, to process data collected during the Hispanic Health and Nutrition Examination Survey (NHANES) for the Mexican-American population in the southwestern United States.

The same nutrient data base that was used for CSFII 85 is being used for CSFII 86, but as coding of dietary records progresses, new foods are added as needed. When the food consumption data are released for CSFII 86, an updated version of the nutrient data base will also be released.

The remainder of this paper discusses the CSFII nutrient data base and its development and describes its relationship to two other nutrient data bases prepared by the Nutrition Monitoring Division (NMD) at the USDA's Human Nutrition Information Service (HNIS).

Food codes

Food codes are 7-position numeric codes. The first position represents a major food group; positions 2-3 represent subgroups. For example, all foods with "2" in the first position are meat items, those with "21" in positions 1-2 are beef items, and those with "211" in positions 1-3 are beef steak items. The nine major foods groups are listed in Table 1.

Table 1. Major Food Groups for CSFII

1. Milk and milk products
2. Meat, poultry, fish, and their mixtures
3. Eggs and their mixtures and substitutes
4. Dry beans, peas, other legumes, nuts, and seeds
5. Grain products
6. Fruits
7. Vegetables
8. Fats, oils, and salad dressings
9. Sugars, sweets, and beverages

Foods

Foods are described in as much detail as necessary to distinguish between different forms having different nutrient profiles. For example, eight items are present for spinach:

1. spinach, fat added in cooking
2. spinach, fat not added in cooking
3. spinach, not specified as to fat added in cooking
4. spinach, raw
5. spinach, creamed
6. spinach souffle
7. spinach with cheese sauce
8. spinach and cheese casserole

Food items containing nonspecific or general descriptions were assigned nutrient values for a commonly eaten form of the food or for a composite of more than one form. For example, the third spinach item above was assigned nutrient values for "spinach, fat added in cooking," but nutrients for the item "ground beef, not specified" were developed by combining data for regular, lean, and extra lean ground beef. Items with non-specific descriptions were included because experience has shown that survey respondents cannot always be specific about the foods they have eaten.

Development of nutrient profiles

The nutrients for which data are included on the three nutrient data files discussed in this paper are listed in Table 2. In selecting the food components to include in the CSFII nutrient data base, the key consideration was the needs of the scientific community, but adequacy of available data, by necessity, was taken into account. The final selection of 28 food components plus food energy was made jointly between HNIS and the National Center for Health Statistics.

Since nutrient data are not available for most mixed dish items, a procedure to calculate nutrient values based on recipes was used extensively. General nutrient retention factors were applied to account for cooking losses. All nutrient values used in the development of the CSFII data base were first drawn together in the Primary Nutrient Data Set for USDA Food Consumption Surveys (PDS), which is described below. Foods on the PDS include not only commonly consumed items but also those normally used only as ingredients in mixed dishes such as baking powder.

Table 2. Nutrient Data Bases
Development of the Continuing Survey of Food Intakes by Individuals (CSFII) Data Base, by Betty Perloff

	Individual Food Intake Survey (for CSFII)	Primary Nutrient Data Set for USDA Food Consumption Surveys	Standard Reference	
			Updated	Not Updated
Proximates:				
Water	x	x	x	x
Energy	x	x	x	x
Protein	x	x	x	x
Total lipid	x	x	x	x
Total carbohydrate	x	x	x	x
Crude fiber			x	x
Total dietary fiber	x	x	[1]	
Ash			x	x
Minerals:				
Calcium	x	x	x	x
Iron	x	x	x	x
Magnesium	x	x	x	
Phosphorus	x	x	x	x
Potassium	x	x	x	x
Sodium	x	x	x	x
Zinc	x	x	x	
Copper	x	x	[2]	
Manganese			[2]	
Vitamins:				
Ascorbic acid	x	x	x	x
Thiamin	x	x	x	x
Riboflavin	x	x	x	x
Niacin	x	x	x	x
Pantothenic acid			x	
Vitamin B-6	x	x	x	
Folacin	x	x	x	
Vitamin B-12	x	x	x	
Vitamin A (IU)	x	x	x	x
Vitamin A (RE)	x	x	x	
Carotene (RE)	x	x		
Vitamin E	x	x	[3]	
Fatty Acids:				
Total saturated	x	x	x	x
Total monounsaturated	x	x	x	
Total polyunsaturated	x	x	x	
Oleic			x	x
Linoleic			x	x
Others			x	
Cholesterol	x	x	x	x
18 amino acids			x	
Alcohol	x	x		

[1] Only a limited number of values are present for neutral detergent fiber
[2] Values are not included for dairy and egg products or spices and herbs
[3] Only a limited number of values are present

Table 3. CSFII Recipe Examples

CSFII Item		PDS Items		
Number	Name	Number	Name	Grams
1. 611-1901	Orange	09200	Orange	100
2. 622-0101	Ambrosia	09200	Orange	378
		09040	Banana	357
		12104	Coconut	120
		92310	Confectioner's Sugar	30

Table 4. CSFII Recipe Fats

1. Olive oil
2. Corn oil
3. Soybean oil
4. Soft margarine, unspecified oils
5. Regular margarine, unspecified oils
6. Imitation margarine (approximately 40% fat), unspecified oils
7. Margarine-like spread (approximately 60% fat), unspecified oils
8. Butter
9. Lard
10. Shortening, hydrogenated soybean-cottonseed oils

A computerized file was constructed to link each item on the CSFII data base to the PDS. This file also links CSFII items that are mixed dishes to all appropriate ingredient items on the PDS. This linking file is actually a file of recipes, with items that are not mixed dishes coded as single-ingredient recipes. Examples of single and multi-ingredient recipes are presented in Table 3. The CSFII data base was generated by a computer program using the recipe file to determine which nutrient values on the PDS to use for each CSFII item. The program calculated the nutrient content of mixed dishes as necessary. The recipe calculation procedure and recipe file were discussed in detail at the Tenth National Nutrient Data Bank Conference (4).

Recipes containing salt as an ingredient were calculated both with and without the salt, and both sets of nutrient values appear on the data base. A special field in each record indicates if a set of values was calculated directly from the recipe or calculated by omitting salt from the recipe. Recipes including fat as an ingredient or recipes involving the absorption of fat during cooking were calculated in several ways--by using data for the type of fat specified in the recipe and also by substituting data for several other types of commonly used fats (Table 4). For example, if a recipe normally used butter as the ingredient, the nutritive values were calculated by using butter as the ingredient and also by using the other nine fats listed in Table 4. Complete sets of nutrient values for these different calculations are included in the CSFII data base. The type of fat used for each calculation is designated in a field in the data record.

Primary Nutrient Data Set for USDA Nationwide Food Consumption Surveys

The Primary Nutrient Data Set (PDS) was developed for use in generating and updating the USDA Nutrient Data Base for Individual Food Intake Surveys. It is continually updated as needed for survey purposes. The one and, to date, only public release of this data set was made in May 1986. It is available on magnetic tape with two other data sets used to create Release 2 of the USDA Nutrient Data Base for Individual Food Intake Surveys--the recipe file and the nutrient retention factors file (5). Together, they serve as documentation for that specific release of the survey nutrient data base. The next release probably will be made after CSFII-86 is completed and at the same time that a new USDA Nutrient Data Base for Individual Food Intake Surveys is issued.

Most of the data on this version of the PDS are from Release 5 of the USDA Nutrient Data Base for Standard Reference (described below) (6). Values were added for the nutrients missing from the Standard Reference Data Base, and complete nutrient profiles were added for missing food items. If analytical data were not available, the values were imputed from other forms of the foods or were estimated from data for similar foods. The values are for 100 grams of the edible portion of a food. Included with each value is a code to indicate whether or not it is from the Standard Reference Data Base and whether it is based on analytical data or is an imputed value. A date is included with each value not from the Standard Reference Data Base to indicate when it was added to this data set.

All items from the Standard Reference Data Base carry Standard Reference identification numbers. Added food items have been assigned special identification numbers. Values in the data base for carotene are those assumed by HNIS in arriving at the values for total vitamin A and should not be interpreted as representing solely beta-carotene. Values for beta-carotene content of foods have not been reported frequently, and existing reports are often not clear as to whether a value is explicitly for beta-carotene or whether it includes other carotenoids. Only limited analytical data are available for vitamin E and dietary fiber.

HNIS' working version of the PDS has been updated with new data from Release 6 of the Standard Reference data base (7) and is currently being used to develop the nutrient data base that will be used with the Nationwide Food Consumption Survey 1987.

USDA Nutrient Data Base for Standard Reference

This nutrient data base corresponds to Agriculture Handbook No. 8 "Composition of Foods . . . Raw, Processed, Prepared". It contains all the data that have been published in the revised sections of the handbook (8), and for those food groups for which revision is incomplete, it includes data from the 1963 edition (9). However, values for enriched flour and bread and for other products made with enriched flour have been changed to reflect the current revised standards of identity. The current release is the sixth for this data base. As new sections of the Agriculture Handbook 8 revision are published, new releases of this data base will follow.

As indicated in Table 2, data for more nutrients are present for the items taken from the revised sections of the handbook than are present for the items from the 1963 edition of the handbook. Where blank spaces appear in the handbooks, values were imputed and included in the data base, if possible. Nutrient values are present for 100 grams of the edible portions of each food and, for most items, two common household measures and 1 pound as purchased. Five-position numeric food codes are used.

This data set is available on both magnetic tape and floppy disk.

Summary

The current release of the USDA Nutrient Data Base for Individual Food Intake Surveys was developed for the Continuing Survey of Food Intake of Individuals 1985. All nutrient values used in its generation are found on the Primary Nutrient Data Set for USDA Food Consumption Surveys. A computerized file links the two data sets and includes recipe ingredient information for calculating nutrient content of CSFII mixed dish items based on nutrient content of their ingredients. The main source of nutrient data on the PDS is the USDA Nutrient Data Base for Standard Reference.

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HNIS-USDA UPDATE

Frank N. Hepburn

Recent Publications and Publication Plans for 1987

The following publications are now available or are expected to be available this year:

AH-8-16 Legume Products (published)
AH-8-15 Finfish and Shellfish Products (in preparation)
HG-90 Conserving Nutritive Values in Foods (revision in preparation)
HERR- Sugar Content of Selected Foods (in preparation)
Provisional Table on Vitamin K (published)
Provisional Table on Sugars (published)
Provisional Table on Vitamin D (in preparation)

Machine Readable Tapes Available through NTIS in 1987

Two tapes have just been submitted to NTIS and should be available for purchase now or in the very near future:

USDA Nutrient Data Base for Individual Food Intake Surveys, Release 2.1, 1987.
USDA Nutrient Data Base for Standard Reference, Release 6, 1987.

Both of these tapes are described in Betty Perloff's presentation. Briefly, the first is identical to Release 2 but with additional foods. The second incorporates data for the revised sections on Beverages, Beef Products, and Legume Products.

Plans for Future Publications

The following Agriculture Handbook publications are expected to be released in the approximate order shown, beginning early in 1988:

AH-8-21 Fast Foods
AH-8-17 Lamb, Veal, and Game
AH-8-19 Sugars and Sweets
AH-8-18 Baked Products
AH-8-20 Cereal Grains, Pastas, Snacks
AH-8-22 Mixed Dishes
AH-8-23 Miscellaneous Foods
AH-102 Food Yields Summarized by Different Stages of Preparation (revision)

Two provisional tables are in the planning stage:

Provisional Table on Dietary Fiber
Provisional Table on Selenium

Data Base Evaluation

In the previous presentation Betty Perloff described the Primary Nutrient Data Set (PDS) and explained that it is linked to the Nutrient Data Base for Individual Intake Surveys through a recipe linking file. The recipe linking system permits conversion of food consumption data into equivalent amounts of PDS components so that the contribution of a given nutrient by a food can be measured and principal sources of each nutrient can be identified. Furthermore, since the sources of all data are coded into the PDS, it is possible to evaluate the data base in terms of those codes for foods that are most important in contributing any given nutrient.

An example of this type of analysis is given below. The food consumption data (4 days) for 1,088 women (weighted) in CSFII 85 were equated to the corresponding intake of items in the PDS, and the percentage contribution of the total intake of each nutrient by each item was calculated. The table shows the number of PDS items required to reach 80 percent of total nutrient intake, together with the number of items coded as containing imputed values and the number of items whose values are based on data supported by analyses for label claims.

PDS ITEMS CONTRIBUTING 80% OF TOTAL NUTRIENT INTAKE

Nutrient	No.Items	No.Imputed	No.Label Claim
Protein	150	6	0
Dietary fiber	120	46	0
Fat	107	3	0
Cholesterol	49	4	0
Vitamin B-6	175	23	20
Thiamin	168	5	17
Riboflavin	165	5	15
Niacin	159	9	17
Folacin	129	20	14
Vitamin E	100	50	0
Vitamin A (RE)	60	5	9
Vitamin B-12	58	9	5
Carotene	33	0	0
Iron	217	21	18
Copper	209	30	0
Magnesium	187	27	0
Phosphorus	180	5	0
Zinc	169	20	6
Potassium	159	5	0

The number of items to reach 80 percent is a measure of the distribution of a nutrient among the food items comprising the PDS, while the number of items with imputed values is a measure of data uncertainty.

I have included the number of breakfast cereal items for which data are based on label claims because it is evident that cereals are important sources for some nutrients; however, these data, although based on extensive industry analyses, are calculated to a different basis and do not necessarily represent mean values. In Agriculture Handbook No. 8-8, these label-based data are presented in italics.

At the 10th Nutrient Data Bank Conference in 1985, I presented an analysis of the PDS items that estimated the percentage of analytical data for each nutrient both in the entire database and in those food items of higher nutrient concentration. The results showed the data to be weakest for dietary fiber, folacin, vitamins E, A (RE), B-6, and B-12, zinc, copper, and magnesium. Results of the present study confirm the previous findings, except that data for iron are less reliably known while total vitamin A (RE) is better accounted for in the foods actually consumed.

Extramural Studies

An important benefit of the approach used in the above analysis is that now we can systematically identify the individual food items that account for nutrient intake for which additional analytical data are most needed, and we can use this information to set priorities for foods and nutrient studies that will make the greatest improvement in the database. We have been following such a procedure in developing our extramural contracts. In addition to improving the database in terms of nutrients now under study, the procedure has been used as one of the steps in establishing the foods to be studied for developing reliable data for selenium.

The most important advance in our extramural studies has been the development of a protocol to provide for the validation of analytical procedures and the use of proper laboratory quality control procedures by a contractor. This development is the result of close cooperation between the staffs of the Nutrient Data Research Branch and of the ARS, Nutrient Composition Laboratory. Some of the aspects of their cooperative efforts will be discussed in more detail by Dr. Beecher in the following presentation.

Use of the PDS and recipe linking system offers distinct opportunities for maintaining and improving the reliability of our nutrient database. We realize that the system's accuracy hinges on the ability of the recipe system to predict the nutrient content of a prepared mixed food. Two extramural studies are underway to measure this ability.

We believe that real progress is being made in our efforts to upgrade and maintain nutrient databases. We welcome your comments and suggestions for further improvement.

INFOODS UPDATE: 1987

THE GOALS OF INFOODS

What INFOODS is attempting to do is to add an option to:

* create an environment for *horizontal* consistency within each of the four groups, so that information (data) can be shared and, at the very least, workers can tell each other, easily and unambiguously, what they are doing. Note that this can be done with a common language, and does not require a restrictive set of rules,
* create standardized linkages between the groups so that electronic communication can be used. Note that in order for this to occur, with minimum difficulty, there must be precise rules, however these rules need not restrict the method or procedures involved.

HOW INFOODS IS PROCEEDING

To reach these goals, INFOODS is proceeding with work in three distinct areas:

I. the international linking of people and organizations to determine the status of the field and set up channels of communication;
II. the establishment of standards and guidelines to permit and promote exchange of expertise and data, designed ultimately to lead to compatibility and consistency; and
III. the development of the "machinery" to permit an actual linking of food composition data through electronic channels and media.

I. Linking Individuals and Organizations

The first task is that of linking those interested in and involved with food composition data. This began with the establishment of a secretariat office at the Massachusetts Institute of Technology, serving as the focus of INFOODS. The more important among the INFOODS secretariat activities are:

The International Directory of Food Composition Tables. We have prepared a listing of the food composition tables which are currently in use around the world. Our first edition was published over a year ago; a corrected and augmented edition is due out this month. It contains 177 tables, primarily from outside the United States. It contains the tables that we have been able to find, and we have looked long and hard. There are, however, some limitations to this directory:

* There are few US tables included (other than those of USDA)--we refer those interested to the directories of Professor Loretta Hoover of the University of Missouri-Columbia for databases and Darlene Hildebrand of the University of Washington for programs.
* We include few industrial databases (e.g., those of food companies). There are lots of these in the US, and elsewhere as well. They tend to be difficult to find out about, and more difficult to access.
* The focus is on published tables rather than electronically maintained databases. There are not too many electronic databases about at present.
* There is no easy cutoff point in the spectrum from food composition data tables to articles in the literature reporting food composition data. We have made ad hoc decisions.
* There is lots of interesting and useful information about these tables that is not included in the directory--such as what foods and nutrients each table includes. We plan to expand the directory to include much of this, as part of the production of a computer readable (and consultable) directory database.

The INFOODS Newsletter. Every three months INFOODS distributes a newsletter to everyone we know about that we think should be interested in food composition. This begins as our NCI quarterly progress report and is massaged into something which we think will be of interest to the community. We are currently including such things as future meetings of interest and new and revised tables that we receive. Like any newsletter we are always looking for news and information to include, and ask that you send relevant items to us.

Journal of Food Composition and Analysis. By the end of the year we hope that the INFOODS Journal of Food Composition and Analysis will have begun to appear. This journal will publish articles in the areas of:

* New data and methods for food components, additives, and contaminants;
* Effects of processing, genetics, storage conditions, preparation on the composition of foods;
* Quality control procedures and standard reference materials for use in the assay of food components;
* Statistical and mathematical manipulations involved with the preparation and utilization of food composition data; and
* Processes of development and dissemination of food composition databases.

This journal is sponsored by the United Nations University, published by Academic press, and edited by Professor Kent Stewart of Virginia Polytechnic Institute and State University. We are actively soliciting papers for the first issues, and anyone with work or ideas in these areas is urged to get in touch with Professor Stewart.

Regional FOODS. In the United States, the NNDB serves as a focus for food composition database activities, and INFOODS has relied heavily on it and on the contacts made at these meetings. Elsewhere in the world there are few comparable organizations. What INFOODS is trying to do, with the major assistance of the United Nations University, is to forge links to those organizations that do exist, and organize them where they do not. Thus, there are strong groups in Scandinavia (NORFOODS) and Europe itself (EUROFOODS), and we have helped to organize NOAFOODS (in the US and Canada), ASIAFOODS and LATINFOODS (for Central and South America). Plans exist for similar groups in the Pacific (OCEANIAFOODS), in Africa (AFRICAFOODS), in North Africa and the Middle East (MENAFOODS), and in the Gulf Arab States (GULFOODS).

It is expected that these groups will work with INFOODS in:

* assessing regional problems;
* detailing regional resources, such as tables and data that exist;
* proposing regional needs and solutions;
* planning regional activities--workshops, seminars, courses;
* effecting interchange of information both within their region and with other regions;
* exploring the concept of a regional computer facility to hold regional data and produce national and special purpose tables; and
* advising INFOODS on how it can best interact and serve the region.

Standards and Guidelines

In order to develop communication and consistency we have begun to develop specific guides to assist in activities to insure that there be "good data", that these data be "carefully handled", and "well-described", and that they be "properly used". These considerations define the documents that INFOODS is preparing.

Data Quality Manual. One of INFOODS' first activity was that of commissioning Drs. David Southgate (of the ARC's Food Research Institute in the UK), and Heather Greenfield (of the University of New South Wales in Australia) to produce a revised and expanded version of David Southgate's 1974 manual on production of food composition data. This document covers in depth the procedures for collecting and analyzing food samples within the full context of putting together a food composition database. This document has been in review for over a year now and it is hoped that it will be published late this year.

Data Compilation. Last October a group gathered in Washington to discuss the problems of "Missing Data"--how to fill in food composition data when analytic data do not exist. At the conclusion of this meeting four of us began to write a manual of how to compile food composition databases. The original scope of this document has expanded, as we try to deal with general concerns of both users and compilers. We currently have produced what we consider a solid, intermediate draft, and earnestly solicit review and suggestions.

Next, in order that food composition data be interchangeable, we are working in three areas of data description--the nutrients or components, the foods, and the data themselves.

Nutrient descriptions. Definition of food components is not as straight forward as we initially, rather naively, thought. The underlying problem is, of course, the discrepancy between biological activity and chemical specificity. We can observe what happens to individuals, and we can analyze what is in the foods that they eat--however, the correlation is often not as tight as we would like. For example, when a biologist or nutritionist talks of iron they talk in relation to anemia and that substance which, when given, ameliorates anemia. When chemists talk of iron they mean the element Fe. Nutrition is becoming more and more sensitized to how fundamentally these two concepts differ, and is now entering into a very exciting period of research--centered on "biological activity". However, this very excitement brings with it complexity and, especially now, confusion. We are working with Diane Feskanich, of the NCC as well as part of the INFOODS secretariat, to produce the first step toward dealing with these problems--a compendium of those food components that are included in major tables, with indication of which are the same and which are different. What this listing does is to distinguish those components which have the same name in various tables but in reality differ because different methods were used to measure "almost" the same thing. (For example, carbohydrate by difference and carbohydrate by sum.) This listing currently defines a standard set of almost 300 abbreviations which can be used so that table users (and computers) will be less likely to be confused. This listing has just recently been sent out for review, and we expect to issue generally a draft within a few months.

Food descriptions. One of our greatest difficulties has come from our attempts to generate a "universal food nomenclature scheme", to completely define and name foods in order that data could be easily compared from one table to another. It has become obvious that foods are so firmly embedded into individual cultures that such a nomenclature, while it may be possible in theory (and we have our doubts), is impossible in practice. The connotations of the name of a food defy literal translations and even explicit documentation. Moreover, it has become very obvious that how one looks at a food in terms of definition depends on just what one wants to do with the data. For each special use there are special needs--for example, with milk, a nutritionist might want to know what specifically is the milk that most people drink, an epidemiologist might want to know where the fodder for cows was grown, while the toxicologist might want to know how the milk was packaged and handled.

To deal with the problem of communication, INFOODS is developing a manual of "Food Description"--a project being run by Prof. Stewart Truswell (of the University of Sydney in Australia). This is an attempt to compile and define, not ways to "name" foods, but a vocabulary to describe foods--terms that can be used internationally to identify the major aspects of foods. It is expected that this document, which is currently still in draft form, will provide the context for the generators of data in their identifying of the foods that they analyze, and for the compilers in labeling their data. This is essential for intelligible communication.

Data descriptions. The third component of description of the food composition table or database is that of defining precisely what the numbers represent. Usually a single number is given which indicates some sort of average value, but sometimes indicates an upper or lower limit, and furthermore, this is often chosen only after a certain amount of "data cleaning" has taken place. Basically, what is needed is language for the information on what the numbers themselves mean, in relation to a nutrient in a specific food. This needs to include how and when the number was derived, what it represents, and how trustworthy it is. INFOODS is just beginning to work on such a manual.

Statistical considerations. Additionally, since food composition data are numbers, it is felt that there needs to be some compendium of statistical techniques that are reasonable to use with food composition data. There is a lot of relevant statistical theory, however, this theory needs to be translated to the particular field of food composition data. Again, INFOODS is just starting to put together this document.

User's guide. Finally, it is obvious that there needs to be a User's guide. Such a manual would address the issues of choice and evaluation of food composition data and of relevant software; the interpretation of food composition data; the integration of food composition data with other sorts of data, such as requirement and consumption data; as well as the pitfalls that are so ubiquitous in the field. We have developed an outline for such a document, and if no one writes it soon, we will try to organize such an effort.

Linking Data

A long-term goal of INFOODS is that food composition data be conveniently accessible by computer. Reaching this goal requires work in two distinct areas--precise definition of what makes up food composition data and building the mechanisms for finding and moving them. Work in this area is being directed by Dr. John Klensin, a computer scientist at MIT, who is now helping direct and manage INFOODS as it focuses more and more attention on this topic.

Defining what gets moved around. Basic to computer linkage of food composition data is the precise definition of just what form data will take as they are moved from place to place. For this we have devised an "interchange format" which attaches to each piece of food composition data one or more carefully defined identifiers of that data point,(which are called "tags"). For example, were we to want to send the USDA milk data cited earlier we would attach to the number "31" the following information:

* item no. 01-077, from USDA AH-8-1 (1976) milk, from a cow, *Bos taurus*, whole, 3.3% fat, fluid
* vitamin A, total; expressed in retinol equivalents derived from analyses of retinol and beta-carotene
* a mean value based on 2800 samples of butter

Much of our current work is directed to defining precisely how this information can be optimally encoded, without constraining the producer, compiler, and user of the data. This includes devising:

* a format for interchange of the data;
* nutrient tags to uniquely identify the components;
* classification tags to assist in the identification of the foods;
* data tags to describe the numbers and symbols involved; and
* precise identifiers for the origin of the data in terms of the region, country, table, and version from which they appear.

To date we have devised an interchange format, the nutrient tags, as mentioned above, are out for review, and we are in the midst of working on tags for foods and data. INFOODS Information Systems working papers describing our progress are available from the secretariat.

How the data get moved. Additionally, the Information Systems group has been working to develop the machinery for the actual moving of the data. We have started by using an existing network (BITNET) and written software to send data sets to those who make requests. This is working intermittently now, as we experiment with it, in a very prototypic mode using USDA data, and we are now exploring and defining the necessary extensions in order to get to the stage where most existing databases can be delivered to the user upon request to a single node.

The various components of such a system, as is currently envisioned, include:

* protocols for network access--machinery to utilize the capabilities of specific computer networks.
* database servers--computer programs for automatically locating and sending out data to those who request it over a network.
* conversion programs--programs to convert standard databases into and out of the interchange format.
* automated directory--programs and a database to initially inform the user of the availability of specific sets of data.
* query language--a computer language to facilitate the requesting and receiving of food composition data.

These projects and their various aspects are also detailed in the series of Information Systems working papers which INFOODS issues. These are available for comment, and such comment would be very welcome.

THE FUTURE

What is the object of all this effort? The goal is that, sometime in the future, the world will be served by a number of regional food composition groups which will coordinate and link the activities and the data within geographic regions. The data facilities associated with these regions will be linked together so that access to all the data of the world will be "easy". We are not there yet, and there are lots of difficulties in this plan, but, our ultimate goal is that:

* someone with a specific problem requiring food composition data (e.g., determination of the potential nutrient intake of a group of Southeast Asian vegetarians living in Texas) can sit down at a terminal and find exactly what relevant data exist, and then request and obtain those data in a form easily adapted to his or her needs;
* someone interested in exploring some particular aspect of food composition data (e.g., vitamin A in milk around the world) can sit down at a terminal and put together a food composition database with bits and pieces from around the world, and have confidence in the result;
* someone about to embark on an analysis program (e.g., indigenous foods of Patagonia) can easily determine what has been done already, what the best methods are, what aspects of the effort need special attention, how to best make the results available to others, and even where to turn for assistance.

For such a vision to be realized, it is obviously necessary for the tasks outlined above to be completed, and this requires the involvement of the entire food composition data community. INFOODS is now producing guidelines documents for which we solicit comments and suggestions. This is an important step but only the first.

WHAT IS A NUTRIENT DATA BASE?

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Each year the list of nutrient data bases and systems grows longer. As more food composition information becomes available, it becomes even more practical to computerize it. As we continue to make comparisons among the various data bases we become more confident about the resulting calculations. A computerized food composition table, a nutrient data base, is the heart of the data base system; therefore it is essential that the compilers provide descriptive information and documentation for users. It is then the user's responsibility to become aware of the integrity of the data and any limitations in their use.

In today's discussion I will start with some definitions, describe the elements of a nutrient data base, identify the related types of data required and conclude with a list of issues still confronting us.

DEFINITIONS

A *data base* may be defined as "a collection of interrelated data stored together without harmful or unnecessary redundancy to serve one or more applications in an optimal fashion; the data are stored so that they are independent of programs which use the data; a common and controlled approach is used in adding new data and in modifying and retrieving existing data in the data base" (1).

A *nutrient* is a "substance obtained from food and is used in the body to promote growth, maintenance, and/or repair" (2).

For purposes of our discussion, we will consider that the primary elements of a nutrient data base are foods and any constituents of foods as consumed, which we will call nutrients. All other data included are related to these primary elements and are used for identification, documentation and applications. The size of the data base may or may not be related to the degree of specificity of the information included and will be determined by the user.

THE DATA

Foods

A reference data base, such as USDA Data Base I, includes a very large number of foods with unambiguous descriptors. These descriptors include food group, species, variety, maturity, season of year, geographical location, soil conditions, processing or preparation method, form, cut, size, brand name, packaging, etc. Not all of this information is necessary for all applications. This has led to the development of a series of data sets of varying smaller sizes. As this kind of aggregation and reduction occurs, the naming of many food items in common, easily interpreted names has presented problems. Food identification systems have been developed, such as the Factored Food Vocabulary being used by the Food and Drug Administration (3). The Nutrition Coding Center at the University of Minnesota is developing a hierarchical food identification system with coded descriptors to facilitate interactive food identification dialogue (4).

The selection of which foods to include is dependent on the users' needs. Since the capabilities of hardware at affordable prices have increased, the size of the database has become of lesser concern. However, a large number of foods, in some cases, may not be the optimal choice as I am sure my colleagues will point out today.

Nutrients

Nutrient information may be obtained from a wide variety of sources. In many countries, the national food composition table, compiled under governmental direction, serves as the primary source. In the United States, USDA Handbook 8 is this source. These data are available in printed and machine readable forms. Additional sources of nutrient data from USDA include specialized data sets used for food consumption surveys, Home and Garden Bulletin 72, Provisional Tables published as nutrient data become available prior to inclusion in a revised Handbook 8 section and articles published in the research literature.

Other primary sources of nutrient information include food composition tables from other countries, published journal articles and manufacturers' information. With the advent of nutrition labeling in the 1970's, most manufacturer's have generously made results of their laboratory analyses available. Some data base compilers have funded independent laboratory analyses of food products.

Among the many secondary sources of data are tables published in books, such as Pennington and Church's Food Values of Portions Commonly Used, or machine readable data sets compiled independently.

In spite of the seemingly great availability of food composition data, we do not yet have information for all nutrients for all foods and all forms of foods. Therefore, calculated and imputed nutrient values are often used. USDA has used these methods and has carefully documented them in the explanatory information in each Handbook 8 revision volume. All imputed values are flagged in the printed and machine readable tables. Any calculation and imputations made by a data base compiler must be precisely documented.

Nutrient values for recipes or formulated foods are frequently included in nutrient data bases. The validity of these calculations will depend on the accuracy of yield factors applied to ingredients, to total recipe yield, and to consideration of nutrient retention.

Most nutrient data bases use nutrient values for a standard weight of food, e.g., 100 grams. This allows for uniform validation checks in a systematic manner. A decision must be made on the number of decimal places to include. This may depend on available computer space, operating system capabilities, and desired level of precision related to use of the data.

Nutrient nomenclature and units from different sources frequently differ and it is wise to establish a single standard such as those used for the current Recommended Dietary Allowance or USDA Handbook 8. Conversion factors may be included as related nutrient information in the data base to reduce calculation errors. Additional related information for each nutrient may include the source or reference, sampling method, analytical method, number of samples, variability with median, standard deviation or data quality codes, and date of inclusion of data or revision. Nutrient data for one food item may be obtained from several different sources; therefore it is important that source information be included for each nutrient. Maintenance of the nutrient data is an ongoing process and requires quality control procedures to maintain integrity. Most of these can be automated in a data base management system. The following are examples of such procedures:

- The sum weight of protein, fat, carbohydrate, alcohol and ash to equal standard weight, e.g., 100 grams
- Energy factors applied to protein, fat, carbohydrate and alcohol to equal total calories
- Range checks for each nutrient and food group for reasonableness of values
- Duplicate entry of manually entered nutrient data
- Sum of nutrient components to equal total weight of nutrient, e.g., total fatty acids not greater than total fat

Missing nutrient values should never be represented as zeros. Just as imputed and calculated values are documented, these should be documented so that a retrieval system will make these known to the user.

Related Information

A third critical element in any nutrient data base is a systematic identification of foods and nutrients which allows for translation of food names and nutrients into a machine readable form. Alphabetic and numeric codes, or a combination of both may be very simple or quite complex. A hierarchical code may include food item descriptors which begin with a food group and range through more specific levels of description. A decision tree approach may be used based on logical queries by the user. Both of these approaches may be made invisible to the user (4).

Weight-volume equivalent factors, nutrient retention factors and yield factors are usually included. Other information related to foods may include color, texture, use frequency, cost, menu group, etc. User needs and practicality will determine the extent of additional data to include.

DATA BASE MAINTENANCE

A nutrient data base may be static or dynamic in nature. Most static data bases have been compiled for specific purposes. New foods come into the market place, reformulations occur, nutrient fortification regulations change, new nutrient information becomes available and consumer consumption behaviors change continuously. It is therefore necessary to keep a nutrient data base current. As this is done, data validations should be made and documented. If at all possible, a data base management team should have members or consultants who have knowledge of food science, food composition, nutrients and computer data base structure. Awareness of users' needs and ongoing dialogue with users is also necessary. The proceedings of nutrient data bank conferences contain a wealth of information for data base compilers and users.

CURRENT ISSUES

Since the first data bank conference in 1976, we have been identifying, discussing and resolving issues. We have come a long way since then and recognize that the mutual support fostered by these conferences has led to greater knowledge in the community of users and compilers.

Work yet to be done includes:

- Food nomenclature conventions
- Common conventions for food descriptors
- Nutrient retention
- Food yields
- Weight - measure equivalents (density factors)
- Missing nutrient values
- Recipe calculations
- Timely availability of data
- Standard analytic procedures
- Variability among data bases
- Standardized documentation procedures

CONCLUSION

A nutrient data base is an organization of food composition values, related information and supporting documentation. Its size may range from being large and complex to very small and specialized. It may be static or dynamic. The discussions which follow will elaborate on applications and selection of a nutrient data base to meet specific needs.

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SOURCES OF NUTRIENT COMPOSITION OF FOODS

1. USDA Publications
2. USDA - Reports Published in Journals
3. Laboratory Analyses - Published in Journals
4. Directly from Industry
5. Tables Published in Books
6. Independently Compiled Data Bases
7. Labels On Food Products
8. Own Laboratory Analyses
9. Calculations of Recipes - From One or More Data Sources
10. Imputed - Varying Criteria

SELECTING OR DEVELOPING A NUTRIENT DATA BASE TO MEET THE REQUIREMENTS OF YOUR APPLICATION

Loretta W. Hoover, Ph.D., R.D.

Selecting or developing a nutrient data base and associated software for a particular situation deserves careful consideration of special needs. The intended use of a system is an important factor when appraising alternative options. The purpose of this paper is to identify some areas that deserve attention and to acquaint potential users with some resources that may be useful prior to and during this decision process.

Several sources of information can be used to become familiar with the types of applications that are feasible and the software products available in the marketplace. Some sources of information are:

1. Vendor materials
2. Software directories
3. Nutrient data bank conference proceedings
4. Professional literature

On the attached sheets, references are provided for some of these types of materials. The Nutrient Data Bank Directory prepared for this conference contains information for 108 software products. With the expanding marketplace, comparative information is needed to identify those products that satisfy requirements. A bibliography compiled by Hoover (1985) provides citations to the professional literature relating to the use of computers in nutrition, dietetics, and foodservice management. Each citation is coded to indicate the content of the reference. A copy of the set of codes used in the most recent edition of the bibliography is attached.

After becoming familiar with the many options that exist, a user is ready to assess the needs of a particular situation. Some factors for consideration are:

1. Setting and target audiences
2. Long-term plans
3. Amount of use
4. Comprehensiveness required
5. Interfacing requirements

The results from this analysis will be useful in determining specifications for either selecting a commercial software product or developing a custom application.

In a recent article, Frank and Pelican (1986) enumerated several primary considerations to guide the selection process. They recommended using the following criteria:

1. Validity of data base
2. Soundness of programs
3. Complete, understandable documentation
4. Output clarity
5. Soundness of developer's credentials

Evaluation of nutrient data base software applications or products both in terms of these criteria and the needs of a particular situation helps a user to make a suitable selection.

A tool has been developed by Hoover and Perloff to appraise the capabilities of a nutrient data base system. The monograph entitled *Model for Review of Nutrient Data Base System Capabilities* includes the following components: a questionnaire, five computing tasks, instructions and worksheets, and an interpretation guide. The aspects that can be reviewed with the computing tasks are:

1. Updating a data base
2. Calculating nutrients for a recipe
3. Reporting of baseline data for 100 gram quantities
4. Reporting nutrients for various portion sizes

5. Dietary record computation

The interpretation guide provides data from USDA sources for comparison with the results from each of the computing tasks.

Calculation methodologies provide one way to estimate nutrient profiles for foods as consumed when laboratory analyses are not available. Any one of a variety of methods may be used in a software product to estimate the nutrients for mixed dishes. Summaries of four methods have been compiled by Powers (1986) and are attached for reference. These methods vary in data requirements, complexity, and suitability for given situations.

Assessment of nutrient analysis applications involves consideration of a number of factors. An assessment checklist is attached to encourage evaluation in a number of areas such as maintenance and support, the contents of the data base, software characteristics, hardware configuration and suitability for needs.

A sound assessment made by an informed user improves the possibility of selecting a nutrient data base system that meets a user's requirements. In addition to the acquisition or development process, users need to recognize ongoing responsibilities for assuring the integrity and usefulness of a system.

ASSESSMENT CHECKLIST

1. Maintenance and support
   - Quality control for updating
   - Policies and procedures
   - Documentation
   - Qualifications of staff
   - Vendor support
   - Custom services

2. Contents of data base
   - Primary data source
   - Additions to primary data
   - Nutrients included
   - Foods included
   - Missing values
   - Mixed dishes

3. Software characteristics
   - Compatibility with hardware
   - Interfacing options
   - Speed and response time
   - Storage of dietary records
   - Storage of analysis results
   - Features of software
   - Database maintenance
   - Data entry options
   - Analysis options
   - Comparisons with standards
   - Presentation of results
   - Dietary guidance
   - Custom features

4. Hardware configuration
   - Number of users
   - Printer speed and output quality
   - Data storage requirements
   - Suitability to setting

5. Suitability for needs
   - Accurate outputs
   - Adequate for intended use
   - Integrates with existing applications
   - Cost-effective

SELECTING OR DEVELOPING A NUTRIENT DATA BASE

METHODS FOR CALCULATING NUTRIENT COMPOSITION OF RECIPES

Retention Factor Method*

Step 1. Convert each ingredient amount to a gram weight.
Step 2. Compute the edible-portion weight for each ingredient.
Step 3. Calculate the value for each nutrient per ingredient before cooking adjustments.
Step 4. Apply nutrient retention factors.
Step 5. Compute the total uncooked gram weight of the recipe.
Step 6. Calculate the value of each nutrient for the total recipe.
Step 7. Adjust kilocalories and fat components to reflect fat change.
Step 8. Compute the cooked weight of the recipe.
Step 9. Compute the yield percentage.
Step 10. Calculate the value for each nutrient per 100 gram portion.

* Modeled to reflect the method employed by the U.S. Department of Agriculture for the Nationwide Food Consumption Survey.

Simplified Retention Factor Method*

Step 1. Convert each ingredient amount to a gram weight.
Step 2 Calculate the edible-portion weight of each ingredient.
Step 3. Calculate the total raw weight of the recipe.
Step 4. Convert each ingredient weight to a 100 gram unit.
Step 5. Calculate the value for each nutrient per ingredient.
Step 6. Apply a nutrient retention factor to the values for Vitamin A, thiamin, riboflavin and Vitamin C.
Step 7. Compute the value of each nutrient for the total recipe.
Step 8. Adjust kilocalories to reflect fat change.
Step 9. Compute the value for each nutrient per portion.

* Modeled to reflect the Nutrient Standard Menu Planning System method developed by the U.S. Department of Agriculture for the school lunch program.

Yield Factor Method*

Step 1. Compute the total cooked weight of the recipe and the consumable weight for each ingredient by multiplying the weight of each ingredient by yield factors.
Step 2. Convert each ingredient weight into the number of 100 gram units.
Step 3. Calculate the value for each nutrient per ingredient.
Step 4. Calculate the value for each nutrient per edible portion.
Step 5. Calculate the weight per portion served.

* Modeled to reflect the method employed by the University of Missouri - Columbia Hospital.

Summing Method

Step 1. Convert each ingredient amount to a gram weight.
Step 2. Compute the total weight of the recipe.
Step 3. Compute the number of 100 gram units.
Step 4. Calculate the value of each nutrient per ingredient.
Step 5. Compute the total value of each nutrient for the recipe.
Step 6. Compute the value for each nutrient per portion.
Step 7. Compute the value for each nutrient per 100 gram portion.

CAUTION: The summing method may result in poor estimates of nutrient values if ingredient weights and nutrient profiles do not reflect the *as served* form of the foods.

Source: Powers, P. Recipe Calculations--New Research in Methodologies. Proceedings of the 11th National Nutrient Data Bank Conference, University of Georgia, Athens, 1986.

DIETARY INTAKES OF METALS AND MINERALS: RESULTS FROM THE FDA'S TOTAL DIET STUDY

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Food and Drug Administration's (FDA) Total Diet Study is a yearly program that monitors the levels of various organic and elemental contaminants and nutritional elements in the United States (U.S.) food supply and estimates the intakes of these substances in representative diets of specific age-sex groups (1,2). The yearly data provided by the Total Diet Study allow for the identification of changes and trends in the levels of contaminants and nutrients in the food supply and thereby assist in identifying potential public health problems.

Through the Total Diet Study, typically consumed foods are purchased in specified cities and sent to the Total Diet Laboratory in Kansas City, MO, where they are prepared for consumption and analyzed for the contaminants and nutrients of concern. The foods collected and the age-sex group diets developed from these foods are updated periodically as food consumption data become available from national food consumption surveys. When the Total Diet Study began in 1961, it was based on data from the 1955 USDA Household Food Consumption Survey. The program was updated when data from the 1965 USDA Household Food Consumption Survey became available, and it was again updated in 1982 when data from the 1977-78 USDA Nationwide Food Consumption Survey and the NHANES II (the Second National Health and Nutrition Examination Survey, 1976-80) became available.

Two other major changes were made to the Total Diet Study during the 1982 revision. The number of age-sex groups was expanded from three (adult males, infants, and 2-year-old children) to eight. The current program includes infants, 2-year-old children, teenage girls and boys, adult men and women, and older men and women. The second major change was the analysis of individual foods, rather than food commodity groups. In the current program, there are 234 foods which include traditional meat, fruit, vegetable, grain, and dairy products plus fast foods, mixed dishes, alcoholic beverages, desserts, and commercially prepared infant foods (3).

The Total Diet Study foods are purchased four times per year, once from each of the four regional areas of the U.S. Each of the four yearly collections consists of the purchase of each food from supermarkets in three cities. Three portions of each food (from the three cities within a region) are composited and test samples of each composite are then analyzed.

The elements that have been routinely analyzed in the Total Diet Study include the toxic elements lead, arsenic, cadmium, and mercury and the nutritional elements sodium, potassium, calcium, phosphorus, magnesium, iron, zinc, copper, manganese, selenium, and iodine. Portions of foods from one of the four yearly collections are routinely sent to the FDA Winchester Engineering Analytical Center in Boston, MA, where they are analyzed for radionuclides including strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40. In a special study of one of the 1984 Total Diet Study collections, portions of foods from the Total Diet Laboratory in Kansas City were sent to the Division of Contaminants Chemistry, Center for Food and Applied Nutrition in Washington, DC, where they were analyzed for aluminum, molybdenum, nickel, cobalt, vanadium, and strontium.

The analytical methods used for these elemental analyses include:

- beta-counting of yttrium-90 for strontium-90;
- gamma-ray spectroscopy for cesium-137, iodine-131, ruthenium-106, and potassium-40;
- dry ash-graphite furnace atomic absorption spectrometry or dry ash anodic stripping voltammetry procedure for cadmium and lead;
- atomic absorption spectrometry with rapid hydride evolution for arsenic and selenium;

- flameless atomic absorption spectrometry for mercury;
- inductively coupled plasma emission spectroscopy for sodium, potassium, calcium, phosphorus, magnesium, iron, zinc, copper, manganese, aluminum, molybdenum, nickel, cobalt, vanadium, and strontium; and
- colorimetry method for iodine.

Last year at the Nutrient Databank Conference in Athens, GA, the results for the nutritional elements for the first two years of the revised Total Diet Study program (1982-84) were presented. These results (4,5) indicated that:

- levels of calcium, magnesium, iron, zinc, copper, and manganese were less than 80% of the Recommended Dietary Allowance (RDA) or below the low end of the Estimated Safe and Adequate Daily Dietary Intake (ESADDI) range for some or all age-sex groups;
- those most at risk of low intakes were young children, teenage girls, adult women, and older women;
- non-discretionary sodium intakes exceeded the upper ESADDI range for two age-sex groups;
- iodine was considerably above the RDA for all age-sex groups; and
- levels of potassium, phosphorus, and selenium were adequate for all groups.

Currently the nutritional element results for the first four years of the revised Total Diet Study (1982-86) are being evaluated to compare the yearly levels of these elements in the food supply and in daily diets to determine if any trends or changes are occurring. Of particular interest are the intakes of sodium and iodine.

The intake levels of radionuclides have remained within safe levels during the years of analyses as have the levels of the toxic elements lead, arsenic, cadmium, and mercury (6,7). The results of the special study on aluminum, molybdenum, nickel, cobalt, vanadium, and strontium have provided information on elements not traditionally evaluated in dietary studies. Of these six elements, three (molybdenum, nickel, and vanadium) are considered essential, but only for molybdenum has an ESADDI been established. These and other trace elements are of interest because it is possible that the balance between adequate or safe levels and toxic levels of these substances may be upset by the use of supplements or by changes in agricultural or manufacturing practices, food additive use, or nutrient fortification practices. For example, an increase in the intake of one trace element (as through supplementation) may affect the absorption or metabolism of one or more other trace elements.

Intakes of aluminum are of interest because of the known toxic effects of aluminum from drugs and dialysis fluids. Previous estimates of dietary aluminum intake are old and are based on older analytical methods for this element. In connection with this analysis of Total Diet Study foods, an extensive database on the aluminum content of foods was developed by compiling literature data (8). To this was added the results from the Total Diet Study (9). The results indicate that few foods are naturally high in aluminum, the exceptions being tea, spices, herbs, and some subtropical plants and leafy vegetables from Nigeria and South America that are able to concentrate this element. Aluminum may migrate to foods if aluminum utensils and aluminum wrap are used; however, to be of practical significance, the foods must be acidic and heated or stored for long periods. Migration is probably not a major source of dietary aluminum. The most impressive source of dietary aluminum is that from foods which contain aluminum additives such as processed cheese and baked goods made with aluminum-containing baking powder. For example, a one-ounce serving of cheddar cheese contains only 0.005 mg of aluminum, while a one-ounce serving of processed American cheese containing an aluminum additive may contain 11.5 mg of this element. Baking powders without aluminum additives contain no measurable amount of this element; such baking powders will not contribute to the aluminum content of baked products. Baking powders with aluminum additives may contain 2,300 mg of aluminum per 100 g (69 mg of aluminum per teaspoon); muffins, pancakes, cornbread, etc. made from these baking powders may contain 3-18 mg of this element per serving.

The daily intakes of aluminum for the eight age-sex groups included in the Total Diet Study (2-14 mg/day) were considerably lower than most values previously reported (18-36 mg/day). By food group, the major sources of aluminum were grains and grain products; milk, yogurt, and cheese; and desserts. By individual foods, the major sources of aluminum were American processed cheese, cornbread, yellow cake with white icing, cream substitute, flour tortillas, blueberry muffins, chocolate cake with chocolate icing, pancakes, and fish sticks.

The levels of molybdenum (10) found in the Total Diet Study diets (50-126 ug/day) met the ESADDI's for infants (40-80 ug/day) and 2-year-old children (50-100 ug/day), but were below the 150-500 ug ESADDI range established by the National Research Council for teenagers and adults. The two major food group sources for molybdenum were grains and grain products and legumes. For infants and young children, the milk, yogurt, and cheese group was also a major source. The individual foods with the highest concentrations of molybdenum were legumes, liver, breakfast cereals, and grain products.

Nickel intakes for the eight age-sex groups ranged from 69 to 162 ug/day (10). The major contributors to nickel intake were mixed dishes and soups; vegetables; legumes; grains and grain products; and desserts. Individual foods with the highest nickel concentrations were legumes, foods containing chocolate, canned foods, and grain products.

Cobalt intakes ranged from 3 to 12 ug/day (10). Major contributors to cobalt intakes were meat, fish, and poultry; vegetables; desserts; and grains and grain products. For infants, the milk, yogurt, and cheese group was the major source of cobalt. Individual foods with the highest cobalt concentrations were liver, breakfast cereals, and foods containing chocolate.

Vanadium intakes ranged from 6 to 18 ug/day (10). Vanadium was obtained primarily from grains and grain products. Fruits and fruit juices were major contributors to vanadium intake for infants and young children, while beverages were a major contributor for adult males and females and older males. Individual foods high in vanadium included breakfast cereals, fruit juices, fish sticks, several vegetables, several sweet items, wine, and beer. Previous reports indicate that vanadium may be introduced into foods during processing.

Strontium intakes ranged from 490 to 1,390 ug/day (10). Strontium was obtained primarily from grains and grain products; vegetables; and mixed dishes and soups. Milk, yogurt, and cheese were major sources of strontium for infants and 2-year-old children, while beverages were the major source for adult males. Strontium levels were highest in fried shrimp, some vegetables, pecans, breads, cheeses, some fruits, and chocolate powder.

The levels of aluminum, molybdenum, nickel, cobalt, vanadium, and strontium in Total Diet Study foods, commodity groups, and in age-sex group diets may serve as baseline data until more information becomes available. It is hoped that the Total Diet Study will be expanded to include some of these lesser known elements on a routine basis.

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NHANES UPDATE: PLANS FOR NHANES III

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National Center for Health Statistics

Background

Since 1960 the National Center for Health Statistics (NCHS) has been responsible for producing vital and health statistics for the United States. Over the years the Center has developed a diversified Program of surveys and inventories. NCHS is currently planning a National Health and Nutrition Examination Survey (NHANES III) to begin in 1988. This is the latest of a series of studies (see below) involving interviews, physical examinations, and diagnostic and biochemical testing of a representative sample of Americans.

Surveys	Dates	Ages
NHES I	1960-62	18-79 yrs
NHES II	1963-65	6-11 yrs
NHES III	1966-70	12-17 yrs
NHANES I	1971-75	1-74 yrs
NHANES II	1976-80	6 mos-74 yrs
NHANES	1982-84	6 mos-74 yrs
NHANES I Follow-up	1982-	25-74 yrs
NHANES III	1988-1994	2 mos+

The plans for NHANES III incorporate certain features which will distinguish it from earlier surveys in the series. These features include a longitudinal component, meaning that individuals will be followed over time for vital status and possible re-examination; an analytic as well as a descriptive orientation; automated data collection; and long-term biological specimen banking. These special features will increase the public health and scientific yield from the survey and will allow for responsiveness to emerging hypotheses and health issues.

The survey sample selection procedures will be designed to yield national estimates of diseases and health characteristics. A stratified, multistage, probability cluster sample of households will be enumerated. Persons selected from within these households will be requested to respond to a detailed questionnaire about dietary practices, health habits, and diseases. Upon completion of the household interview, respondents will be asked to undergo a voluntary physical assessment which will take place in a mobile examination center (MEC). Each MEC will consist of four large, 45-foot long inter-connected trailers. The trailers will contain facilities for conducting interviews in a private clinical setting, and for making physical assessments such as anthropometric measurements and bone densitometry, for blood drawing, and for physical and dental examinations. Each MEC will also contain a laboratory and a computer room.

Sample Design Features

It is estimated that up to 60,000 Americans in randomly selected communities will be interviewed, and 45,000 examined over two 3-year sequential waves of data collection. Interviews and examinations will begin in the fall of 1988 after a period of extensive developmental work and pretesting. Special sampling of children (as young as 2 months) and the elderly (with no upper age cutoff) will permit reliable estimates of the health of these groups. Another special design feature, oversampling of the black and certain Hispanic populations, means that the health of these groups can be evaluated.

Public Health and Research Goals for NHANES III:

1. To estimate the prevalence of diseases and risk factors
2. To estimate the incidence of diseases
3. To estimate the prevalence of functional impairment
4. To provide population reference distributions of health characteristics
5. To monitor secular changes in diseases and risk factors
6. To identify reasons for secular trends in health
7. To assess the natural history of diseases
8. To establish the need for health care based on physical diagnosis
9. To identify new risk factors for disease and contribute to an understanding of disease etiology
10. To estimate the attributable risk of disease

Survey Content

Extensive solicitation of topics for inclusion in NHANES yielded nearly 100 proposals from the Federal, State, and private sectors. The NCHS identified 30 areas of public health relevance to NHANES III and then developed 30 comprehensive planning proposals, drawing heavily from the 100 solicited proposals in some cases, and augmenting them in others. These NCHS proposals outlined the rationale and aims to be met by the survey. These proposals were reviewed intensively with careful assessment of a set of guidelines related to scientific merit, public health importance, feasibility, and joint relevance to other proposed topics.

As in previous surveys, nutrition assessment will be a focal point of the survey and nutritional status will be measured by estimating food and nutrient intake, performing hematological determinations and nutritional biochemistries, and taking physical measures (see page 4). These procedures will provide reference distributions and risk factor prevalence estimates and will also permit etiologic studies. Anthropometry will be performed and related to nutrition, disease, and health habits. A dental exam will provide valuable data on trends and correlates of caries and periodontal disease. NHANES III will also be particularly useful in establishing reference distributions for hearing levels and visual acuity. Specialized examination procedures will be tailored to the elderly and children; for example, additional assessments of physical disabilities and cognitive functioning are planned for the elderly.

Gallbladder sonography will yield national prevalences of gallstones, an important contributor to hospitalization stays in the United States. Another chronic disease with high morbidity, diabetes, will be evaluated by glucose tolerance testing. Lung function and conditions of the respiratory system will be assessed by spirometry and by questions on asthma and symptoms related to chronic obstructive pulmonary disease. The NHANES III program will continue to make an important public health contribution by monitoring secular changes in the prevalence of cardiovascular disease (CVD) risk factors. Physical activity, awareness and treatment of high blood pressure and elevated blood cholesterol, smoking, and CVD-related dietary intake and dietary habits will be assessed by questionnaire.

Laboratory analyses of biological specimens will measure exposure to toxic metals, serum antibody levels for sexually transmitted diseases as well as common childhood diseases, and hormone levels. One innovative and important study component will involve storing specially treated white blood cells to allow estimation of the prevalence of genetic alleles in order to study genetic susceptibility to selected major chronic diseases. To estimate the prevalence and severity of allergic syndromes, the allergy component will include an integrated series of measurements: skin testing and serologic measurements of immunoglobulins.

The NHANES III efforts in the area of cancer research involve obtaining questionnaire data and biologic specimens, and conducting certain medical examination procedures to estimate the prevalence of known risk factors; confirming the importance of suspected risk factors; and identifying new risk factors. Tobacco use data, measured by questionnaire with biochemical validation, will be used as a covariate in numerous analyses and as a primary variable in the assessment of health effects, particularly those due to exposure passively to the smoke of others. Similarly, information on reproductive characteristics will be obtained to aid in the interpretation of health findings and as primary analytic variables. The prevalence of depression and anxiety will be measured by questionnaire.

Radiographs of the hands, feet, and knees will be collected to estimate the prevalence of arthritis. The osteoporosis component will include bone densitometry. Kidney function will be measured primarily by means of questionnaire items and laboratory tests of serum creatinine; persons with high serum creatinine may be followed to explore the natural history of kidney diseases. Occupational health needs will be served by obtaining estimates of lung function, central and peripheral nerve functioning, and hearing levels for working persons.

For further information regarding NHANES III contact:

Survey Planning and Development Branch
Division of Health Examination Statistics
National Center for Health Statistics
3700 East-West Highway, Room 2-58
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Tentative Content for NHANES III Nutrition Component
March 1987

A. **Dietary intake data**

1) 24-hr dietary recall - automated interview in Mobile Exam Center - quantitative dietary intake data
2) General food frequency - qualitative dietary intake data - targeted to vitamins A and C and calcium
3) Alcohol intake - current, historical, binge drinking
4) Use of discretionary salt, food preparation methods
5) Type and amount of tap water intake

B. **Other dietary questionnaire data**

1) Family income, education, household composition, etc.
2) Infant feeding practices - breastfeeding, introduction of solid foods, milk or type of formula fed, etc.
3) Participation in school breakfast, school lunch, food stamps, supplemental feeding programs (e.g., WIC), etc.
4) Periodic food shortages in the home
5) Lifestyle questions - salt and fat used in food preparation, meal patterns, meals eaten away from home, etc.
6) Historical dairy food (calcium) consumption

C. **Vitamin/mineral supplement usage - detailed type (brand) and quantity of supplements taken**

D. **Anthropometry data**

1) Height, weight, skinfolds, circumferences, breadths
2) Bioelectrical impedance to estimate body fat
3) Questions on weight history, diet aids, bulimia, weight loss diets

E. **Blood and urine assessments**

1) Hematological assessments
2) Nutritional biochemistry assessments
3) Blood lipids and lipoproteins
4) Urinary assessments

DESIGNING A COMPUTERIZED NUTRIENT DATABASE FOR INDUSTRIAL APPLICATIONS: FOOD INDUSTRY

Jenny Chin

Best Foods
Union, New Jersey

INTRODUCTION

Computerized nutrient analysis systems are powerful tools with a variety of applications in research, health care, academia, and the food industry. Best Foods' original computerized nutrient analysis system was developed in 1972. In 1980, its design and applications were presented at the Fifth National Nutrient Data Bank Conference hosted by Michigan State University. Our system, which consists of a database and software program, was originally developed by a consultant and is accessed by a modem through General Electric time-sharing. The system was designed as a tool to enable us to assess the nutrient profile of our products and to disseminate nutrition information on product labels, in advertising, in publicity releases, in nutrition education materials, and in cookbooks. High time-sharing costs, the inability to easily update our database, and expanding needs made it necessary to enlarge and enhance our nutrient database system. This presentation identifies the specific nutrient database and program needs of one food company, Best Foods, and describes the computer system which is currently being modified to fulfill those needs.

DATABASE NEEDS

General Needs

The primary source of nutrient data in the database is USDA's Standard Reference Data Set which includes the revised Handbook No. 8 series. These data are supplemented with information from other common references of food composition such as Bowes and Church's Food Values of Portions Commonly Used, and McCance and Widdowson's Composition of Foods. Additional sources of data include Best Foods' ingredient and product data, other manufacturers' composition data, current scientific literature values, and analytical values. The source of all nutrient values in the database is documented to allow questionable values to be easily validated. When nutrient values for an ingredient are missing, the ingredients are flagged in the printout with an asterisk to indicate that for at least one nutrient, data are unavailable; also missing values are identified with a "-1" in the database and on the computer printout to alert the user that the calculated values may be underestimated and an adjustment may be necessary. The database can be easily updated, revised, and expanded as new food items or nutrient values become available.

Specific Nutritional Components

The specific nutritional components which must be included in the database are those which are needed for nutritional labeling. They are complete proximate analyses data, and the capability of verifying that these data are equal to 100 grams, the polyunsaturated and saturated fatty acid composition, the cholesterol content, and selected micronutrient data.

The nutritional components in the database are listed below. All underlined components are needed for nutritional labeling of food products. The other components are not required for nutritional labels, but are used in other ways such as in preparing prudent menus or recipes, and to support nutrient intake studies.

DATABASE NEEDS: SPECIFIC NUTRITIONAL COMPONENTS

Proximate	Minerals	Vitamins	Fats	Amino Acids
water	calcium	ascorbic acid	saturated fat	
energy	iron	thiamine	monounsaturated fat	
protein	magnesium	riboflavin	polyunsaturated fat	
carbohydrate	phosphorus	niacin	others	
fat	potassium	pantothenic acid	cholesterol	
crude fiber	sodium	vitamin B-6		
dietary fiber	zinc	folacin		
ash		vitamin B-12		
		vitamin A		

Wants

Some additional features of databases which we have identified as "database wants", rather than "needs" include dietary fiber values, allergy flags, nutrient values for branded products and diabetic exchanges.

PROGRAM NEEDS

General

The Best Foods' program allows food items to be entered by name or code number; household units of measure as well as gram weights are also acceptable. The printout lists each ingredient by name, corresponding code number, the amount of the ingredient used in the recipe, weight of the ingredient as grams per 100 grams, the amount and source of each nutritional component in a total recipe, per 100 grams, and in two serving sizes. The program allows the user the option of selecting and calculating individual components.

Printout for Selected Nutrients

A printout for a Peanut Butter Shake recipe would show the ingredient name, code number, amount of each ingredient used in the recipe, as well as the percent or amount each ingredient contributes by weight to 100 grams of a recipe. If the caloric value and the protein content are selected for output, the distribution of calories, and the amount each ingredient contributes to the total protein content can easily be determined. If the caloric value is too high, the ingredient responsible can be identified and the recipe can be easily modified. Note that the nutrition information per total recipe, per 100 grams, and per two serving sizes are output simultaneously. Also, the program is designed to round the appropriate nutritional components for nutrition labeling. This will be discussed in more detail later.

User Accessibility and Needs

The system can be accessed by other Best Foods' departments. The primary users are the home economists in our test kitchens, the food technologists in product development, and the publicists supporting our marketing groups. They will have "read" only capability; that is, they will be able to utilize all programs but they will not be able to make modifications to the database. Another feature is the ability to calculate subtotals; this can be useful to the home economist and to the food technologist. In menu development, the nutritive values of individual meals such as breakfast, lunch, dinner, as well as the daily total can be determined. This feature also has applications for the food technologist in product development where the nutritive values of components of products can be determined. Recipes or product formulas undergoing formulation can be stored in a recipe file and can be recalled at a later date and analyzed, revised and reanalyzed if necessary. With authorization, a recipe or product formula can be stored in the database as a food item; the program will transfer this information directly into the database eliminating time spent and reducing errors in data entry.

A variety of reports can be generated. The most frequently generated reports are the ingredient list report, the nutritional labeling report, the approximate composition report, and the recipe nutrient density guide.

Ingredient List Report

The preparation of an ingredient list report requires listing the ingredients of a product in order of predominance by weight. This procedure may require the breakdown of complex ingredients into their simple components, combining like components together (that is, components with the same labeling term), and then ordering them according to their respective weights. The specific guidelines for labeling terms are found in the Code of Federal Regulations issued by the Food and Drug Administration. For example, let's take a hypothetical product, Seasoned Spread, where the ingredients are seasoning salt, partially hydrogenated corn oil, garlic spread, and salt. The printout shows the seasoning salt (salt, pepper, parsley, oregano) and garlic spread (partially hydrogenated corn oil, garlic, salt) broken down into their simple components. Like ingredients are combined (that is, the "salt" from the "seasoning salt" is added to the "salt" in the "garlic spread" and the "added salt") and then sorted according to weight. Appropriate labeling terms may be assigned if applicable. In this case, the term "spices" includes "pepper", "parsley" and "oregano", so the final ingredient statement would become: "partially hydrogenated corn oil, salt, spices, garlic".

Nutrition Labeling Report

The Nutrition Information Per Serving report expresses values for specific nutrients as they would appear on a nutritional label. Values for calories, protein, carbohydrate, fat, the percent of the U.S.RDA for vitamin A, protein, vitamins C, thiamine, riboflavin, niacin, and minerals calcium, iron, must be declared and are rounded by the program according to guidelines in the Code of Federal Regulations. Other nutritional components such as the fatty acid composition, sodium, and cholesterol content are optional and can be printed out as needed.

Approximate Composition Report

The approximate composition report reflects values for nutritional components in 100 grams, and in two other units of measure (e.g., in a tablespoon and in a cup). This report is more informative in that the values are not rounded as they are for nutrition labeling, and values for additional components not found on the product label are provided (for example, the moisture content, the P/S ratio, and the ash content).

Recipe Nutrient Evaluation Report

The recipe nutrient density guide is used as a tool to help (1) evaluate how well recipes and menus meet prudent dietary guidelines or (2) how they need to be modified. The guide is based on a daily caloric level of 2000 Calories and nutrient levels are based on (1) the U.S. RDA for protein, vitamins, minerals, (2) total fat at 30% of calories, (3) saturated fat and added sugars at 10% of calories, (4) cholesterol at 300 milligrams per day and (5) sodium at 2000 milligrams per day. Each of these numbers are divided by 20 to arrive at the nutrient density guide per 100 calories. These values are printed in the output along with the calculated nutrient density values of the recipe so that they may be easily compared.

CONCLUSION

The Nutrient Data Bank Directory, edited by Loretta Hoover, and the Model for Review of Nutrient Data Base System Capabilities, edited by Loretta Hoover and Betty Perloff were valuable resources in identifying and designing a computer system to meet our needs. In the Nutrient Data Bank Directory, 87 computerized nutrient analyses systems are listed along with the appropriate contact person, a description of the characteristics of each system, and its availability. Several systems were evaluated following the methodology presented by Loretta and Betty in their Model for Review of Nutrient Data Base System Capabilities. Unfortunately, none of the available systems met all of our needs and would run on available computers without considerable program modification. Most systems were designed for applications in health care, research, or for personal nutritional assessment. Therefore, a software consultant was contracted to design a specific program for us. The system is in the advanced development stage and the initial results look promising. Our upgraded system will be up and running by early summer.

DESIGNING A COMPUTERIZED NUTRIENT DATABASE

Nanci D. Garoon, M.S., R.D.

Kraft, Inc.

Nutrition has entered the computer age. While nutrient database systems have traditionally been used by institutions to plan diets, evaluate school lunch menus, and calculate an individual's daily nutrient intake, these systems have become increasingly popular in the food industry as tools for formulating new products or recipes, generating nutrition label information, comparing the nutrient content of competitor's products, determining marketing trends and supporting advertising claims.

Approximately four years ago, the Nutrition Research Laboratory at Kraft, Inc. identified the need to develop a novel computerized nutrient database to supplement the systems already in place. The strategic planning process began and by January, 1985 the development of an in-house computerized nutrient database was approved by management.

The purpose of this presentation is to describe how an on-line interactive computerized database system was created at Kraft, Inc. The presentation will:

1. identify the problem;
2. describe how the system was created; and
3. illustrate key functions of the system.

The first step toward creating the database was to identify exactly what the situation was and why something had to be done. The Nutrition Research Group at the Kraft Technology Center is not only a true research laboratory but also a very active service group. That is, the group is continuously asked to provide information on the nutrient composition of generic foods and food categories, on competitor's products and, of course, on the entire line of Kraft products.

Certainly, many of you have seen a Kraft-sponsored television special and heard a recipe from the famous Kraft Kitchens. Calculating the nutrient content of individual food items as well as the recipes from the Kraft Kitchens are routine activities in the group. The mechanism in place to accomplish these tasks was manual, slow and narrow in capability. There was no doubt that an interactive on-line computerized nutrient database with query capabilities would reduce the time spent searching for and calculating nutrition information.

After gathering the facts and analyzing the significance of each, a list of needs and requirements of the database was generated. At the very least, the database had to:

1. calculate the nutrient content of selected food items on a per serving and per 100 gram basis;
2. calculate the RDA or USRDA of a generic, branded, ethnic or fast food product;
3. create and store recipes using either common measuring units (cups, tablespoon) or metric units, and calculate a nutrient profile on a per serving basis;
4. provide an editing capability that would allow a user to add, modify or delete a food item; and
5. provide an updating feature.

The next step was to determine whether or not there was an existing system suitable for our purposes. If any of you have perused the 1986 (5th) edition of the Nutrient Data Bank Directory you will see that last year, 99 different systems were listed in the directory and (as stated in the preface) this listing is not comprehensive. A number of databases were screened and evaluated, and a decision was made to purchase the Michigan State University (MSU) Nutrient Database. This decision was based on the following attributes of the MSU database:

1. Approximately 5,000 foods including ingredients, brand-specific products and fast food items are listed.
2. Fields exist for 74 different nutrients.

3. The source of the data is documented and is extracted from USDA handbooks, periodical literature and food manufacturers.
4. Regular (yearly) updates are available.

Hardware and software issues were not important for the development of this Kraft system. We were not concerned about program languages or implementing outside computer services. The goal was to purchase an existing database and augment it to meet our specific needs in a Kraft environment. We defined our own processes and are maintaining our own database.

In August, 1985 the first MSU computerized data tape arrived at the Kraft Technology Center. The data was in a flat or sequential file format. Again, no software programs were purchased to access and manipulate the information.

Documentation accompanying the tape described how the data was blocked. The data was divided into 80 unique fields. This slide illustrates the layout form:

Note: 1. Group-item number (unique)
2. Field for source code
3. Weight relationship fields
4. Nutrient content fields
- 10 characters in length
- implied decimal at hundredth place

A comparable form was designed and Kraft data was transcribed into a structure analogous to that of the MSU data structure. This information was subsequently key-punched. At this stage, a software specialist was hired to mesh the Kraft data with the MSU data and create "The Kraft/MSU Hybrid Nutrient Database".

Identifying data requirements and designing informational processes took several months of work with a consultant. A relational database management system (VAX-Rdb) as opposed to a hierarchical or network (VAX-DBMS) type database structure was selected for these reasons:

1. Our system was small to medium in size. Hierarchical database management systems are usually applied to large systems.
2. Hierarchical or network database management systems require more technical expertise than relational databases. A less experienced staff person is needed to implement a relational database.
3. For a relational system, ad hoc queries make up the majority of database activity. Rdb forms relationships as they are requested, they are not rigidly built into the database. Conversely, in a hierarchical or network model the data items and their relationships must be hard coded making them inflexible. Therefore, a relational model was preferred because it allowed the user to redefine data and data relationships. A relational database is a better fit when you don't know ahead of time exactly how the data will be used.

In addition to defining the exact functions the system was to perform, many other issues surfaced during the design phase. Two of these were first, how users were going to query the system and second, how to identify Kraft data as separate from MSU data.

An example of the dilemma surrounding database query had to do with a user requesting information on Kraft Mild Cheddar Cheese? or was that Kraft Natural Mild Cheddar Cheese? or even Kraft Mild 100% Natural Cheddar Cheese? This problem was solved by adding three "new" fields to the database:

1. class;
2. group; and
3. sub-group.

A class, group and sub-group name was assigned to each of the over 5,000 food entries comprising the Kraft/MSU Hybrid Nutrient Database. Therefore, one way for a user to access the system is by declaring a class, group and sub-group category. The system searches the database and generates a list of items that fit the specified categories. The user scrolls down the list and selects the item or items of choice.

The documentation issue was easily solved by using the established source field in the MSU database to specify "Kraft CA" (calculated) and "Kraft AN" (analytical) data. This delineation not only helps to maintain the integrity of Kraft data, but is also used as a distinguishing feature when the Kraft/MSU Hybrid Database is updated with new Michigan State University data.

Several months of programming passed before the system was finally ready for installation and testing. Today, the system is implemented and can perform a number of functions. This list illustrates a few key features:

1. Retrieve nutrition information for food items.
2. Rank selected database items by the nutritional content of a selected nutrient. The user specifies the food items or categories to rank and the nutrient to search.

   For example: User selects ice cream, yogurt and cheese and directs the computer to rank these items according to the amount of calcium in a serving.
3. List the food items that have a selected nutrient in an amount less than or greater than a specified RDA or USRDA.

   For example: User requests a list of all the ready-to-eat cereals that provide greater than 25% of the RDA per serving for children age four.
4. Determine the nutrient content of a recipe. The user must enter the ingredients, the quantity of each ingredient and the number of servings in the recipe. The system displays requested nutritional information on a per serving basis and prompts the user for any ingredient, nutrient or quantity changes.
5. Update the Kraft/MSU Hybrid Database from new MSU data. This function runs in batch mode. The system first determines if the record is a new or existing food item. If it is a new food item the record is added in the correct sequence to the database. If it is an existing food item, the system replaces the existing record with the new record.

There is one task yet to complete before use of the Kraft/MSU Hybrid Database is in full force. A "User's Manual" will be written to provide step by step instructions on each query option. This document will describe both the functional and operational characteristics of the database. All users will receive a copy of the manual and receive on-line training so that shortcuts and/or nuances in the query capabilities can be individually described.

DESIGNING A COMPUTERIZED NUTRIENT DATABASE FOR ACADEMIC/EDUCATIONAL APPLICATIONS

Suzanne P. Murphy, Ph.D., R.D.

I. General objectives/applications of the database.

At the University of California, Berkeley, we respond to a variety of users of computerized nutrient data:

- *Students* in our Nutritional Sciences and Public Health Nutrition classes analyze diets as part of various assignments. All nutrition majors are required to analyze three days of their own dietary data, collected according to various methodologies. In addition, there are occasionally specific needs, such as a recent exercise in a laboratory class to compare vitamin C intakes with urinary levels of ascorbic acid.
- *Dietetics* trainees also require access to nutrient data. Their curriculum emphasizes design as well as assessment, so they require a system that allows rapid feedback on changes to proposed diets.
- *Researchers* require accurate data for a variety of nutrients, primarily to assess intakes of survey participants. Occasionally nutrient data are used to calculate the content of research diets, although investigators are more likely to have these chemically analyzed. Traditionally, our researchers need nutrient information that is not commonly available, particularly for trace elements such as zinc and copper, or the various forms of iron.

After several years of working with researchers who use nutrient data (including my own research) and of teaching both nutrition and dietetics students, I have come to the conclusion that no nutrient data base that we currently have on our campus is ideal for everyone. Researchers want a data base with a large number of foods and nutrients, and high specificity of food items. They are less concerned with ease of coding or with the costs to run analyses. The dietetics students have almost opposite requirements - they want a fairly small nutrient data base so sample diets can easily be changed and costs of analysis are low. The nutrition students fall somewhere in between - perhaps one of the most important considerations for them is that the coding and data entry scheme not be too complex, as they are usually novice computer users (1).

II. What nutrient data are collected and how.

We now maintain three nutrient data bases, one for each of the three types of users. All are derived primarily from the various versions of Agriculture Handbook No. 8 (2) or Home and Garden Bulletin No. 72 (3).

1. For classroom dietary assessment assignments we use the diskette version of Home and Garden Bulletin No. 72 (1985 version) with 908 foods and 19 nutrients. This academic year we switched all our assessment laboratories to microcomputers, and have been pleased with the results. Many students have their own microcomputers now, and the vast majority of scientists will be using them in the future, so it is logical to use microcomputers in our classrooms. We have written a Fortran program for the IBM PC that interactively accepts the Home and Garden codes as well as serving sizes in multiples of the standard serving in the bulletin. Although this data base has fewer foods than the Agriculture Handbook No. 8 data base used previously, the foods are more representative of those in students' diets, and there is considerably less frustration about missing food items. Another advantage is the ability to purchase the "coding manual" for $2.75, and have a useful food composition table as well.

2. For dietary design applications we wanted a nutrient data base that would fit on a microcomputer spread sheet, so students could see immediately the effect of entering and deleting food items, and of changing serving sizes. After searching unsuccessfully for an existing database, we chose to develop our own with help from a campus group called the Instructional Technology Program. We entered 85 foods and 11 nutrients from the Home and Garden Bulletin No. 72 into Microsoft Multiplan for the Apple Macintosh. Students used this program last semester for the first time, with considerable success. Spread sheets can become unwieldy if they greatly exceed the size of the screen, so it is best to keep the number of foods small, and add items as needed for a specific diet assignment. If assignments could be solved using only foods already on the data base, the system worked very well. However, learning how to add food items for specific assignments was difficult for some students. I'd be very interested in suggestions any of you in the audience might have on how to simplify the use of spread sheets for this purpose.

3. Our most demanding needs come from our researchers. They want high specificity *and* a large number of nutrients. We have addressed the latter problem for many years with the UCB Minilist (4). This nutrient data base has relatively few food items (235) but a fairly extensive set of nutrients (49). The data come from many sources, including the USDA Standard Reference tapes and journal articles. There are no missing values, which means a relatively high maintenance cost, especially when new foods or nutrients are added. In order to achieve the high specificity required, we have developed an automated system of recipes and multipliers to allow substitutions of Minilist foods, or combinations of foods, for items reported in diets. Some work I did a few years ago showed that nutrients present on the Minilist and also on the NHANES II nutrient data base correlated well for individual diets when this system was used (5).

III. What data are available to the public.

All three of our data bases are available to the public. The Home and Garden Bulletin No. 72 data base can be ordered from the National Technical Information Service (order forms are usually available at this conference). Anyone who would like to have a copy of the spread sheet data base for classroom use may contact me. It is copyrighted by the U.C. Regents, which means it can't be sold by others, or further distributed without permission. The UCB Minilist is also copyrighted, and is available on a diskette for the IBM PC for a fee which helps cover the cost of maintaining this data base. Contact me for more information.

IV. Nutrition labeling and appropriate uses of label values.

We use very few data directly from nutrition labels. The major exception is for ready-to-eat breakfast cereals--since we have been particularly interested in trace mineral levels, it is important to distinguish levels of fortification in these cereals. The labels are used as a guide to the amount of fortification that is currently being used by a manufacturer. Some of the data from USDA's revised Handbook 8 (6) are already out-of-date (and were also based on label values in a number of cases), due to the rapid reformulations and introduction of new products. In this situation, I believe a trip to the supermarket to read the labels is the fastest way to be sure a nutrient data base reflects current fortification levels in a specific area. Although label values are likely to be lower than actual values, the level of accuracy is adequate for most purposes.

We also use label information to determine proportions of ingredients for mixed dishes. For example, if the nutrient content of macaroni and cheese is given (for several nutrients), the proportion of the ingredients can be estimated. We would probably carry this item as a recipe on our data base, rather than add the nutrient values, even if they were all known. The usual case is that only a few nutrients are given on the label, and the rest must be estimated from the ingredient proportions. Thus, we find it easier to just carry the recipe.

V. Impact of missing nutrient values.

We do not have any missing values on any of our data bases. The ones used for nutrition and dietetics students are taken directly from USDA data bases, which come without missing values (the staff at USDA calculate and impute values if necessary). For the UCB Minilist, a nutritionist fills in the missing values for the 49 nutrients that we carry. This is done via literature searches, calculations, and substitutions, as appropriate. Our policy has been that a reasonable estimate is better than always assuming (by default) that a missing nutrient value is zero.

VI. Summary.

The task of developing nutrient databases for academic and educational applications is a constantly challenging one. I appreciate the opportunity offered by this conference to share with you my experiences, and to learn from yours.

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DESIGNING A DATA BASE FOR HEALTH CARE APPLICATIONS

Diane M. Clapp, M.S., R.D.

The Ohio State University Hospitals

Introduction

The Ohio State University Hospitals is a 1,000 bed teaching hospital located on the Ohio State University campus in Columbus, Ohio. The hospital supports the needs of patients in the community and state through direct patient care, outpatient services and medical research. To provide for the nutritional well being of hospital patients, the need for extensive as well as reliable information on the nutritive value of foods is essential. The Ohio State University Hospitals' Department of Nutrition and Dietetics' Nutrient Data Base (NDB) was developed for in-house use for the therapeutic dietitian involved in dietary planning and patient education, as well as the medical research community.

In my presentation, I will be discussing the background of the OSUH NDB, considerations for nutrition software design, and our systems applications at OSU Hospitals.

Historical Background

The Ohio State University Hospitals recognized the need for an all-inclusive reference source for nutrient information as early as 1973 (Schaum, K.D., M. Mason and J. Sharp. Patient-oriented dietetic information system. J.A.D.A. 1973). As part of a Masters thesis, an extensive food composition table containing approximately 3600 food items was compiled and stored as a nutrient data bank on magnetic tape media. The file contained storage space to expand to a maximum of 9,999 food items, with 63 nutrient components for each item.

Format and data selection criteria for this study were as follows:

a) Nutrient values for 100 gram edible portions were to be stored in the data bank
b) No data published prior to 1960, with the exception of USDA Home Economics Research Report No. 4 were to be used
c) No foreign data were accepted. If more than one source contained data for the same food item, then:
   1. Data were selected from the study designed with better or best analytical methods or sampling procedures.
   2. The most recent data were chosen if analytical method and sampling procedures were comparable.
   3. Original data were selected rather than compiled data.

The USDA Agricultural Handbook No. 8 data cards were machine converted to our desired format. Form letters were sent to various food manufacturers whose products were used at University Hospitals and by individuals in the Ohio area. A MEDLARS (Medical Literature Analysis and Retrieval System) computer search was obtained which provided a bibliography of all the articles related to food analysis published in the journals listed in Index Medicus since 1964.

The original data bank took approximately two years to design, compile and store on magnetic tape. Although the file contained many gaps with regards to missing values, it was considered one of the most complete files available for that time.

OSUH Computer Center wrote programs for our mainframe system to manipulate the nutrient data in order to calculate nutrient values for intakes, menus, and recipes. These programs could be accessed either batch mode or on and on-line basis. We have continued to use these programs until the completion of our microcomputer program in 1985.

Maintaining the Data

Since 1973, OSUH Department of Nutrition and Dietetics has continued to maintain the NDB for internal use and for other users throughout the country. Dietitians have managed the project of data entry, selection and conversion of units. Yearly updates provided by USDA in either pamphlet, book, or most recently, magnetic tape or diskette format have been added to expand food items to approximately 9,200 items. Food manufacturers are continually contacted by mail or phone to try to keep up with new products. The popularity of fast foods has warranted the soliciting of nutritional data from these operations.

Missing Data

Nevertheless, we still receive criticism concerning lack of data in the areas of ethnic foods, enteral formulas, and vitamin and mineral supplements. We are trying to expand these data to the best of our ability.

The other criticism is with regards to "holes" in the data. These missing data are inevitable because:

a) The number of nutrient analysis studies reported are limited.
b) Most investigators do not analyze a food item for every nutrient in our data base. They usually analyze only the nutrients involved in their study.
c) Many manufacturers do not provide nutrient information for their products because of cost of analysis. We have seen an increase in the availability of manufacturers' data through the years due to food labeling and FDA requirements.

We do not impute values for missing data. However, with the number of food items available from which to choose, the researcher has the option of looking for a food item which has the most complete data for the particular nutrient under study.

Our data analysis reports do distinguish between true zero values and missing values.

The Microcomputer Nutrient Data Base System

When the decision was made to reprogram our Food Management system, we were looking at microcomputer hardware for data storage. However, with the advent of the fixed disk microcomputers, we saw the opportunity to gain an enormous amount of flexibility in terms of programming and system operations.

In terms of program design, we naturally wanted to integrate our NDB with our food system. We saw the need to automatically analyze patient recipes on a per serving basis when an ingredient or amount changed. We were able to incorporate yield factors involved in food preparation and cooking to allow for the accurate calculation of nutrient values. We also needed the ability to calculate both in-patient and out-patient food intakes as well as perform nutritional screenings and assessments.

We decided to delete some of the nutrients of the original 63 which were no longer of interest for nutrition researchers and add others. We now have 68 nutrient components in our system. Our nutrient data selection criteria essentially remains the same except that USDA Handbook revisions are now included.

The NDB microcomputer system was programmed using a Data Base Management System language called "The O'Hanlon Database Solution". We chose a Data Base Management System to insure flexibility in data handling as well as ease in programming. We no longer were limited in file space except by the size of our hard disk.

The programming language is very easy to use and therefor has saved us time in the development and debugging of the programs. One of the functions within the DBMS called "INQUIRE" allows us to compare data within a file so that we can produce "quick and dirty" reports within a matter of minutes. These report formats can be saved for future use. The DBMS allows us to access food items by name, partial name or code number. A next or previous function allows us to scroll through the file if we are unable to find the item immediately.

System Reports

The NDB reports give us a wide range of information. One of our system reports prints a hard copy of the 68 nutrient values for any item on a per 100 gm basis. We can also get values based on the weight of the first household conversion code listed for each item.

To aid in data maintenance, we have the computer automatically convert nutrient data to 100 gram portions rather than our former method of hand calculation by conversion factor. This has greatly improved the accuracy of our data as well as the speed of data entry.

As previously mentioned, food items can be accessed and entered for nutrient analysis by item name, partial name, or code number. Amounts are entered by selecting any one of three household conversion codes. The gram weight of the item can also be used to input amounts.

The Analysis Report includes P:S and Ca:P ratios, percent of food and/or supplement from diet, percent protein, fat, and carbohydrate from diet, nutrient values per item per meal and total of those nutrients for a day. We are currently working on an enhancement to enable us to analyze mean values of diets for up to 99 days. The user can select 68 nutrients, any combination of nutrients or a single nutrient for analysis. The analysis data is compared to the RDA's and Maximum Dietary Levels.

The Percent Nutrient Report shows us the percent and number of records containing a specified nutrient. This lets us know how complete our data is for a specific nutrient and where we might want to concentrate our efforts for data searches.

The Specific Nutrient Catalog allows us to select up to 7 nutrients to produce a listing of data base items which contain that nutrient. These values are reported per 100 gram portions. This information has proven most helpful for dietitians or researchers interested in a particular nutrient.

The Nutritional Assessment Report includes fields to search for enteral formulas in the NDB. Protein, carbohydrate, fat, calories, and nitrogen ratios are calculated using the values from the NDB.

Applications

The primary applications of our data base programs at OSU Hospitals have been in the areas of patient care, therapeutic dietetics and nutritional research studies. Food intake analysis studies are used for our diabetic patients, on the Oncology unit, the Renal unit and for the Eating Disorders Clinic.

The clinical dietitians have access to information on the nutrient values of various recipes. This information is often used for patient education purposes during diet counseling. We also use the recipe analysis information for planning menus.

A subset of our NDB is used by the University in their CAI (Computer Assisted Instruction) programs for teaching medical and dietetic interns.

Conclusion

The OSU Hospitals has maintained and continually enhanced the Nutrient Data Base for 15 years. We believe that we have developed a state-of-the-art system to access this data and appreciate the opportunity to share this information with you at this conference.

DESIGNING A COMPUTERIZED NUTRIENT DATABASE FOR MEDICAL RESEARCH APPLICATIONS

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Purpose and development of the NCC nutrient database

The nutrient database developed at the University of Minnesota's Nutrition Coordinating Center (NCC) was designed to facilitate nutrient calculation for a standardized system of collecting and analyzing dietary data for medical research studies. The NCC Nutrition Data System (NDS) was established in 1974 through the collaborative efforts of experts in nutrition, computer science, education and statistics (1). The development and maintenance of the NDS has been supported by the National Heart, Lung and Blood Institute (NHLBI). The original emphasis on intake of dietary lipids for cardiovascular research has been maintained as the system has been expanded to include dietary components of research interest to all major diseases.

Food specificity

The design of the NCC nutrient database differs from that of most large nutrient databases in the manner in which foods are described and in the flexibility provided for specification of fat and sodium intake. Through the use of computerized algorithms to calculate added fat, salt and flour used in food preparations and the use of numerous coding guides and coding rules to specify the coding for brand name products and various food combinations, the system can accommodate nutrient calculations for over 150,000 foods using a database of less than 2,000 entries. A schematic representation of the design of the NCC nutrient database to minimize database redundancy while maximizing specificity of food descriptions is shown in figure 1.

To permit maximum specificity for fats used in preparation, few entries for foods cooked with fat are included in the database. The computerized food preparation algorithms permit detailed specificity of the type of fat used in preparation. The amount of the designated fat, in addition to the appropriate amounts of salt and/or flour, are automatically calculated based on the amount of the food consumed. For example, there is no entry in the database for breaded and fried chicken. Coding of breaded and fried chicken requires selection of one of four entries for chicken (light or dark meat, with or without skin) and selection of one of a possible 141 cooking fats included in the current database. Thus, a total of 564 combinations of chicken and cooking fat are possible as shown in figure 2. Preparation with or without salt increases the possible number of preparations to 1,128. If all of these preparation options were separate entries in the database, the result would be a massive database that could not be efficiently maintained.

Detailed specificity for fats is also permitted for recipes containing fat as a major ingredient; any one of the current 141 fats in the database may be selected for the recipe. On-line coding procedures which facilitate rapid access to all recipes in the database allow further specificity for recipe ingredients such as fat levels of milk or ground beef. Ingredients and amounts may be altered to reflect individual documentation of recipe modifications. For example, if oyster stew was documented as having been prepared with 1% milk, without salt and with only half as much margarine as specified in the recipe, the recipe would be accessed on the coding screen, the whole milk code replaced by the 1% milk code, the salt deleted and the amount of the selected margarine reduced by one-half.

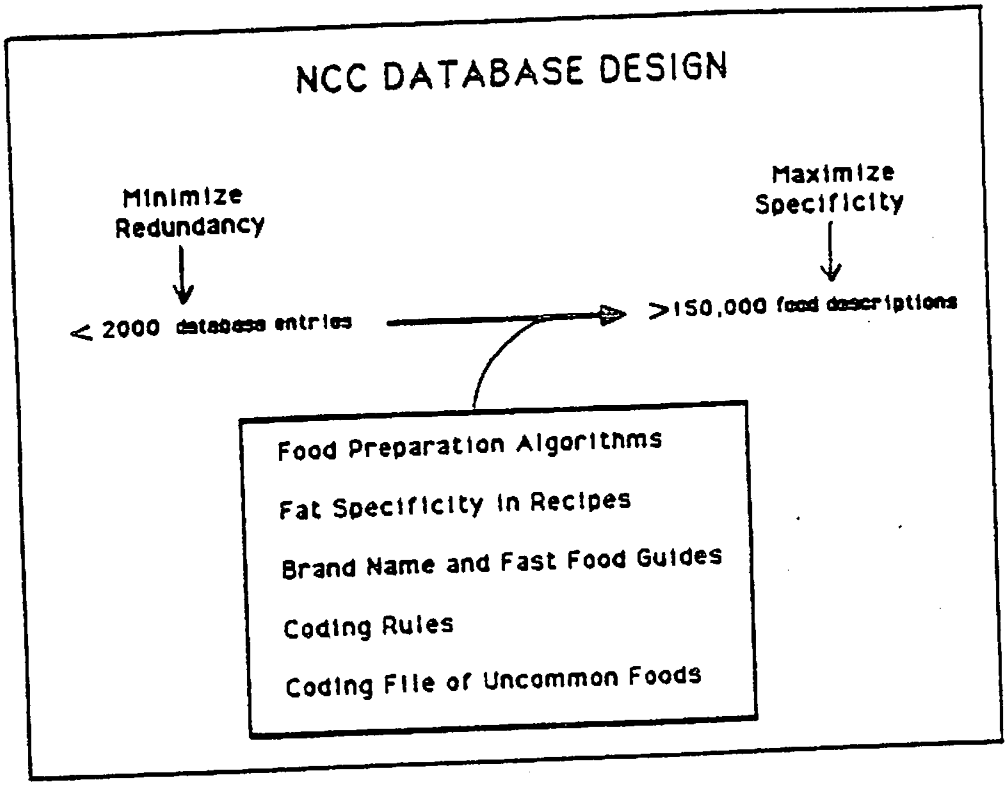

Figure 1. Schematic representation of the design of the NCC nutrient database.

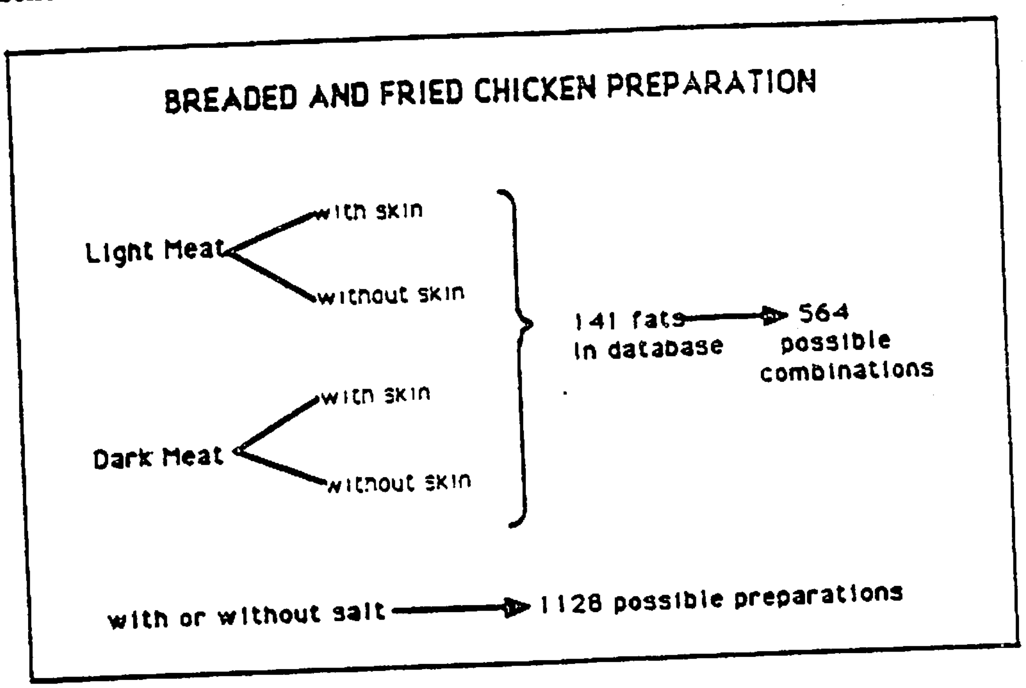

Figure 2. Diagram of number of possible breaded and fried chicken preparations using the NCC system.

All commonly consumed commercial products are listed in brand name coding guides which specify the appropriate database entry to use for each brand name item. The 39 brand name coding guides currently used for the NCC system include foods such as cookies, crackers, margarine, salad dressings, cheeses and vitamin-mineral supplements. For example, the current database includes 22 generic entries for salad dressings based on ingredient oils, total fat and sodium. The salad dressing guide lists 207 brand name salad dressings and specifies which of the 22 salad dressing entries in the database best represents each brand name product. Similarly, the margarine guide directs the coding of approximately 350 brand name margarine based on 82 entries in the database.

Other NCC procedures for minimizing database redundancy include the use of standardized coding rules which specify the coding for numerous food combinations and the maintenance of a file of coding directions for infrequently consumed foods. These procedures ensure standardized coding while further reducing the number of entries that must be maintained in the database.

Nutrients

The most recently released version of the NCC nutrient database (Version 14) includes values for 73 nutrients. These nutrients are listed in table 1. The working version of the nutrient database, known as the Reference Food Table, contains values for 107 nutrients. The additional 34 nutrient fields are in preparation for future research use but are not yet considered complete enough for use in nutrient calculations. The incomplete nutrient fields include 18 amino acids, manganese, chromium, cellulose, hemicellulose, lignin, gums, and 10 sugars and sugar alcohols.

Quantification of amounts

Food amounts may be entered in any standard unit of weight or volume since the calculation software includes conversion factors for all standard units. Conversion factors for food specific units such as a slice of bread, a large egg or a stalk of celery are also maintained in the database. Multiple densities are maintained for foods that may be consumed in more than one form. This allows all forms of the same food to be represented by a single entry. For example, cheddar cheese measured as a solid piece, a cubed volume or a grated volume are all represented by the same database entry using the appropriate density for each form. The calculation software can also be modified to accept amounts entered in terms of study specific food models.

Sources, selection and documentation of nutrient data

The NCC nutrient database is a compiled database derived primarily from USDA sources including the Nutrient Data Base for Standard Reference, the revised sections of Handbook 8, and tables of provisional data. Other data sources include the scientific literature, information from manufacturers, international tables of food composition and standard cookbook recipes. Approximately 30 scientific journals are routinely reviewed for food composition data; others are accessed on an ad hoc basis as relevant articles are identified through standard reference indices. Information on thousands of commercial products is maintained in a manufacturers' reference file. Updated ingredient and nutrient information is requested at least annually from several hundred major food manufacturers. This information is used to update database entries and brand name guides. An average of five brand name guides are updated each month. Label information is occasionally used to specify the coding for a particular product if the required information cannot be obtained from the manufacturer. For example, it is sometimes difficult to obtain manufacturers' nutrient information on products distributed under store name brands since the distributors are not the manufacturers. Label information is also used to specify product ingredients when manufacturers do not provide this information with the nutrient data.

When multiple sources of data are available, selection of nutrient values for the database is based on criteria such as the source of the data, the analytic methodology used, laboratory quality control procedures including use of reference standards, representativeness of the sample and the sample size. If USDA data are available, they are given priority. Refereed scientific journals are prioritized over non-refereed journals, and scientific publications are preferred to non-scientific published materials. Preferred laboratory methods are based on USDA guidelines whenever possible.

Occasionally, when data cannot be obtained from any other source, the NCC generates the required data. For example, the NCC funded two studies conducted by the University of Minnesota Food Science and Nutrition Department; one study involved the determination of fatty acid values in candies, and the other involved the estimation of the uptake of sodium in cooked pasta. Results of these studies have now been published (2,3). Generation of food density data by the NCC involves activities such as the preparation of recipes, measuring the volumes of candy bars, and weighing measured volumes of dry mixes.

The NCC nutrient database contains a minimum of missing values. Since missing values are calculated as zeros in the analysis of research data, missing values are permitted only when there is no available information on whether or not a nutrient is present in a food. Table 1 includes the percent complete for each nutrient n the current database as well as the percent of imputed values. Assumed zeros, such as cholesterol in plant products, are not classified as imputed values. Most imputed values are either values substituted from a similar food (such as the micronutrient values for low sodium cheeses substituted from the regular cheeses) or calculated values. Calculated values are based on one of the following procedures: 1) calculation from another form of the same food using yield and/or retention factors such as raw to cooked conversions; 2) calculation from a related nutrient in the same food such as retinol and beta carotene from total vitamin A content; or 3) calculation from a product formula or a product ingredient list. Imputed values are replaced by analytical values as soon as they become available.

A computerized reference code system documents the source of data for every nutrient and non-nutrient value in the database. A free-text comment section is used to describe data sources in more detail such as the actual calculations used to impute values, analytical methods used to obtain certain values or recipe sources. A paper file is also maintained for every entry in the database. All changes ever made to the entry and the rationale for every change are included in this file.

Maintaining database stability and reanalysis capability

To meet the needs of long term research studies, the NCC must provide database stability for ongoing studies as well as the capability to reanalyze data collected in the past using an updated version of the Food Table. This is accomplished by limiting all updating to the Reference Food Table which is the working version of the nutrient database. Periodically (approximately every 6-12 months), all updating effort ceases on the Reference Food Table, and the database nutritionists spend several weeks verifying the accuracy and internal consistency of the database using a series of computer generated integrity reports. Prior to the release of a new version of the database, nutrients are calculated for a test set of dietary intake records, and the calculated values are compared with those from the previous database version; all differences must be verified as due to intentional changes in the database since the previous version.

At the beginning of a study, the most recent version of the nutrient database is assigned to the study. For the duration of the study, no changes are permitted in the database other than the addition of new entries for new foods that come on the market. At the end of the study, investigators may elect to rerun all study data on a newer version of the nutrient database. To allow the capability for reanalysis, no entries are ever deleted from the database, even though a product is discontinued. Database entries for discontinued products are "deactivated" which means that they are no longer used in coding. When a product reformulation affects the nutrient profile of the item, the previous database entry is deactivated and the reformulated product is assigned a new food code. Deactivated entries are maintained in the database so that previously collected data can be reanalyzed on an updated version of the database.

Availability of NCC nutrient data*

The NCC nutrient database is available to the public on magnetic tape. Computer generated reports can be produced to meet individual needs. Other available items are the 500 page coding manual and monthly updates of the coding guides. A nutrient calculation software system designed for use on an IBM-XT or compatible microcomputer with hard disk is under development. Features of the NCC Nutrient Calculation System (NCS) include data entry using food names or food codes, prompts for added fat and salt in food preparation, screen display and running totals for five nutrients selected by the user, access to 73 nutrient fields for each food or an entire menu or food record, recipe breakdown screens for recipe modification, and vitamin/mineral supplement screens. A master index of common food descriptions will include brand names. The system is targeted for completion by the end of 1987.

* Requests for information on NCC materials may be directed to: Jeanne Nelson, Nutrition Coordinating Center, University of Minnesota, 2829 University Avenue S.E., Minneapolis, Minnesota 55414; 612-627-4871.

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COMPUTERIZED 24-HOUR DIETARY RECALL DATA COLLECTION FOR NHANES III

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The National Health and Nutrition Examination Survey (NHANES) is conducted by the National Center for Health Statistics (NCHS) to monitor the health and nutrition status of the nation's population and to gather data for further study of the relationships between diet and disease. The collection of 24-hour dietary recalls is a major component of the NHANES program. In past surveys, the recalls were conducted by trained dietary interviewers who documented the reported foods and food quantities on dietary intake forms. To prepare these recalls for analysis by a nutrient analysis system, all food and quantity descriptions were manually translated into appropriate food codes and quantity measurements by the dietary interviewers in the field.

A sophisticated system of computer hardware available in the Mobile Examination Centers for NHANES III makes possible the automation of these labor intensive procedures for collecting and preparing the dietary data for nutrient analysis. Furthermore, as demands increase for more detailed data on national food consumption, a computerized 24-hour recall system becomes essential to ensure standardized collection of the most complete and detailed dietary data possible within the thirty minutes allotted to the dietary interview portion of the survey.

The Dietary Data Collection (DDC) system, under development at the Nutrition Coordinating Center (NCC), University of Minnesota, has been selected for collection of the 24-hour dietary recall data for NHANES III. The DDC system, which runs on an IBM-AT or compatible microcomputer, is designed to guide a trained interviewer through a 24-hour dietary recall. The system collects the dietary information as described by the survey participant and automatically translates this descriptive information into food codes and quantities for subsequent analysis by a nutrient analysis system.

The specific goals of the DDC system for use in NHANES III are:

- to standardize procedures for collecting the 24-hour recall data.
- ensure specificity of the dietary intake data.
- to simplify the collection of food descriptions and quantities as reported by the survey participant.
- to improve the efficiency of collection, preparation and timely release of the dietary data.

The DDC system design and functions are described below as they relate to each of the stated goals.

1) Standardize procedures for collecting the 24-hour recall data

The DDC system obtains standardization in data collection by requesting all of the information required to precisely define each food item consumed by the survey participant during the 24-hour recall period. This information includes description of the food, specification of recipe ingredients and cooking methods used in preparing the food, and description of the amount of food consumed. The food data are collected interactively through a series of menu selection

```
FOOD SELECTION muffin,

BRA  bran
COR  corn
ENGL English
OAT  oatmeal
PUM  pumpkin
WHI  white
WW   whole wheat
OTH  other type
U    unknown type

food: _
```

Figure 1a DDC system screen menu of choices for description of type of muffin.

```
FOOD SELECTION muffin,bran,

FRU  with fruit
NUT  with nuts
FN   with fruit and nuts
NFN  no fruit or nuts

food: _
```

Figure 1b DDC system screen of choices for detailed descriptin of a bran muffin.

screens.

Collection of food data is begun by entry of the primary name of the food reported by the survey participant. This entry initializes a pathway of system-generated menus of progressively detailed food descriptions. The interviewer selects one description from each menu. For example, if the interviewer enters "muffin", the system responds with a menu containing choices to describe the type of muffin, as illustrated in figure 1a. If a bran muffin in specified, another menu is displayed with further description choices for bran muffins with fruit or nuts, as illustrated in figure 1b. Selection of "with nuts" completes the food description selection process. The muffin is then identified in the recall by its list of food descriptions, "muffin, bran, with nuts".

Once a food has been precisely identified by its list of descriptions, the DDC system continues to present menu selection screens to solicit the information required to specify recipe ingredients, cooking methods, and food items used during preparation. The system also displays screens with choices of food quantity measurements for estimating the amount of food consumed by the survey participant.

Further standardization of data collection is achieved with the inclusion of "unknown" choices in system menu screens when the participant or proxy may not be able to provide the level of food detail requested. For example, the muffin descriptions presented above include a choice of "unknown type". The DDC system assigns the white flour muffin data to this selection, while retaining the "unknown type" description. By providing defaults for unknown selections, the system standardizes the assignment of data to incomplete food descriptions. If the food descriptions displayed on the DDC system menu screens are not adequate to describe a food reported by the survey participant, a "Missing Food" mechanism is available for capturing descriptive and quantitative information about the food item. For example, if a chocolate chip muffin were reported by the survey participant, the interviewer would enter a description of the muffin including its brand name, ingredients, and size. To standardize processing of these data for NHANES III, all "Missing Food" descriptions will be sent to a central location. If required, new food descriptions may be added to the DDC system to accommodate collection of the new food item in future 24-hour recalls.

2) Ensure specificity of the dietary intake data

To obtain specificity of food description, the DDC system menus include such details as the source of the food (home prepared or commercially prepared fried chicken; fresh, canned, or frozen packaged vegetables), major ingredients (white, whole wheat, or spinach pasta; condensed soup prepared with milk or water), and special food labels (reduced sugar jelly; low sodium canned tomatoes; vitamin C fortified juice). Food descriptions require maximum detail for specifying dietary fat and sodium.

For many foods, variation in recipe ingredients may affect the type of fat or the level of fat or sodium in the food item. The DDC system identifies these key ingredients and requests the interviewer to determine the recipe ingredients used in the food consumed by the survey participant. The mayonnaise or salad dressing in egg salad, the salt in scrambled eggs, and the margarine, butter, oil, or shortening in a muffin are examples of key ingredients.

The ingredient specification screen for a bran muffin is illustrated in figure 2. If the participant reports that the muffin was made with margarine, the system generates menu selection screens to obtain the brand name or further description of the ingredient margarine. If the participant is not familiar with the recipe ingredients in the food consumed, the DDC system provides "unknown" choices and will assign a default ingredient. The default is often based upon whether the food was prepared at home or by a commercial establishment.

```
INGREDIENTS IN muffin,bran,with nuts

  1. fats,

        BUTT butter
        MARG margarine
        OILS oil
        SHOR shortening
        C    unknown commercial preparation
        H    unknown home preparation

food: _
```

Figure 2. DDC system menu of choices for type of ingredient fat in a bran muffin

For further specification of fat and sodium intake, the DDC system displays a menu of cooking methods for meat, fish, poultry, and vegetable food items. If the participant indicates that the food consumed was prepared using one of the methods listed on the screen, further specification is requested for the type of cooking fat and whether or not salt was used in preparation.

Figures 3a and 3b illustrate the system menu screens for selection of a breaded and fried preparation for chicken. Selection of this preparation generates additional menu screens for specification of the frying fat and the use of salt, as illustrated in figure 3c. The DDC system includes "unknown" choices to describe the fat and salt if the participant is unable to provide the detailed information. The amounts of fat and salt added in preparation are calculated by the system using algorithms based upon the amount of food consumed.

The DDC system obtains additional specificity of dietary intake data by permitting the

```
PREPARATION OF chicken,leg,skin eaten

     FRI  fried
     BAK  baked
     BRO  broiled or grilled
     STE  stewed or boiled
     NONE none

prep: _
```

Figure 3a DDC system screen menu of choices for preparation of chicken.

```
PREPARATION OF chicken,leg,skin eaten
               fried,

     BRE  breaded
     BAT  batter dipped
     MAR  marinated in oil mixture
     SOY  marinated in soy sauce mixture
     NCM  no coating/no oil or soy marinade

prep: _
```

Figure 3b DDC system screen menu of choices for type of fried chicken.

```
                chicken,leg,skin eaten
INGREDIENTS IN fried,batter dipped

  1. salt,none used
  2. fats,

     BUTT butter
     MARG margarine
     OILS oil
     SHOR shortening
     LARD lard
     ANI  animal fat
     C    unknown commercial preparation
     H    unknown home preparation

food: _
```

Figure 3c DDC system screen menu of choices for type of fat used to fry chicken.

interviewer to group foods eaten together as a single item. For example, if the survey participant reports a ham and cheese sandwich, the interviewer can proceed to enter a detailed description and precise quantity for each individual item. The DDC system retains the "ham and cheese sandwich" description reported by the participant and links the individual foods into one multi-component food item.

3) Simplify the collection of food descriptions and quantities as reported by the survey participant

At the beginning of the dietary interview, the survey participant is urged to briefly report all of the foods and beverages consumed during the previous 24-hour period. The DDC system provides a blank "Quick List" screen on which the interviewer may list the foods, meals, and eating times as initially described. An example of this screen is illustrated in figure 4. The

```
QUICK LIST

   /bre 730a                   Meal Codes
   oj                          bre = breakfast
   muffin                      bru = brunch
   coff,blk                    cof = coffee break
                               lun = lunch
   /lun 1230p                  sna = snack
   tossed salad                din = dinner
   asparagus soup              sup = supper
   crackers                    oth = other

   /3p
   candy bar
   coff

   /din
   fried chicken
```

Figure 4. DDC system screen for notation of all meals and foods in a 24-hour recall.

information may be entered using any convenient shorthand notation. This mechanism allows the interviewer to capture eating occasions and general descriptions of food intake without distracting the participant with detailed questions about a particular food item. After completion of this "Quick List", the system prompts the interviewer for detailed information on each of the foods reported.

To simplify the process of selecting the food descriptions for each food reported in the 24-hour recall, the DDC system includes common food terms, brand names of commercial products, and names of fast food restaurant chains in its menu choices of food descriptions. For example, salad dressing may be identified as "Featherweight Imitation French - low calorie", and a fast food ice cream sundae may be described as "Dairy Queen, sundae, chocolate".

In addition, foods are grouped into categories which may be used as initial entries for food description. These categories are structured from a consumer viewpoint of foods, and a food may appear in multiple categories. For example, orange juice is classified in both the fruit and beverage categories. The food description process may begin with the interviewer entry of either one of these general category descriptions, or the interviewer can enter a more specific food name. If "orange" is the initial entry, a subsequent system menu will contain, juice" as one it its choices of descriptions. If "juice" is the initial entry, the next system menu will contain "orange" as one of its choices of descriptions. Either pathway would generate additional system menus with the descriptions "canned or bottled" and "unsweetened" to complete description of the orange juice.

The DDC system simplifies quantity measurement by accepting a variety of methods for estimating the amount of food consumed by the survey participant. A quantity may be expressed in terms of a weight or household volume, and for some foods, a pre-cooked weight or volume or a weight with refuse may be used. When necessary, the DDC system requests the form of the food (solid, grated, cubed, etc.) in the household volume measurement. Food volumes may also be described using dimensions of common shapes. For foods with standard thickness, such as crackers or pita bread, only the surface dimensions of the food are required. For many foods, quantities may also be expressed in terms of food-specific portions, such as a "stalk" of celery, a "medium" sized shrimp, or a "piece" of pie. A maximum serving size is associated with each food item; quantities which exceed the maximum serving size must be verified by the interviewer.

4) Improve the efficiency of collection, preparation and timeliness of release of the dietary data

The DDC system improves the efficiency of dietary data collection by replacing manual collection of the 24-hour recall data with computerized data collection on interactive menu screens. At the end of the dietary interview, the system generates a printed report of the foods and quantities in the 24-hour recall to replace the hand-written document. Figure 5 is an illustration of a 24-hour recall report.

The most significant improvement in efficiency is realized in preparing the data for nutrient analysis. The DDC system automatically translates the food and quantity descriptions collected during the 24-hour recall into food codes and gram weights of the edible portions of the foods as consumed. The output data file of food codes and amounts is suitable for processing by a nutrient analysis system. This automated preparation of the 24-hour dietary recall data is expected to result in a substantial time savings for nutrient calculation and data analysis in NHANES III.

The DDC system is designed to accommodate food coding for multiple nutrient databases. Currently, the system is equipped to produce food codes from the database of the USDA Continuing Survey of Foods for Individual Intake (CSFII), release 2, and the NCC Nutrient Database, version 13.

```
breakfast           7:30 A

muffin,bran,with nuts
1 each (2" diam X 2 1/2" high)

    I: fat,unknown commercial preparation

coffee,regular caffeinated,instant
1 cup

lunch               12:30 P

COMBO: tossed salad

       lettuce,iceberg
       1.5 cups

       tomato,red,raw
       3 slices  (2 1/2" diam)

       dressing for salads,[Featherweight Imitation French - low calorie]
       2 tablespoons

       cheddar cheese,unknown if natural or processed
       0.25 cups  grated volume

soup,asparagus - cream of,prepared from condensed can,diluted with milk
1.5 cups

crackers,whole wheat,low sodium
4 circle shape-2" diam

coffee break        3:00 P

MISS:  candy,candy bar without chocolate,

       candy bar with crisp rice, peanut butter type filling, and candy
       coating; candy bar is new on the market - brand name unknown

       consumed one bar 4" long, 1" wide, 1/2" thick

dinner              7:15 P

chicken,leg,skin eaten
5.5 ounces   weight with refuse before cooking

   P: fried,batter dipped
      I: oil,[Wesson]
      I: salt,none used
```

```
Key of Abbreviations
I      ingredient used in recipe or during
       food preparation
P      preparation or cooking method
COMBO  combination of foods eaten together
MISS   food which could not be accurately
       described with the available DDC
       system food descriptions
```

Figure 5. Sample print-out from a DDC 24-hour recall.

USING USDA CONTINUING SURVEY DATA

Howard A. Riddick, Ph.D.

The Continuing Survey of Food Intakes by Individuals (CSFII) is a timely and unique source of information on the dietary intakes of women and children. Potential uses of this dietary data include comparisons of food and nutrient intakes of different population groups; comparisons of food intake behavior with other health-related behavior like smoking and exercise; and evaluations of diurnal, seasonal, and yearly variations in food intake. In addition to analytical work, the nutrient data tapes and related material used in processing the survey data are useful to people who conduct their own dietary intake surveys.

The core of the CSFII is a national sample of women 19 to 50 years of age and their children 1 to 5 years of age in the 45 conterminous states. This sample, sometimes referred to as the "core monitoring group", was selected because previous surveys have shown that women and young children are more likely than other population groups to have diets low in certain nutrients. The 1985 survey also includes a sample of low-income women and children in the same age ranges as the core monitoring group and a sample of adult men 19 to 50 years of age. The 1986 survey included newly drawn samples for both core and low-income women and children.

The CSFII contains many of the basic features of the individual intake component of the Nationwide Food Consumption Survey of 1977-78 (NFCS 1977-78). There are some differences, however. Information in NFCS 1977-78 was collected for 3 successive days using a 1-day dietary recall followed by a 2-day food record completed by respondents. CSFII data was collected using 1-day dietary recalls only. Men were surveyed once, while women and children from the core and low-income samples were surveyed on 6 separate days over a 1-year period. The first day of intake for CSFII was collected using a personal interview in the respondent's home. Subsequent days of data were collected by telephone at approximately 2-month intervals. Individuals in households without telephones were contacted in person.

Since the 1977-78 survey, the food codes, food code descriptions, quantity measures, and nutritive values have been revised. Revisions include a greater number and variety of products (such as low-sodium products) and updated information on nutrients in foods. The 1977-78 data were analyzed for food energy and 14 nutrients and other dietary components. For CSFII, 14 more components were added. Because of the considerable interest, three of these components--dietary fiber, tocopherol, and carotene--were added despite some limitations in the data.

One of the first steps in using, or in deciding whether to use, Continuing Survey data should be a review of the reports that have been published. Four reports are already out (CSFII Reports Nos. 85-1, 85-2, 85-3, and 86-1) and five others are in progress. These reports give an overview of the nature of the survey and present food and nutrient intakes by characteristics such as age, race, income, region, and urbanization. Food intakes are classified in 60 food groups and subgroups. Mean quantities of food eaten per individual per day are presented along with percentages of individuals who reported eating any food from the specified food group or subgroup.

The nutrient intake tables include data on mean nutrient intakes, mean intakes as a percentage of the 1980 RDA, mean intakes per 1,000 kilocalories, and the percentages of total food energy from protein, carbohydrate, and fat (total fat, saturated fat, monounsaturated fat, and polyunsaturated fat). Also presented are the frequency of eating; the nutrient contributions of snacks and of food obtained and eaten away from home; the percentages of individuals following special diets; and the percentages using vitamin and mineral supplements. Each report also contains an extensive set of tables describing the sample.

The next step is to obtain HNIS Administrative Report No. 378, which describes machine-readable data sets on composition of foods and results from food consumption surveys.

Single copies of this report are available from the Human Nutrition Information Service (HNIS), 6505 Belcrest Road, Room 304, Hyattsville, Maryland 20782. The report gives ordering information, including prices, for the data sets (and for supporting materials on microfiche or paper) that are available from the National Technical Information Service (NTIS) of the Department of Commerce.

For each survey report, there is a tape that contains the survey results (including many variables not presented in the report) as well as tapes containing the nutrient data base used to calculate nutrient intake values. These tapes are organized into six files.

File 1 contains descriptive information about methodology and sample design that is basically taken from the report.

File 2 contains dataset characteristics such as the logical record length, blocksize, and the number of records. The file structure and format are also presented. CSFII data are in a hierarchical file containing four types of records for 1-day data tapes. Record type 10 contains basic characteristics of the household. Record type 20 contains data about each individual in the household. Record type 30 provides considerable detail about foods reported by all individuals who were age-eligible and participated in the survey. One record type 30 appears for each food item the individual reported. In addition to the amount consumed (in grams) and the nutritive values supplied by that amount of food, each food item contains descriptors such as time of day, name of eating occasion, a 7-digit USDA food code, whether salt was added at the table, and whether the food was obtained and eaten away from home. Record type 40 contains the sum of the nutrient values from all of the foods on record type 30 for each individual.

The data file format describes each variable on the tape by record type and column location, indicating whether there are implied decimals for the data field. The variable description is particularly useful since it repeats the entire question used to obtain the data, designates the question number and schedule used (screener, household, or individual), and indicates acceptable values, along with value labels, for each variable. Control counts for selected variables are contained in File 3. For categorical variables, such as race, the counts are the number of responses in each category. For continuous variables, such as last year's income, the counts are the number of responses within a given range. Also given are the counts of "don't know" and "no answer" responses. The file is intended to serve as a point of reference for those doing their own analysis of the data. The counts are also useful in helping to decide which variables (and variable categories) to include in an analysis plan.

File 4 contains the actual data. I will skip File 5 until I have described File 6.

File 6 is the Manual of Food Codes for Individual Intake. It is composed of approximately 5,000 7-digit food codes used for coding individual intake in CSFII. For each code, the manual includes a description of the food or beverage, common measures or weights of edible portions, conversion of measures and weights to grams, and a portion size used when the amount consumed was not specified.

Accompanying the manual on the CSFII tape are a list of food groups as categorized by the first three digits of the food code to serve as an aid to location of food groups and individual food codes; a list of notes and abbreviations used in the manual; and the coding guidelines used for CSFII. Specific guidelines include those for coding salads, fast-food sandwiches, and fast-food breakfast sandwiches.

File 5 contains the 7-digit food codes found in File 6 with an abbreviated (51 characters or less) version of the description for each code. This file does not contain all of the information found in the descriptions in the manual. It is provided as a time-saver for users. The 51-character description file can be linked to the data file when generating listings of individuals' food intakes or to other listings when exact identification of the food items is not necessary.

The microfiche that accompanies each data tape includes identical information with one exception--File 4. File 4 of the tape includes the actual data, whereas Chapter 4 of the microfiche includes the interviewer instructions, food instruction booklet, screening forms, and questionnaires.

The interviewer instructions cover the following information: finding the specific geographic areas to be surveyed; identifying sample households; screening households; and obtaining cooperation from eligible households. There are general interviewing instructions as well as specific question-by-question instructions.

The Food Instruction Booklet (FIB) was developed to guide interviewers in collecting individual intake information. Anyone planning to use data from the CSFII should become familiar with it. In the interview, respondents are asked to give complete descriptions of the foods and beverages consumed the day before the interview and the actual quantities consumed. These descriptions must be complete and precise in order to make full use of the detailed set of food codes available. The FIB contains the specific questions or probes that should be asked for each food or food type. Copies of the microfiche may be ordered separately for those more interested in the printed support materials than in the survey data.

In addition to tapes of survey results, there are tapes of the nutrient data bases that correspond to the particular food consumption surveys. For example, Release 2 of the USDA Nutrient Data Base for Individual Food Intake Surveys was used to process the first day of intakes from the 1985 core monitoring group. This release was also used by the National Center for Health Statistics, U.S. Department of Health and Human Services, to process data collected during the Hispanic Health and Nutrition Examination Survey for the Southwestern United States. Release 2.1 covers the entire 1985 CSFII.

Three data sets are used to create each nutrient data base release. The Recipe File is a data set that controls the generation of the survey nutrient data base using the Primary Nutrient Data Set (PDS) and the table of retention factors. In the recipe file, each survey code is linked to one or more PDS items through a set of recipe codes. Links to single PDS items are treated as one-component recipes.

The amount of timely data available and the extensive documentation represent a major effort by USDA. A discussion of appropriate ways to interpret this data is beyond the scope of this talk. As a useful first step, I would suggest a review of a recent report by the Life Sciences Research Office of the Federation of American Societies for Experimental Biology (FASEB). The title of the report is "Guidelines for Use of Dietary Intake Data". Copies are available at a cost of $14.00 prepaid from the FASEB Special Publications Office, 9650 Rockville Pike, Bethesda, Maryland 20814.

USDA'S DIETARY ANALYSIS PROGRAM FOR THE PERSONAL COMPUTER

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OVERVIEW

USDA's Dietary Analysis Program is a user-friendly software package developed by Human Nutrition Information Service in cooperation with Extension Service for use with consumers. The program performs dietary analyses for food energy and 27 nutrients and food components using up to 3 days of reported food intakes.

For this program, approximately 850 foods were drawn from those commonly reported in the USDA Nationwide Food Consumption Surveys. The program uses a menu-entry approach for individuals to select foods for analysis. Foods are grouped in commonly recognized food groups, considering both nutrient composition and use in meals. Quantities of foods are selected from screens that list common household measures and serving units typically reported in USDA surveys.

The dietary analysis program produces: 1) a complete listing of foods and reported quantities; 2) bar graphs showing the percentage of user's RDA for 15 nutrients; 3) total quantities of fat, fatty acids, cholesterol, fiber, sodium, potassium, and copper; and 4) percent of calories from protein, carbohydrate, fat, and alcohol. In addition, the program can report data for any single nutrient or food component, listing the total quantity and the amount provided by each food reported. Users are able to assess the effects of changes they might want to make in their current diet because the program allows for the addition, deletion, and change in quantity of reported foods.

Objectives

USDA's Dietary Analysis Program was designed to provide a relatively rapid and easy-to-use nutritional assessment of a reported diet. The user-friendly system was developed for use with Extension Service clients--primarily homemakers interested in evaluating the nutritional adequacy of their own diets or the diets of other family members.

In addition to showing dietary analyses on the screen, the program can produce a printed copy of the results. This permits the user or Extension agent to document dietary changes over time.

The program can also serve as a useful educational tool. For example, single-nutrient analysis can be used to point out major sources of any selected nutrient or food component in a particular diet. In addition, the capacity to add, delete, or change quantities of foods permits users to examine the effects of alternative selections on their current nutrient intake. To do this, the user simply makes changes in foods or quantities selected and reanalyzes the diet.

SYSTEM CHARACTERISTICS AND FEATURES

The approximately 850 foods used in the dietary analysis program were drawn from over 4,000 foods reported in USDA Nationwide Food Consumption Surveys. In order to select foods that we hoped were familiar, we looked at those foods that were reported most frequently. To keep the number of foods at a workable size, we gave particular attention to foods that would be representative of other items similar in nutrient composition and use in meals. We selected foods in their prepared, ready-to-eat forms. In the future, we hope to add raw ingredients in a supplementary data base to provide the capability of analyzing recipes. Although a number of combination dishes are included, most items are represented in their simplest prepared form (cooked plain vegetables, for example). Users need to enter prepared sauces, condiments and dressings, etc. separately. We included a wide variety of food items to ensure that reasonable substitutes were available for items that were not included. Infant formulas and infant foods are not included, however.

Nutrient Composition Data

Nutrient values for foods used in the dietary analysis program were taken from the 1986 USDA Nutrient Data Base for Individual Food Intake Surveys. The program is, therefore, capable of analyzing diets for food energy and 27 nutrients and food components:

food energy (kilocalories)	thiamin
protein	riboflavin
total fat	preformed niacin
saturated fatty acids	Vitamin B_6
monounsaturated fatty acids	Vitamin B_{12}
polyunsaturated fatty acids	folacin
carbohydrate	calcium
dietary fiber	phosphorus
cholesterol	magnesium
Vitamin A (IU and RE)	iron
carotenes	potassium
Vitamin E	sodium
ascorbic acid	zinc
alcohol	copper

Of these nutrients and food components, sodium, potassium, zinc, copper, folacin, cholesterol, fatty acids (polyunsaturated, monounsaturated, and saturated), Vitamin A (as retinol equivalents), carotene, Vitamin E, dietary fiber, and alcohol have been added to this USDA nutrient data base since the 1977-78 Nationwide Food Consumption Survey. Food composition data supporting the nutrient values are stronger for some nutrients than for others. The USDA Nutrient Data Base for Individual Food Intake Surveys contains no missing values because nutrient values were imputed for foods for which no data were available. Thus, we believe that the nutrient data used in the dietary analysis program are the best available.

DIETARY STANDARDS

The dietary standards used to evaluate the nutritional adequacy of diets are the 1480 Recommended Dietary Allowances (RDA) for the following nutrients: protein, Vitamin A, Vitamin E, ascorbic acid, thiamin, riboflavin, niacin, vitamin B_6, vitamin B_{12}, folacin, calcium, phosphorus, magnesium, iron, and zinc. Estimated Safe and Adequate Daily Dietary Intakes of sodium, potassium, and copper are listed for comparison with intakes. For the remaining nutrients and food components, totals are reported and interpretive materials are being developed to help the user evaluate the adequacy of his or her diet.

OPERATIONAL FEATURES

Selecting Foods

Users have two options in entering foods. One option is the "direct-entry" approach, used in a number of other dietary analysis programs. This approach requires that users look up food items in a complete listing of the data base that accompanies the software. Users then enter the food using an identification number or code that corresponds to the particular item. The second option is the "menu-entry" approach developed for this dietary analysis program. This approach eliminates the need to use food item identification numbers. Instead, users find the desired food item by using a progression of food classification screens.

Our primary objective in structuring the food group classification system was to allow the user to locate specific foods quickly and easily. The main classification groups are:

1. Meat, Poultry, Fish, and Mixed Dishes
2. Dry Beans and Peas, Nuts and Seeds, and Eggs
3. Breads and Baked Goods, Crackers, and Snacks
4. Cereals, Pasta, Rice, and Mixed Dishes
5. Fruits
6. Potatoes, Vegetables, Salads, and Salad Bar Items
7. Dairy Products
8. Desserts and Candies
9. Beverages
10. Fast Food Sandwiches
11. Fats and Oils, Salad Dressings, and Spreads
12. Sugars and Syrups, Dessert Toppings, and Sweet Spreads
13. Soups, Sauces, Gravies, and Condiments

The user works through a series of menu screens which become more and more specific until the food group is small enough to list all individual items in the group on the screen. The user then selects the desired food.

When grouping foods, we considered in which food group a user might look for the item, as well as the food's nutrient composition and its use in meals. Food items were also listed under more than one food group heading if we felt it was likely that a user might look for them in more than one place. For example, fluid milk is listed under dairy products as well as under beverages, since users might conceivably look in either category.

Estimating Serving Sizes

After selecting a specific food item, the user enters the quantity consumed from serving unit options listed on the screen. For most foods, quantities can be estimated in terms of several serving units. Decisions about which serving units to include in the system were made for each individual food item. Therefore, the serving unit options are not the same for all foods. Common household weights and measures are options for most food items. However, these units were excluded where we felt users could not reasonably be expected to use them accurately (for example, "cups" is not used for meat items and most desserts). In addition to weights and volume units, we gave some foods other commonly used units, for example, a slice of bread or a medium piece of fruit.

MAKING SUBSTITUTIONS

Users may have to select alternative items when reporting foods not included in the program's data base. For single items, the best option is to select the most similar item available. For example, havarti cheese is not included in the data base, but brick and muenster cheeses are. Users can look at all the available substitutions for havarti cheese and select the one which they believe is most similar.

For combination dishes that are not in the data base, users have two options. They can select the most similar food item or they can enter component foods individually. The decision on which option to use for a particular combination dish can be determined by considering: 1) how many foods are involved (time factor), 2) whether all foods in the combination item are included as individual items in the data base, and 3) how large a quantity of the item was eaten. If some food components are not included in the data base, or if small quantities of the food were eaten, selecting the single closest alternative food available may be the best option.

PROGRAM OUTPUT

Standard Output

The standard output includes those results of the individual's dietary analysis that we thought would be of greatest benefit and interest to the consumer.

The standard output components are:

1. background information about the user (name, age, sex);
2. a complete listing of foods being analyzed, including food description, serving unit, and serving quantity selected;
3. bar graphs showing the percentage of the user's RDA provided in the diet for each nutrient that has an RDA;
4. total quantities of selected nutrients and food components provided by the diet, including calories, total fat, saturated fatty acids, mono-unsaturated fatty acids, polyunsaturated fatty acids, cholesterol, sodium, and dietary fiber;
5. percentages of total calories from protein, carbohydrate, fat, and alcohol in the reported diet; and
6. total quantities of copper, sodium, and potassium and their corresponding Estimated Safe and Adequate Daily Dietary Intakes.

Standard output can be generated for a single meal or for up to a 3-day intake. It can be generated on the screen for the user to examine or printed for the user to keep. Figures 1 and 2 show a sample 1-day food record and accompanying standard output.

Single Nutrient Analyses

In addition to the standard output components, the program is designed to provide single nutrient analyses for user-selected nutrients. For each nutrient included in the data base, a report can be generated showing:

1. a complete listing of all reported foods included in the analysis, including item descriptions, serving units, and serving quantities;
2. amount of the nutrient contributed by each food item;
3. the total amount of the nutrient in the reported foods; and
4. the RDA for the nutrient (where applicable).

Figure 3 shows single nutrient analyses for fat and iron using the same sample 1-day food record analyzed in the standard output.

Pilot Testing

Plans are currently being finalized with Extension Service to pilot test the dietary analysis software package at four Extension locations. At least 50 participants at each testing site will evaluate the software for the following characteristics: ease and speed of use, clarity of instructions (on screen and in the user manual), usefulness of analysis output components, and additional features or information desired.

We want suggestions for improving the system. Extension professionals will be asked about anticipated uses of the software. For example, Extension personnel and other professionals may want to be able to store data for later use. Possible uses of stored records include evaluating nutrition education programs' effectiveness in promoting dietary change and surveying food and nutrient intakes in the user population.

Food		Amount
1.	grapefruit	(1) 1/2 medium
2.	whole wheat cereal	(2) 1/2 cup
3.	sugar, brown	(2) one teaspoon
4.	milk, fresh, lowfat (1 percent)	(1) 1 cup
5.	frankfurter, all-beef	(1) one frankfurter
6.	roll, hotdog/hamburger	(1) one roll
7.	mustard	(1) 1 teaspoon
8.	baked beans with tomato sauce	(1) 1/2 cup
9.	cabbage, green	(1) 1/2 cup, chopped
10.	carrots	(.5) small carrot
11.	pepper, sweet, green	(.25) 1/2 cup, chopped
12.	salad dressing, mayonnaise-type	(3) one teaspoon
13.	cola	(1) 1 can (12 fluid ounce)
14.	roast, lean	(1) 3 ounces, boneless
15.	rice, white, instant	(2) 1/2 cup
16.	spinach	(1) 1/2 cup
17.	corn, yellow	(1) 1/2 cup
18.	roll, white, soft (dinner)	(1) one roll
19.	margarine, soft, tub	(2) one teaspoon
20.	banana	(1) medium banana
21.	tea, brewed, plain	(2) 6 fluid ounces
22.	lemon juice	(1) 1 teaspoon
23.	crackers, saltines	(4) one saltine
24.	cheese, swiss	(1.5) 1 ounce

Figure 1. Sample 1-day food record to be analyzed

PERCENTAGES OF RECOMMENDED DAILY DIETARY ALLOWANCES

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

Protein	163%
Vitamin A	429%
Vitamin E	85%
Vitamin C	243%
Thiamin	144%
Riboflavin	144%
Niacin	119%
Vitamin B6	86%
Folacin	113%
Vitamin B12	146%
Calcium	139%
Phosphorus	165%
Magnesium	137%
Iron	98%
Zinc	94%

FAT, SODIUM, AND FIBER TOTALS

Total calories: 1907 kilocalories
Total fat: 57 grams
Total saturated fat: 22.3 grams
Total monounsaturated fat: 22.1 grams
Total polyunsaturated fat: 10.2 grams
Total cholesterol: 144 milligrams
Total sodium: 3478 milligrams
Total dietary fiber: 25.5 grams

PERCENTAGE OF CALORIES FROM

Fats	Protein	Carbohydrates	Alcohol
27	17	59	0

SAFE AND ADEQUATE DAILY RANGES

	Copper	Sodium	Potassium
Safe values:	2.0-3.0 mg	1100-3300 mg	1875-5625 mg
Your values:	1.4	3478	3164

Figure 2. Standard output for sample 1-day record

Food	Amount	Total fat g
grapefruit	(1) 1/2 medium	0.1
whole wheat cereal	(2) 1/2 cup	1.0
sugar, brown	(2) one teaspoon	0.0
milk, fresh, lowfat (1 percent)	(1) 1 cup	2.4
frankfurter, all-beef	(1) one frankfurter	13.6
roll, hotdog/hamburger	(1) one roll	2.4
mustard	(1) 1 teaspoon	0.2
baked beans with tomato sauce	(1) 1/2 cup	0.7
cabbage, green	(1) 1/2 cup, chopped	0.1
carrots	(.5) small carrot	0.0
pepper, sweet, green	(.25) 1/2 cup, chopped	0.1
salad dressing, mayonnaise-type	(3) one teaspoon	5.0
cola	(1) 1 can (12 fluid ounce)	0.2
roast, lean	(1) 3 ounces, boneless	7.1
rice, white, instant	(2) 1/2 cup	0.0
spinach	(1) 1/2 cup	0.2
corn, yellow	(1) 1/2 cup	1.0
roll, white, soft (dinner)	(1) one roll	1.6
margarine, soft, tub	(2) one teaspoon	8.0
banana	(1) medium banana	0.5
tea, brewed, plain	(2) 6 fluid ounces	0.0
lemon juice	(1) 1 teaspoon	0.0
crackers, saltines	(4) one saltine	1.4
cheese, swiss	(1.5) 1 ounce	11.5
TOTAL		57.2 g
RDA VALUE		*

Food	Amount	Iron mg
grapefruit	(1) 1/2 medium	0.1
whole wheat cereal	(2) 1/2 cup	1.5
sugar, brown	(2) one teaspoon	0.2
milk, fresh, lowfat (1 percent)	(1) 1 cup	0.1
frankfurter, all-beef	(1) one frankfurter	0.6
roll, hotdog/hamburger	(1) one roll	1.2
mustard	(1) 1 teaspoon	0.1
baked beans with tomato sauce	(1) 1/2 cup	2.7
cabbage, green	(1) 1/2 cup, chopped	0.3
carrots	(.5) small carrot	0.1
pepper, sweet, green	(.25) 1/2 cup, chopped	0.2
salad dressing, mayonnaise-type	(3) one teaspoon	0.0
cola	(1) 1 can (12 fluid ounce)	0.0
roast, lean	(1) 3 ounces, boneless	2.4
rice, white, instant	(2) 1/2 cup	2.2
spinach	(1) 1/2 cup	3.4
corn, yellow	(1) 1/2 cup	0.5
roll, white, soft (dinner)	(1) one roll	0.8
margarine, soft, tub	(2) one teaspoon	0.0
banana	(1) medium banana	0.4
tea, brewed, plain	(2) 6 fluid ounces	0.0
lemon juice	(1) 1 teaspoon	0.0
crackers, saltines	(4) one saltine	0.6
cheese, swiss	(1.5) 1 ounce	0.1
TOTAL		17.6 mg
RDA VALUE		18.0mg

Figure 3. Single nutrient analyses (fat, iron) for sample 1-day food record

USING RELIABILITY CODES

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The accuracy and precision of nutrient composition data have a significant impact upon the assessment of nutrient intake and the evaluation of relationships between intake and the incidence of certain disease states (1). Many users of nutrient data assume that a value which appears in print or in a data tape is of the highest quality and absolutely correct. However, the quality of an individual data point in a database or table is dependent upon several factors and merely represents an estimate made from available sources. For a single nutrient, the values for some foods may be accurate and precise; for other foods the values may be of poor quality due to the limitations of the source(s) from which the value was taken. Quality indicators of nutrient composition data quality could provide users of such data with information to determine the reliability of estimates of nutrient intake. In generic terms, such quality indicators could be called "reliability codes".

As mentioned above, a nutrient value for a specific food represents the compilation of values for that nutrient and food taken from various sources. Therefore, the quality of each tabular value is dependent upon the quality of those individual values. Furthermore, a published study may contain nutrient composition data which may be appropriate in its original context but may not be suitable for use in a nutrient data bank. For example, the primary objective of a study may be to develop analytical methodology and may include nutrient composition data as an example of methodological performance. For such a study, the selection of samples may be limited. Similarly, the objective of a study may be to test the effects of a new feeding regime on the level of a particular nutrient which results in the animal consuming that diet or to evaluate a new crop variety not currently marketed. Each of these situations would produce nonrepresentative data and would not be appropriate for use in assessments of nutrient intake by population groups.

In addition to the lack of representativeness of a particular value, the accuracy and precision of a nutrient value for a specific food taken from a single source is dependent upon several other factors. One factor concerns the appropriateness of the analytical method used, including its validation by reference materials or by another definitive method. Furthermore, the evidence of analytical quality control, satisfactory execution of the method on a day-to-day basis, is necessary for determining the quality of a single value. In addition, the sampling plan which had been used for selecting the samples should be fully documented and appropriate. Finally, sample handling techniques and the number of samples analyzed must be known in order to determine the soundness of the estimate.

A system for evaluating published data for these various factors or categories and for quantifying the degree to which each of these requirements has been met has been developed by the Nutrient Composition Laboratory (NCL) for the evaluation of selenium (Se) data (2,3) and, more recently, modified for the evaluation of copper data (4). For illustrative purposes, Table 1 contains a portion of the information presented in the article by Schubert et al. (3). This system provides detailed documentation of the data which have been compiled from various published sources to yield a single nutrient (e.g., Se) mean for a given food product. In addition to the mean selenium value, the table includes the references for acceptable studies, that is, studies whose mean values have been included in the computation of the grand mean. Also, the numbers

USING RELIABILITY CODES

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A system for evaluating published data for these various factors or categories and for quantifying the degree to which each of these requirements has been met has been developed by the Nutrient Composition Laboratory (NCL) for the evaluation of selenium (Se) data (2,3) and, more recently, modified for the evaluation of copper data (4). For illustrative purposes, Table 1 contains a portion of the information presented in the article by Schubert et al. (3). This system provides detailed documentation of the data which have been compiled from various published sources to yield a single nutrient (e.g., Se) mean for a given food product. In addition to the mean selenium value, the table includes the references for acceptable studies, that is, studies whose mean values have been included in the computation of the grand mean. Also, the numbers

Table 1. Selenium content of selected foods*

food aggregate	mean	min.	max.	no. of Se values accept.	no. of Se values total	Conf. Code	ref. no. of acceptable studies
	µg Se/100g						
BEEF, LAMB, PORK, VEAL							
Beef, raw	22	5	42	19	27	a	10,12,14,15,18-24
Beef, ckd.	26	15	52	11	17	a	9,12,25
Beef gravy	1.0			1	2	c	12
Beef liver, raw	40	18	63	7	10	a	10,12,14,15,18,19,26
Beef liver, ckd.	56	43	71	3	5	b	9,12
Lamb, raw	21	6	32	7	11	a	10,12,15,18,19,27
Lamb, ckd.	17			1	5	c	9
Meat loaf, beef, ckd.	17	12	27	3	3	b	9,12
Pork/ham, fresh/ cured, raw	33	19	51	8	12	a	10,12,14,15,19,28
Pork/ham, fresh/cured, ckd./cnd. (incl. roasted, pan-ckd.)	35	19	92	8	12	a	9,12,29
Veal, raw	28	20	35	2	2	c	15
Veal, ckd.	12	12.0	12.3	2	2	b	9

*Taken from Schubert et al. (3)

of acceptable studies and of studies evaluated are provided. In addition, the range of acceptable values is given. Finally, a confidence code ("a", "b", or "c"), indicating the degree of confidence a user of nutrient composition data can have in a particular value, is provided. For example, a confidence code of "a" indicates the user can have considerable confidence in the mean. In contrast, a code of "c" indicates the user can have less confidence in this value due to the limited quantity and/or quality of data.

Data which have been evaluated in a systematic way and coded to indicate the quality of the individual means may be used in several ways. Initially, Se data were evaluated by the NCL to determine where resources for additional analyses should be used. Foods were ranked by their contribution to the population's daily intake of this nutrient. Foods which had "c" codes or no acceptable data were designated for further analysis. High ranking foods were included in the list for verification analysis regardless of their code. Finally, new foods which did not appear in the original list were considered for limited analysis to obtain "ballpark values". As additional analyses were completed the individual data were added to the previously evaluated data for that food; new means and confidence codes were generated (5). As one can see, the process is iterative. In fact, the process of improving the Se composition data is a three year effort. Following a pilot study of eighty foods collected in each of three cities, a more extensive sampling in five to nine cities is currently in progress. Beginning in late 1987, a second sampling of five to nine cities will be conducted to provide more data and to investigate more fully the variability of selenium in foods.

The published systematic evaluation of nutrient data can provide several different kinds of information to users of food composition data. In addition to the mean for a single food, the inclusion of confidence codes provides the user with some measure of the quality of each mean. Means and confidence codes for foods can be grouped by food category, e.g. red meats, breads, fruits and vegetables, etc. The user can view the distribution of confidence codes within a food category. For example, in Table 1, the range of confidence codes for Se values within the Beef-Pork-Veal-Lamb category indicates six "a" codes, three "b" codes, six "c" codes (3). This is an important and, perhaps, comforting observation since beef and pork are ranked as the first and third contributors of Se as determined from the data evaluation. In contrast, the tally for fruits and vegetables indicates that five codes were "c", four were "b", and three were "a". In view of the fact that fruits and vegetables do not provide a significant amount of Se to the diet of the population, the poorer quality of Se data for this category is not so disturbing.

In the evaluation of Se data (3), data for the first 10 ranked food items were of high quality (7 "a's" and 3 "b's"). Beyond the tenth food item the three confidence codes appear in random order, with "b's" and "c's" approximately equally represented and "a's" occurring 30% as frequently as either "b" or "c". If these data were used to calculate the Se contents of diets for a population, the user could have good confidence in the estimates of population intake obtained. Those frequently consumed foods which are important contributors of selenium are characterized by good data. In general, less frequently consumed foods with lower selenium concentrations have data of poorer quality. In view of this, estimates of intake would be fairly reliable. In the future it would be possible to tally the confidence codes for a specific nutrient for all food items consumed in a survey to determine the overall quality of data for foods actually consumed. Foods of particular concern could be designated for additional analyses.

In addition to seeing the quality indicated by the confidence code, the user of data can see the list of individual sources which were evaluated and compiled to obtain a mean value. A concerned user could review a specific reference. Furthermore, compilers of nutrient data could determine if the nutrient mean which appears in the data base or tape includes values from an additional reference or source at hand. In this way the user could avoid duplicate entry and double weighting of a given value.

Finally, a well-documented system of evaluating data provides generators of nutrient data with guidelines which can be incorporated into planning for new studies. Similarly, editors and reviewers can use guidelines to facilitate the review process. In fact, the various criteria which have developed for the categories in the Se system have been reviewed and modified by the editors of a new journal, Journal of Food Composition and Analysis, to serve as guides to authors. This journal will be published, starting in 1988.

More than ever, users of food composition data are requiring accurate and precise nutrient composition data to evaluate the relationships between diet and health. Those of us who generate data, manage databases, or facilitate the flow of data in some other way must provide quality indicators or some other documentation as assurances of data quality and reliability.

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USING A NUTRIENT DATABASE IN A HOME HEALTH CARE ENVIRONMENT

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INTRODUCTION

The Hermann Health Connection (HHC) is a project funded by the Hermann Trust within the Hermann Institute for Futuristic Health Care Delivery. The project was designed to evaluate the effectiveness of using an interactive on-line computer system between users and health care givers. The project provides a new format for delivering educational information and monitoring behaviors of patients who have previously been followed by traditional methods. Although a health education and monitoring network is a new application of technology, computer-assisted instruction (CAI) has been available for many years and has proven successful in a number of different environments. Some of the benefits of CAI mentioned in the literature are: increased motivation, instruction individualized to the user's needs and level, reinforcement of learning through immediate feedback (1), increased confidence, diminished fear of testing, and improved learning (2). In addition to the expected benefits of using computers for instruction, using a computer also offers participants an opportunity to take greater responsibility for their own health care. In this study, the subjects are able to report behaviors and measures, monitor progress, ask questions of health professionals and access information when it is needed. Family members are also able to access information and to ask questions although their health data will not be analyzed for this study.

SPECIFIC AIMS

The overall goal of the project is to improve the quality of life via a communications vehicle rather than through a therapeutic modality. The specific objective will be to characterize two study populations with pre and post measures over one year in the following areas: biochemical, anthropometric, psychological, behavioral, and cognitive.

SIGNIFICANCE

A review of the literature shows no other interactive health network such as this has been implemented. Health and general information networks such as the American Medical Association's MINET (3) and the Compuserve network (4) are available to subscribers but they do not include the kind of interactive communications between lay users and health professionals used in this study. A limited amount of research has been done on the use of computers to monitor health status in: blood glucose reporting (5,6), insulin adjustment (7), recording dietary intake (8,9) and emergency care (4). However, such monitoring has not been integrated with a health information network. The significance of the Hermann Health Connection project is that it will be the first effort to offer a comprehensive network for education, monitoring and analysis. Additionally, the project offers an opportunity to study compliance from a new perspective.

SAMPLE POPULATIONS

Two populations were selected for inclusion, a chronically ill group and a healthy group. The chronically ill group are people with insulin dependent diabetes. The other a healthy group of post-menopausal women.

Diabetic Population

Participants are 50 persons with insulin-dependent diabetes who are patients in The University of Texas Medical School Pediatric or Adult Diabetes Clinics. Persons with diabetes were chosen as the study population because: (1) patients are available through the UT clinics; (2) the required health behaviors are relatively straightforward and measurable: checking blood glucose levels, adhering to a prescribed diet, exercising, administering medications; and (3) compliance with a specific regimen is vitally important for control of the disease and prevention of complications. Yet, compliance has been difficult to obtain (10,11).

Inclusion Criteria: insulin dependent, at least eighth grade reading level, English-speaking, interest in own diabetes, willingness to participate, established record of regular office physician visits or telephone calls.

Exclusion Criteria: severe retinopathy, pregnancy, less than eighth grade reading level, non English-speaking.

Healthy Population

Participants are 80 women who had their last menstrual period within the last two years. These subjects were recruited from the Houston area through public announcements and communications with women's groups or other likely sources. Post-menopausal women were chosen as the second study population because there was an interest in investigating a group which is basically healthy but undergoing a normal life change, in contrast to the first study population, persons with a chronic disease. However, women in this group are at high risk for osteoporosis, (12), and the project provides an opportunity to examine whether providing information about drugs, diet, exercise, stress management, general health and the monitoring of health behaviors will affect physiological and psychological well-being.

Inclusion Criteria: Caucasian, last menstrual period no earlier than June 1, 1984 and not later than June 1, 1986, eighth grade reading level, English-speaking, at least one live delivery, willingness to participate.

Exclusion Criteria: non-Caucasian, last menstrual period before June 1, 1984 or after June 1, 1986, prior hysterectomy, prior reproductive tract malignancy, congenital lipid disorder, history of kidney stones, hyperparathyroidism, hyperthyroidism, history of disease known to cause secondary osteoporosis or osteomalacia, illness developed during recovery from a broken bone, nonambulatory, past or current therapy for osteoporosis, less than eighth grade reading level, non English-speaking.

METHODOLOGY

Once a subject was determined by telephone queries to meet the study inclusion criteria, appointments for various pre-tests and a training/orientation session using the computer were scheduled. Subjects took loaned terminals and monitors home at the completion of the training.

Pre and Post Measures

Diabetic Patients
- Fasting a.m. samples of blood and urine
  - Glycosolated hemoglobin
  - SMAK-15
  - HDL
  - Blood glucose
  - Urine protein
- Percent body fat - sum of 4 skin folds

- Frame determination - wrist measure
- Vital signs
- Diary of 24-hour food intake
- Zung Self-Rating Anxiety Scale
- Rosenberg Self-Esteem Scale
- Multidimensional Health Locus of Control
- Diabetes Self-Efficacy Scale
- Cognitive tests:
  - Nutrition
  - Exercise
  - Drugs
  - Stress Management
  - General Health

Post Menopausal Women

- Fasting a.m. samples of blood and urine
  - SMAK-15
  - HDL
  - FSH
  - Estradiol, estrone, estriol
  - Hematocrit, if low, hemoglobin and serum iron also performed
  - Cyclic AMP 3-hr. urine
  - Calcium 3-hr. urine
  - Creatinine 3-hr. urine
  - Phosphorus 3-hr. urine
  - Hydroxyproline 24-hr. urine (preceded by 3-day modified diet)
- Bone Density - heel scan using single photon osteoanalyzer
- Exercise tolerance test
- Muscle group testing
- Percent body fat - sum of four skinfolds
- Frame determination - wrist measure
- Vital signs
- Pap Smear
- Diary of 24-hr. food intake
- Zung Self-Rating Anxiety Scale
- Rosenberg Self-Esteem Scale
- Multidimensional Health Locus of Control
- Self-Efficacy Scale
- Cognitive tests:
  - Nutrition
  - Exercise
  - Drugs
  - Stress Management
  - General Health

INTERACTIVE HEALTH NETWORK

The subject of this paper is to describe the nutrient data available to subjects in their homes. However, other services and information were made available along with the nutrient data. Services provided are: Electronic Mail, Weekly Health Letter, Health Encyclopedia Resource, Glossary, Personal Health Record and Analysis of Health Data. Nutrient data and analyses of foods can be accessed from the "Contents" menu in two ways. It is available through the Health Encyclopedia Resource and the Personal Health Record.

The nutrient database was purchased from Ohio State University because it offered a large number of fields and nutrients and other food constituents, has a large number of items, is a credible source, is useful for researchers, clinicians, and home users, and can be modified easily. Criteria for the HHC with respect to hardware and software were that the system be easy to use, visually pleasing and colorful, no previous computer experience needed by users, no typing ability needed, interactive and easy to access *only* the desired information quickly.

FEATURES OF HHC SOFTWARE FOR NUTRIENT DATABASE

The Hermann Health Connection is presented in full color graphics using the NAPLPS standard for graphics. Desired information is accessed through a series of menus by using key letters. Users may move directly to desired information by entering up to 26 key letters. The nutrient database is accessible through the Personal Health Record and the Health Encyclopedia Resource. In the Health Record, a menu option for Personal Health Diary contains all the health logs: food intake, exercise, medications and monitoring, illness and absence log, and stress management techniques. Other menu options under Health Record are for setting personal health goals, up to 27, and for analysis of health data.

The Food Log provides for immediate feedback with regard to recommended Kilocalories and ideal body weight (IBW). The user has the option to reject the recommended IBW and enter another weight choice, whereupon the Kcal are recalculated. Each user's record contains height, frame size, sex, age, and usual activity level which are used to calculate IBW and recommended Kcal. Users also get immediate feedback as they record foods regarding cumulative total Kcal and cumulative Kcal from fat.

After selecting "Data Entry" the user is offered either the full nutrient database with all food items or a condensed database complete for 16 nutrients. The latter option may require some substitutions of food items, however, there will be no missing data for the food item. This has appeal to researchers and users who either plan meals in advance or who are knowledgeable is making food substitutions. If the full list is chosen, in the nutrient summaries an asterisk will appear if any of the data were missing for a particular nutrient.

Food items are located by entering a letter or several letters of a word in a desired category. The data base is arranged in an index by first words and second words. For example, 2% fat cow's milk would first be accessed by typing in "M". Then selecting milk as the desired category. The user is then presented with a group of 2nd word choices, all the various kinds of milk. For this example, the choice is cow, where upon a "C" can be typed in and the user receives choices of various kinds of cow's milk. The user may scroll until 2% cow's milk is found and either step through the list or choose directly by entering the food item's code number. After the specific food item is selected, the user is prompted to give time of day the food was eaten, and size of serving in decimals. The item is then recorded above the scrolling window and individual and cumulative total Kcal and Kcal from fat are shown. At any point the user may stop data entry and analyze while still in the food log for the energy nutrients and alcohol and for the RDA. Users like this feature because they can look at the nutrient content of single foods or single meals. They may also switch to the other food list or select a previous day's record.

In the analysis option accessed through the Health Record menu, a user may analyze food hourly, daily, weekly or monthly. For analysis exceeding one day, if data is missing, an interpolation of the actual recorded days is plotted for the missing data. Up to seven variables can be selected by key letters from a scrolling window below the graph. Variables other than nutrients may also be plotted. This is particularly useful for looking at trends regarding Kcal consumed versus Kcal expended for exercise, or such variables as units of insulin taken versus various energy nutrients consumed. A selection of "Profiles" will offer the user a combination of nutrients.

The profiles and nutrients in each are:

Energy: Carbohydrates, Total fat, Alcohol, Crude fiber

Lipids: Total fat, Polyunsaturated fat, Oleic, Monounsaturated fat, Saturated fat, Cholesterol, Linoleic, P/S Fat Ratio

Trace Minerals: Copper, Fluoride, Selenium, Cobalt, Total Iron, Nonheme Iron, Manganese, Chromium, Molybdenum, Zinc, Heme Iron

Osteo: Calcium, Magnesium, Vitamin D, Dietary fiber, P/Ca Ratio, Phosphorus, Fluoride, Caffeine, Crude fiber

Carbohydrates: Dietary fiber, Crude fiber, Carbohydrates, Glucose, Fructose, Lactose, Maltose, Sucrose

Water/Electrolytes: Water, Sodium, Potassium, Chlorine

Amino Acids: Tryptophan, Isoleucine, Lysine, Cystine, Tyrosine, Histidine, Threonine, Leucine, Methionine, Phenylanine, Valine

RDA: Food Energy, Total Fat, Carbohydrates, Vitamin A (RE), Vitamin A (IU), Vitamin D, Vitamin E, Vitamin C, Thiamin, Riboflavin, Niacin, Vitamin B6, Folic Acid, Vitamin B12, Calcium, Phosphorus, Iodine, Magnesium, Zinc, Total iron, Protein

Allergies: Gluten, Lactose

A selection of "Daily Energy" will show in bar graph format the user's energy intake compared to the recommended for height, weight, sex and activity level, or the distribution of calories from the energy nutrients. "Total Daily Nutrients" shows in percents the nutrient intake compared to the RDA in bar graph format. The line graphs show actual amounts of nutrients as well as the individual's RDA.

The nutrient database may also be accessed through the Health Encyclopedia Resource. Users who wish to browse in the data base for foods which are high or low in specific nutrients and/or compare them to the RDA or to other standards may do so under the menu choice, "What's in my Food and Drink?". Users enjoy this feature because they can compare foods in the same category or check on specific nutrients in items they have eaten or plan to eat. For example, checking fatty acid content of various oils is a practical use of the browse function. The profiles offered under the analysis choice of the Personal Health Record are also available in the browse function.

Other uses for the nutrient database are in the educational modules of the nutrition section of the Health Encyclopedia Resource. In this section typical modules or mini books under development include "Meal Planning Primer", "The Label Puzzle" and "Recipe Analysis". There are currently 75 modules which have been written in the nutrition category and others under development.

SUMMARY

The Hermann Health Connection is the first comprehensive system to offer health information, health monitoring and the capacity for on-line expert response to queries in the areas of Nutrition, Stress Management, Drugs, Exercise and General Health. This innovative, real time service using the NAPLPS standard for videotext has wide consumer appeal for a number of markets: users with chronic illnesses, institutional facilities, and individuals who are interested in improving their own health status.

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RECIPE CALCULATIONS: WHERE DO WE STAND?

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The development of computerized nutrient data bases has facilitated recipe analysis with respect to calculation of nutrient values, portion sizes and yields. However, the use of computers has not resolved questions concerning which procedures are best for deriving nutrient values. In fact, software makes it possible to consider a number of alternative procedures for calculating nutrient values.

Although there are varying ways to generate yield data for various stages of recipe preparation, there are basically two procedures employed to determine the nutrient value of a cooked recipe: adjusting values of raw (or unprocessed) ingredients, or using analyzed values for cooked ingredients. Simply stated, the latter, involves summing the nutrient values of cooked ingredients, and adjusting the yield to derive the edible portion sizes and nutrient values. To use values for uncooked ingredients is usually inappropriate when considering cooked foods unless nutrient retention factors are applied. The "nutrient retention method", (NRM) involves the application of micronutrient retention factors to uncooked ingredients (at the ready-to-cook yield stage), and subsequently adjusting for fat and moisture changes to derive yields and nutrient values for the cooked product. More detailed descriptions of these procedures have been provided at prior Nutrient Data Bank Conferences (1,2).

Use of the nutrient retention method (NRM) has been quite limited. The method was refined and applied to development of the recipe data base for the new National Food Consumption Survey (3), and a modified version was developed for testing in school food service settings (4). While these applications reinforce the viability and legitimacy of this method, use remains limited outside the USDA. The procedure has not been integrated into commercial nutrient analysis software, and use by other institutionally-based data banks is also limited. Given the potential value of the NRM, this bears further examination to assess factors which may be hindering broader acceptance.

Use of cooked ingredient values to calculate nutrient values of a recipe.

When all the ingredients in a recipe are adequately described and quantified, using values for cooked ingredients is preferable to use of unadjusted raw ingredient values or analyzed values for an entire recipe of comparable make-up. While the procedures for calculating such nutrient values are fairly straightforward, the method has several limitations. Deriving yields can be difficult using cooked food values, particularly when the ingredients go through several stages of preparation. There may be waste or discard in the preparation stage (deriving the "ready-to-cook" yield from the "as-purchased" weight). During cooking, gains and losses arise from fat and moisture changes. After cooking, more discard may be needed to derive the final edible yield. While ingredients used in the recipe of interest may be in a raw or uncooked stage of preparation, the published data for cooked items are usually equivalent to the edible cooked portion (i.e., "as served" stage), wherein waste, fat and moisture changes are factored into a single value. In order to derive the pre-cooked weights of these ingredients, the types and amounts of waste and the cooking methods must be adequately described in the food composition tables or in the data base. If these are comparable to the processing steps used for the recipe being calculated, then published values for the cooked ingredients used would be acceptable.

Frequently, insufficient detail is provided with computerized nutrient data bases to describe such preparation factors. Newer food composition tables provide more detail about preparation and yields than do the earlier tables, but many data bases don't include such descriptions in their programs or manuals. Even when this information is available, it is tedious to calculate.

When preparation and cooking procedures differ from those of foods being referenced, values may not be comparable. This limitation applies not only to waste factors, but also to cooking methods, and even to cooking time and temperature. There can be considerable variation in food preparation methods, but data that takes this into account is not always available. For many foods and complex dishes, nutrient values for the cooked item are supplied for only one or two methods of preparation. Furthermore, most nutrient data covers foods cooked individually. This makes it easier to locate values for most ingredients, but many recipes combine ingredients before cooking, as is done with casseroles and other mixed dishes. Such combinations may affect nutrient retention differently than if ingredients are cooked separately. For example, vitamin and mineral retention may be affected by differences in pH. Similarly, the retention of micronutrients in boiled vegetables will differ if the water is saved, as with soups. In this instance, minerals levels may be higher, but some vitamin levels will be lower due to longer cooking time compared to boiling.

In some instances, cooked ingredients listed in food composition tables (and data bases) have been prepared with unspecified quantities of condiments, fat, and other items which contribute to nutrient levels. This is particularly a problem for breaded or fried foods, where the amount of fat uptake and the type and amount of coating are often inadequately described. Sodium may also be added in unspecified quantities, although this is less frequently found in updated reference sources.

Finally, cooked values are not available for many commonly used ingredients. Dairy products, such as milk and cheese, are used in many recipes, yet data are supplied only for the uncooked product. In these instances, it is necessary to use values for the uncooked items when using this procedure.

In summary, using cooked ingredients to calculate recipes will be most valid when all ingredients are described and quantifiable; when ingredient yields are known and match those of the items selected from the data base; when preparation methods are similar; and when cooked values are available for all ingredients. In such instances, this procedure can certainly be easier than adjusting uncooked values, and probably as accurate. Conversely, when preparation or processing methods don't match those used for comparable items in a data base, or necessary information to determine this is unavailable, less reliance should be placed on the use of cooked ingredients. But is the NRM a viable alternative procedure?

Using the nutrient retention method (NRM).

The NRM uses ingredients in the "as-purchased" or "ready-to-cook" stages. While the quantities must be specified, there are often problems with converting volumes to weights, with standardizing unit values for foods that vary in size (eg., produce), and with matching waste factors to those of foods listed in the data base. These are not resolved by using the NRM. But it is easier to work forward than backward when determining yields at each stage of preparation, and hence to calculate the nutrients and yields of recipes at the final "ready-to-eat" stage when starting with items at the "as-purchased" or "ready-to-cook" stages.

The NRM can be difficult to use for nutrient analysis of published recipes, particularly when the edible portions of foods cannot be determined. It is more useful where a recipe can be kitchen-tested, such that waste factors and subsequent yields can be measured. However, published data on yields can help when direct measurement is unavailable.

The NRM facilitates the calculation of cooked yields when precooked quantities are known, and hence makes it possible to derive the precooked recipe portions or ingredient weights needed to generate a specified yield of the cooked product. This is valuable for standardizing costs and nutrient data and for adjusting ingredients and portions to meet differing cost or nutrition objectives.

The NRM makes it easier to match ingredients and preparation methods in the calculation of yields and nutrient values. There is much more data available for the raw or ready-to-cook forms of foods than for the cooked forms. The amounts of salt, fat, and other ingredients can be specified and varied, as can the amounts and types of discard. Micronutrient retention factors can be applied to most ingredients for a variety of cooking methods. Fat and moisture retention can be estimated, allowing nutrient and cost values to be generated for standardized portions of the cooked products. On the surface, therefore, the NRM appears to allow selection and variation of recipe contents and preparation methods without having to conform to the limited specifications imposed by use of cooked ingredients in the recipe analysis. However, this is not as simple a procedure as the description suggests.

Using micronutrient retention factors.

Estimates for vitamin losses from cooking were published by the USDA in ARS-62-13 (5) and an expanded provisional table was issued in October 1982 (6). The latter furnished values for 18 vitamins and minerals and for 50 preparation categories. To facilitate development of the recipe file for the latest NFCS nutrient data base, this table was expanded to 265 categories, allowing coders to more precisely match foods and cooking methods with those used in a broad range of recipes. Estimates for reheated preparations were included, although many values were extrapolated from the original 50 categories. The NFCS nutrient retention file was developed as part of a program for the calculation of recipes; as such, it could be adapted for other recipe analysis programs. To date, this expanded list has been released only as part of the NFCS recipe file tapes.

Determining fat retention.

In using the NRM, fat gains or losses due to cooking are usually calculated as a percentage of total weight of the recipe. The major source of fat retention data is USDA handbook H-102 (7), with tables also included in ARS-62-13. While these supply extensive information, they are by no means complete, and it is particularly difficult to find values for fried items. The handbook also combines this data with food waste and moisture retention values; as such, it is not as convenient to use or as efficiently assembled as is the micronutrient retention table. It takes more time to locate useful information.

As mentioned, these tables contain limited data for fried foods or recipes, which is most problematic for assessing deep fried foods, since fat absorption is not specified in recipes as an ingredient, and is difficult to measure directly. Absorption will vary with changes in cooking temperature and duration of frying, type of fat used, and type and amount of batter or other coatings applied. A single estimate of fat absorption is inadequate for many foods, and more extensive data are needed to account for variations in preparation and cooking.

Estimating fat levels for pan-fried foods is difficult where the amount of cooking oil is not specified. (Of course, this problem occurs with any method used for nutrient calculation.) The type of cookware, as well as the type of fat, ingredient coating, and time and duration of cooking allow for considerable variation in the amount of fat or oil needed. Where the recipe is kitchen-tested, an appropriate value can be derived and specified in a recipe file for a given set of preparation and cooking procedures. In contrast, such values are not readily available when calculating nutrient values from published recipes. Where the amount of frying fat is not specified, personal judgement is required, as there are few published guidelines for such recipes. This is particularly of concern for those attempting to produce a low-fat recipe by minimizing the total fat used for frying. In this situation, an estimate is needed of a lower boundary for added fat that minimizes the quantity while not severely compromising the integrity of the dish being prepared.

The aforementioned NFCS recipe tape was reviewed to determine whether values for fat retention were included that were not published in H-102. Such values could serve as a reference for others doing recipe analysis. Out of some 3000 recipes, 146 listed fat retention values, 23 with fat losses, and 123 with a net fat gain. Many of these are not contained in H-102, although they are largely derived from this and similar sources. Unfortunately, many foods of interest are contained in the NFCS primary ingredient file, which does not supply fat data of this type. More fat retention data, organized in a streamlined fashioned similar to the micronutrient retention tables, are needed to provide a comprehensive reference that can be adapted for use with nutrient analysis software.

Moisture retention.

When it is necessary to generate values for standardized (eg., 100 gram) portions of a cooked recipe, procedures for determining moisture gains and losses from cooking are needed. The NRM procedures for calculating moisture and fat retention are similar, and contained in the same publications. Likewise, it is difficult to find values for any dishes, as overall data are limited. As with fat, moisture gains and losses can vary with cooking time and temperature and with method of preparation, so a single value is really inadequate for many foods.

Again, the NFCS recipe file was examined for moisture retention data in calculated recipes. As with fat data, values are supplied as a percentage of the total weight of the uncooked ingredients. Values for moisture retention were found for 1255 items, many of which are not found in H-102 or ARS-13-63 although the data for the most part were derived directly from these sources. Again, these values could be organized in a file for ease of reference. As with the fat data, however, many items of interest are contained within the primary ingredient file where moisture retention values are not supplied. Hence values for NFCS recipes can best serve as a guide for comparing moisture retention in recipes whose ingredients and preparation are similar.

Sodium retention.

One nutrient not heretofore calculated by the NRM is sodium, despite the variability in foods that can result from differences in preparation. Like fat, varying quantities of salt or other sodium-containing products can be added to many recipes, and these amounts are not always specified. In processing, sodium retention can be affected by fat gains or losses, although the amounts would tend to be minor. An example where losses could be more significant is the roasting of meat where the exterior has been salted and much of that salt leaches with the fat drippings.

More significant quantities of sodium are gained or lost from boiling foods. Where an item containing sodium is steamed, or boiled in unsalted water, the sodium levels will be reduced. Often these losses are from the naturally-occurring sodium in the food, so that losses may be large as a percentage of total sodium, but less significant in absolute terms. More frequently, salt is added to water in cooking, and the amount of sodium gained is of interest. Estimating sodium absorption from boiling is difficult. If food composition tables give a single value, it is often an amount found in canned products. Such values are unreliable unless the same amount of sodium is added to the cooking water, and the processing is comparable. However, a recent (unpublished) pilot study conducted at the U.S. Army Natick Laboratory in Massachusetts suggests that sodium values can be calculated (6).

In that study, legumes, vegetables, and pasta products were boiled with varying amounts of salt added to the cooking water, and the cooked products were analyzed. Based on chloride measurements, it was found (as expected) that the amount of sodium in the cooked products rose as the amount of added salt was increased. In fact, the increase in sodium added to water produced a proportionate rise in the amount absorbed by the food. It was hypothesized that if a food was thoroughly cooked, an equilibrium in sodium concentration would result, such that:

$$\frac{\text{Water in food}}{\text{Total water}} = \frac{\text{Sodium in food}}{\text{Total sodium}}$$

This implies that, after cooking:

$$\text{Sodium in food} = \frac{\text{Sodium in boiling water} \times \text{Water in food}}{\text{Boiling water}}$$

In order to calculate the sodium in the cooked food using these formulae, it is necessary to know the beginning volume of cooking water and the moisture lost from evaporation, or to measure the volume of water remaining after cooking. The amount of natural sodium contained in the uncooked food and the amounts of water contained in the uncooked and cooked forms of the food can be estimated from food composition tables, such that added salt becomes the independent variable that determines the final sodium level in the cooked food. (However, the amount of sodium added can affect the amount of water absorbed or retained by some foods.)

Lab analyses of the chloride content of the cooked items allowed the sodium values to be derived. These values closely matched the predicted values for items that were thoroughly cooked. This data suggests that it may be quite easy to add sodium to NRM procedures, although more research using sodium analysis and more variations in cooking procedures will be needed to confirm these findings.

Conclusions.

Any method for calculating the nutrient content of recipes has procedural advantages and drawbacks. Having both methods available provides much greater flexibility and can help users produce better calculated values for a wide range of recipes and cooking processes, because the procedures seem to be complimentary. In fact, for many recipes, a combination of methods can be recommended - a procedure that was employed frequently in the development of the NFCS recipe files.

With proper programming, the NRM could be as fast and easy to use as any other procedure for recipe calculation, providing the necessary data are easily accessed. Drawbacks to widespread adoption of the NRM include the lack of data, particularly for moisture and fat retention, and the complex organization of current tables that makes them difficult to use efficiently. This would explain some of the reluctance to adopt this procedure. More data well organized would facilitate the integration of NRM into recipe analysis programs. But concern also exists for the validity and reliability of this method. There is at present little data available comparing this method to others and to analyzed values (7), although the USDA is sponsoring some validation studies at this time. Such data will be most valuable in determining whether inclusion of the NRM in recipe calculation is as worthwhile as proponents suggest.

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TWELFTH NATIONAL NUTRIENT DATABANK CONFERENCE
April 12 - 15, 1987
Houston, Texas

Appreciation and gratitude is extended to all contributors, co-hosting institutions, committee chairpersons and committee members. Their generous contributions helped to make the conference possible.

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POSTER SESSION SCHEDULE

Monday, April 13, 1987

1. FDA's Factored Food Vocabulary
   E. Smith

3. Design of a Nutrient Data Base Using Multiple Sources of Nutrient Information
   B. Hoverson

5. Are Current Methods of Determining Calcium and Phosphorus Intake Accurate?
   L.L. Oenning

7. Design and Use of the Extended Table of Nutrient Values (ETNV)
   M.C. Moore

Tuesday, April 14, 1987

2. Development of a Computerized Food Frequency Questionnaire to Estimate Current Individual Intake of Nutrients
   A. Engle

4. Development of a Nutrient Analysis Program with Enhanced Date Management and Graphics Capabilities
   W. Lehman

6. The Effects of Exercise and Nutrition Regimen on Serum Lipid Concentrations, Dietary Intake, and Body Composition Measurements
   N. DiMarco

8. Construction of an Abbreviated Data Base for Use with a Food Frequency Instrument
   L.G. Borrud

POSTER SESSION

Monday, April 13, 1987

FDA'S FACTORED FOOD VOCABULARY

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The lack of a standardized vocabulary for describing food products limits the effective use and coordination of databases containing diverse food names. At FDA's Center for Food Safety and Applied Nutrition (CFSAN), scientists and information specialists have developed the Factored Food Vocabulary (FFV), which provides a standardized but flexible language for describing foods and food products. FFV is multihierarchic and retrieval-oriented. It provides the capability for coding and retrieving eleven aspects or "factors" of foods, including product type, food source, cooking method, preservation method, container or wrapping, etc.

The FFV provides a structure which can be overlaid with various types of data pertinent to foods, e.g., nutrient data, toxicology data, or demographic data. It has been applied to CFSAN's Total Diet Study and, in collaboration with the National Cancer Institute, to the food names of the USDA's Nutrient Data Base for Standard Reference. These are to be studied to determine retrieval effectiveness. It is hoped that FFV will permit the integration of information from these and other databases, such as the USDA National Food Consumption Survey, the FDA's Food Labeling and Product Surveillance (FLAPS) files, and the National Health and Nutrition Examination Survey (NHANES II), to meet the diverse needs of researchers and to analyze food-related data more effectively in the future

DESIGN OF A NUTRIENT DATA BASE USING MULTIPLE SOURCES OF NUTRIENT INFORMATION

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The requirements of a nutrient data base vary for specific applications. To increase flexibility in a research setting, a data base (GRAND) was developed containing multiple sources of nutrient data. In the GRAND system, each of up to 100 sources can be used independently or can be combined with other sources. The user establishes a priority scheme to select the sources of nutrient values to be included in a working subset of the data base. For example, a person planning diets for a metabolic research study may want to choose values from on-site laboratory analyses of specific foods as the primary source of data. Someone conducting research on free-living subjects may wish to choose as the first source the values from Agricultural Handbook 8. Different subsets of the data base can be used for various applications without altering the master data base. The multiple source design allows new data to be continually added without replacing existing data; updating involves changing only the master data base, from which new subsets of the data base can be generated. Updating the data base with a new source of information involves adding the new source and including it with a user-determined ranking in a new priority scheme. Because existing nutrient values from other sources are not replaced, they are still available to other users who may choose to prioritize sources of nutrient data differently. A multiple source design required substantial computing power and disk storage to handle the larger data base and its rearrangement into subsets for particular applications. When sufficient computing power and disk storage are available, and a data base is needed for several applications, a multiple source design may provide the desired flexibility.

ARE CURRENT METHODS OF DETERMINING CALCIUM AND PHOSPHORUS INTAKE ACCURATE?

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Our earlier studies showing important effects of dietary phosphorus as well as calcium on bone health led us to examine the accuracy of our methods for determining dietary levels of these nutrients. We compared three different methods of calculating calcium and phosphorus content with chemical analysis in 14 daily diets. The diets were taken from general hospital and cafeteria menus, individual food records (some containing restaurant foods) and daily menus designed for research projects. For each diet, meals were assembled from the specified sources or reconstructed from detailed food records; homogenized in deionized water prior to ashing, and chemically analyzed for calcium (atomic absorption spectrophotometry) and phosphorus content (colorimetry). To obviate observer variation, only one observer calculated nutrient content by: 1) hand calculation, using nutrient data given by Pennington and Church (1985) and Leveille, et al. (1983); and 2) two different commercial computer software programs. Comparisons of chemical analyses with calculated values showed an insignificant trend toward overestimation of calcium content (paired-t, $p > 0.05$); but, all these methods significantly underestimated phosphorus content (paired-t, $p <= 0.01$). On average, estimates of phosphorus content deviated from actual by 250 mg/d; however, those diets with a greater proportion of processed or convenience foods deviated by more than 350 mg/d. For accurate calculation of phosphorus and possibly calcium intake, nutrient data sources must be updated to reflect present industrial use of phosphate and calcium additives. In addition, when calculating intakes, we need to secure more information about the foods consumed.

DESIGN AND USE OF THE EXTENDED TABLE OF NUTRIENT VALUES (ETNV)

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New Orleans, LA

The demand for accurate computerized data banks has grown in direct proportion to the increase in emphasis on good nutrition as a vital component of sound health. The ETNV consists of foods and recipes contained in studies from 18 states and one foreign country. Basic and marketplace foods contain information on 97 nutrients. The USDA is the primary data source followed by other accepted sources, journals, correspondence and actual analysis. Before acceptance, all data and recipes are cross-checked for reliability: protein, fat, CHO, ash, and moisture must equal 100.0 gm +/- .01: all have internal checks for missing data, except ash, minerals and moisture. Three recipe programs have options for applying vitamin loss. Each recipe program deals with a "multi-level" approach; recipes containing multi-level dependencies (a recipe within a recipe). Examination of all basic foods via their biological families is made so that not only amino acids, but fatty acids, CHO subgroups, vitamins, and minerals can be checked for consistency. The capability of assessing missing data carries over to case histories so that reliability is enhanced. Estimates of heme- and nonheme iron in a case history are based on percent plant and animal protein obtained from identified ingredients in school lunch, family, or commercial recipes. Dietary intakes up to 99 days can be averaged and analyzed for nutrient content in one to nine food intake periods. Rigid quality controls and calculation of each separate food intake provide opportunity not only to evaluate nutrient components, but also interrelationships, and potential dietary assimilation. Percent of RDA and nutrient to kcalorie ratios are available.

DEVELOPMENT OF A COMPUTERIZED FOOD FREQUENCY QUESTIONNAIRE TO ESTIMATE CURRENT INDIVIDUAL INTAKE OF NUTRIENTS

A. Engle, R. Scarmozzino, L. Lynne, and A.P. Boyar
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The aim of this study was to develop and test a computerized nutrition assessment questionnaire designed for a personal computer which could be used to screen individuals for eating patterns that may be associated with cancer risk. Eighty-five food frequency questions were developed, using food items determined by Block et al. to contribute at least 85% of kcal, fat, cholesterol, vitamin A, vitamin C, and calcium to the daily dietary intake of Americans.

After a simple command is entered, the questions appear on the terminal screen and respondents enter their frequency of intake and portion size with the aid of food models and household measuring cups and spoons which are within reach.

A small nutrient data base was developed containing values for the nutrients of interest and for dietary fiber, using the American Health Foundation's DIAN Nutrient Analysis System. These nutrient values, derived from a representative food or a calculate average of foods grouped together in a question, are used by a second program to calculated estimated daily nutrient intake for each individual. Results are reported on the terminal screen or can be printed out.

Pilot testing with 94 subjects who were staff members in a public school district indicated that 97% of the sample, even without prior computer experience, could successfully respond to the questionnaire when on-site supervision was provided. Average length of time for completion was 45 minutes for the total program.
(Supported by NCI grants CA 411440101, CA 40839)

DEVELOPMENT OF A NUTRIENT ANALYSIS PROGRAM WITH ENHANCED DATA MANAGEMENT AND GRAPHICS CAPABILITIES

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The use of nutrient data base information in conjunction with diet analysis software has become and established tool in clinical dietetics, nutritional counseling, and nutrition education and research. Limitations of current software include the inability to incorporate and analyze large amounts of data collected over a period of time, and to check completeness of data base information for nutrients of interest.

The authors have developed a diet analysis software package and data base which analyzes 44 nutrients for 5600 separate food items. The diet evaluation report includes the number of missing data entries for each nutrient. This indicates to the user nutrient completeness for each diet analyzed. The program can also collect, sort and store unlimited amounts of diet data which can then be accessed for future analysis. The user can define various parameters by which the data can be categorized (e.g., age, sex, supplemental use, demographic location, etc.). Comparisons can then be made between various subgroups or categories (e.g., male vs. female) or between an individual and a subgroup (e.g., Mary Jones vs. all females). the authors have used the program to create ASCII files which can be easily transported into more sophisticated statistical software packages.

The software also has integral graphics capabilities which permit the generation of bar graphs and line plots for the various calculated group or individual files.

THE EFFECTS OF EXERCISE AND A NUTRITION REGIMEN ON SERUM LIPID CONCENTRATIONS, DIETARY INTAKE, AND BODY COMPOSITION MEASUREMENTS

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The Houstonian Preventative Medicine Center, Houston, TX

A six weeks program involving aerobic conditioning, weight training, and two dietary regimens ((Treatment I-120 kcals, low fat (30%) kcal, low cholesterol (300 mg/day) and Treatment II - no caloric restriction, low fat, low cholesterol)) was evaluated in 27 previously sedentary males and females 20 to 55 years of age. (Treatment I = 5 males, 8 females, Treatment II = 2 males, 4 females and Control = 4 males, 4 females). Some of the variables evaluated included dietary intake, body weight, body circumferences, percentage of body fat, concentration of serum total cholesterol, and estimated maximal oxygen uptake. The participants were randomly assigned to one of the two treatment groups or a sedentary control group and were pre- and post-tested on the above variables. Diet and exercise records were recorded daily by all subjects and were turned in weekly. Two days per week from each diet recall sheet were randomly chosen and analyzed by The Texas Woman's University DEC system 2050 computer using The Ohio State University Nutrient Data Base. The Ohio State Nutrient Data Base was chosen for this study because of the relative completeness of its entries, the variety of foods listed, and the ability to provide feedback to each subject on average weekly nutrient consumption. Because of the nature of the variables analyzed, diet records were assessed for total kilocalories, percent fat, and cholesterol consumed per day. The Kruskal-Wallis analysis of the six groups, based on sex and treatment, revealed none of the variables examined were statistically significant (Alpha = 0.01).

CONSTRUCTION OF AN ABBREVIATED DATABASE FOR USE WITH A FOOD FREQUENCY INSTRUMENT

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A food frequency instrument to collect accurate and reliable dietary data in a multi-ethnic population of Whites, Blacks, and Hispanics in South Texas was developed and evaluated as one component of Nutrition Methodology for Epidemiologic Cancer Studies. This instrument was designed to assess usual intake of total fat and vitamins A and C. A unique data base was the foundation of the microcomputer nutrient analysis program used with the instrument. To construct the data base, the diet of the targeted population was first inventoried by means of a 24-hour dietary recall. Foods identified from the recall data were ranked by their percent contribution to each nutrient of interest. All like foods were combined to yield the smallest number of mutually exclusive food types. A master list of these distinct food types was constructed which captured at least 80% of the intake of each nutrient. A weighted average nutrient value per 100 g for each nutrient for each food type was calculated using the individual food codes comprising the food type, the number of times each food code was reported consumed in each ethnic group, and the amount of nutrient in 100 g of the food. A weighted average gram value for each food type was calculated using the food types and associated ethnic-specific nutrient and gram weights was the result of this methodology.

EXHIBITORS

Westchester Room

1. The CBORD Group, Inc.
2. National Technical Information Service (NTIS)
3. The Food Management Group
4. Computrition, Inc.
5. University of Texas School of Public Health