A Method for Estimating Nutrient Values of Mixed Dishes Based on Ingredient and Nutrition Label Information

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Introduction

The Human Nutrition Information Service (HNIS) of the U.S. Department of Agriculture creates nutrient data bases that are used by the food industry and others for various purposes. The basic USDA data set is the USDA Nutrient Data Base for Standard Reference. It contains all nutrient values published in Agriculture Handbook No. 8 and is updated continually. This data set is used as the basis for the USDA Nutrient Data Base for Food Consumption Surveys. Results from analyses conducted by industry, government, universities, and others are evaluated and entered into the data bank. However, sufficient analyses on all nutrients in all foods in American diets are not available from these sources. One technique that is used to estimate the nutrient content of a food when analytical data are not available is to use the information on ingredient and nutrition labels. Today I will discuss that procedure as used with mixed dishes.

Background

HNIS calculates the nutrient content of dietary intakes by individuals participating in its food consumption surveys. HNIS conducts the Nationwide Food Consumption Survey every 10 years; the most recent was in 1987-88, and the smaller Continuing Survey of Food Intakes by Individuals during the years between the decennial surveys. These surveys document much about diets and the nutrient content of diets of the U.S. population. They assess the kinds and amounts of foods households and individuals use as well as the nutrient content of these foods. Information from these surveys is used in the Ten-Year Comprehensive Plan for the National Nutrition Monitoring and Related Research Program.

When a survey respondent has consumed a food for which there is no nutrient data in the USDA data base, then the nutrient content of that food needs to be determined. These items are frequently newly marketed foods; new foods are being introduced to the market at a rapid pace, approximately 15,000 new foods each year. Results from our surveys reflect changes over the years in the availability of convenience foods (mixes and ready-made products) and in technology (more commercially frozen foods). For example, there has been an increased consumption of mixed dishes which are purchased in a "ready-to-eat" or "ready-to-cook" state. A proliferation of frozen microwavable entrees, side dishes, and complete meals are available in the marketplace. They can range from a meat-, poultry-, or fish-based main dish with a side dish of pasta to a complete meal with entree, carbohydrate source, vegetable, and dessert. Nutrient profiles must be determined for these foods so that respondents' nutrient intakes can be calculated.

The results of laboratory analyses are available from some food companies for their products; however, most of these data include only the nutrients reported in nutrition labeling. HNIS contracts for research to determine the nutrient content of selected foods and nutrients, but these analyses are limited to major contributors of nutrients and frequently consumed foods. Analyzing all foods for all nutrients would be prohibitively expensive. For data that are not available, specialists at HNIS who are trained in specific food groups, such as bakery products, cereals, or fruits, develop representative nutrient profiles.

A procedure to estimate the nutrient content of mixed dishes uses (1) a data base of nutrient values of individual food ingredients per 100 grams, with a unique code for each ingredient, (2) ingredient information from the label, listed in descending order of predominance, and (3) any available nutrient values for the mixture.

Mixed dishes, for the purposes of this study, are those manufactured foods considered to be an entree, an entree with side dish(es), a side dish, or a complete meal. Information about the particular food in question is obtained from the survey respondent: A complete description along with a package label is used to identify the food. Current brochures and nutrition information from food manufacturing companies are used as well to help identify the ingredient constituents in the mixed dish.

Method for Rigatoni Entree (Table 1)

To begin, I will describe the process for coding the ingredients in a mixture by using an example of a reduced-calorie frozen entree: rigatoni with meat sauce and cheese. Ingredients are listed on food labels from the ingredient present in the largest amount down to the smallest. For this entree, the first ingredient is tomatoes, the second is cooked macaroni, the third is beef, and so on.

To code these foods, the "Primary Nutrient Data Set for Food Consumption Surveys" is used; it contains data for food energy and 29 food components for about 3,300 "primary" or basic ingredient foods. Most of these data come from the USDA Nutrient Data Base for Standard Reference, which represents the most up-to-date published information available.

The code chosen for the first ingredient, tomatoes (11530), is boiled tomatoes. The second ingredient code chosen is 82990: macaroni, enriched, cooked, firm.

Because this mixed dish is a reduced-calorie product, the code for lean, well-done ground beef is used. Since there would be only a small nutrient contribution by some ingredients in this entree, such as spices and xanthan gum, these are omitted from the coding process even though they were listed among the ingredients. Each of the ingredient codes is for a cooked form of the food, since the product as purchased in the supermarket has been partially or fully cooked and requires only reheating. In some cases there may be more than one appropriate food code to use. For example, the tomatoes could have been coded as canned, whole tomatoes. The pasta code could have been one for tender-cooked instead of firm-cooked, but because this meal undergoes further cooking in the home, the latter was chosen.

An additional data set, the table of nutrient retention factors, is then used. These values are based on contract research designed to study the retention of vitamins and minerals during cooking. These factors account for the effect of cooking by the food preparer on the nutrient content; vitamins and minerals affected by cooking will be adjusted appropriately. In this frozen rigatoni entree, "reheat" retention codes are chosen for the ingredients that would be affected by further cooking in the home.

The label for rigatoni with meat sauce and cheese shows the 9.75 ounce (276 gram) box to contain one serving. The values per serving for eight nutrients are included on the nutrition panel. Nutrient values on a 100-gram basis are calculated based on the total weight of the entree.

An optimization technique using linear programming is then applied to estimate the proportion of each ingredient in the mixture. This model requires (1) the nutrient content of each ingredient, which would come from coding each ingredient using the Primary Nutrient Data Set, (2) a list of ingredients in descending order of predominance, which would come from the manufacturer or the food label, and (3) at least a partial profile of the nutrient content of the mixture, which would come from the manufacturer or the label's nutrition information (usually per serving). The data of the mixture's nutrient content provide the constraint set for the linear programming model. The output consists of a percentage listing by ingredient, providing the best fit to the available nutrient values of the mixed dish. Another important part of the output is the total nutrient content for the product of 18 nutrients, based on the percentage listing of each ingredient.

HNIS maintains an ingredient component file that links each item in the individual survey nutrient data base (that is, each food reported by a survey respondent) to one or more food items on the Primary Nutrient Data Set. The percentage of each ingredient estimated by the model described above is checked for reasonableness and consistency with data for similar items in the HNIS ingredient component file. The totals of the nutrients are reviewed and compared to the derived 100-gram values for the mixture.

Results for Rigatoni Entree (Table 2)

In the example of the rigatoni entree, five controlling nutrients are used in the optimization technique: calories, protein, carbohydrate, fat, and sodium. Results revealed the optimization technique to give an exact match to the label nutrient values of 94 calories, 6.5 grams of protein, 9.1 grams of carbohydrate, and 315 milligrams of sodium. Total fat comes to 3.7 grams, which is very close to the label's 3.6 grams.

Looking at the nutrients alone is not sufficient to evaluate the output for this entree. By examining the percentage listing of ingredients generated (Table 3), one can determine if amounts of the components are reasonable. The entree is about 30% tomatoes; 11% each cooked macaroni, beef, and mushrooms; 4% mozzarella cheese; and so forth down to 0.4% each enriched wheat flour and dehydrated onions. These percentages appear reasonable and in line with what one would expect for a reduced-calorie, pasta-based entree.

The program can set upper or lower limits on the amount assigned to an ingredient, or it can fix an ingredient at a specified percentage. It is sometimes desirable to use bounds if the amount of a particular ingredient in a mixed dish is known. For example, a manufacturer may have made a claim for the amount of an ingredient in an item, or one may expect a certain amount of an ingredient in a mixture. The program works around the established limits to produce a percentage listing of ingredients which will closely approximate the nutrient totals in the mixture.

The computed formulation for the rigatoni with meat sauce and cheese is then entered into the HNIS recipe program (Table 4), which calculates the estimated nutrient content of the formulation and reports food energy and 29 food components per 100 grams for the mixed dish. All nutrient values are reviewed for reasonableness by a food composition specialist.

Method for Meatball Meal (Table 5)

Another example is determining nutrient values of mixed dishes based on food label information for a complete frozen meal. This meal comprises swedish meatballs in a sauce with pasta and a vegetable medley. The ingredient panel shows a composite ingredient list, instead of separate lists for each of the meal components. The optimization technique used for the previous example can be used again with this product, because the predominance of the ingredients is known.

Appropriate food codes and retention codes are chosen for the ingredients. Essentially the same rationale as was used for the previous example is used for this one, since the food requires reheating. Each of the ingredient codes is for a cooked form of the food and "reheat" retention codes are chosen. A few ingredients towards the bottom of the ingredient list are omitted from the coding process due to their small nutrient contribution: flavoring, tapioca maltodextrin, yeast extract, and spice.

The label for the frozen dinner shows the 8.5 ounce (241 gram) box contains one serving. Nutrition information per serving for calories, protein, carbohydrate, fat, cholesterol, and sodium are listed on the food label. Nutrient values on a 100-gram basis are calculated based on the total weight of the frozen meal.

Results for Meatball Meal (Table 6)

The optimization technique, using the nutrient content of each ingredient and five controlling nutrients (calories, protein, carbohydrate, fat, and sodium), estimates the proportion of each ingredient in the mixture and generates the totals of 18 nutrients based on those proportions. Total calories come to 114, compared to the desired label value of 112. We have an exact match to the label nutrient values of 7.9 grams of protein, 12.9 grams of carbohydrate, 3.3 grams of fat, and 270 milligrams of sodium. The difference in calories is due to rounding. Adjustments in the amount of one or more of the ingredients can be made if the nutrient values generated are very different from the label claims.

The next item to check is the percentage listing of ingredients that the optimization technique generates (Table 7). The first seven ingredients have each been assigned about 12%, nonfat dry milk has been assigned 9.2%, and smaller amounts of 3.2% or less are assigned to the remaining ingredients -- modified food starch and various seasonings. The formulation is checked for consistency with similar items in the HNIS ingredient component file.

The computed formulation for the frozen meatball meal (Table 8) is entered into the HNIS recipe program. The meatballs use another recipe, previously developed, signified by the 7-digit code. Running the program produces the estimated nutrient content of the item. This is reviewed and compared to the nutrients whose values are known from the label. The entire nutrient profile of the food is reviewed by the food composition specialist for reasonableness. If necessary, ingredient amounts can be adjusted and the recipe program rerun to generate a revised nutrient profile for this mixed dish.

Because labeling regulations account for variance in the nutrient content of foods and allow for rounding of the percent of the U.S. Recommended Daily Allowance values, calculated values may sometimes differ from those on the label.

Also, the particular foods chosen for coding the formulation may not be identical to the ingredients selected by the manufacturer. The nutrient values generated for mixed dish items are intended to be representative of the type of product, rather than exact for any one particular brand item.

This entire procedure which I have described has also been used with other foods, including reduced fat puddings and lowfat/reduced fat frozen milk desserts. HNIS has subsequently had some of these items analyzed for their nutrient content. Results showed the calculated formula to yield nutrient values close to and/or the same as the analytical values.

Conclusion

In conclusion, determining the nutrient values of mixed dishes that survey respondents consumed is often necessary so that individual nutrient intakes may be calculated. One method has been described that derives the nutrient values of mixed dishes based from ingredient and nutrition label information even though complete analytical data are unavailable. This method is an efficient, low-cost way of providing nutrient profiles for the large and ever-expanding variety of foods available in the United States today.

Table 1
Ingredients in Rigatoni with Meat Sauce and Cheese

Tomatoes	Romano cheese
Cooked macaroni	Modified cornstarch
Beef	Corn oil
Tomatoes with puree	Parmesan cheese
Water	Sugar
Mushrooms	Salt
Tomato puree	Spices
Low water part skim mozzarella cheese	Enriched wheat flour
Onions	Dehydrated onions
Carrots	Xanthan gum
Green peppers	

Table 2
Selected Nutrient Values per 100 grams for Rigatoni Entree

	OPTIMIZATION TECHNIQUE	LABEL
Calories	94	94
Protein	6.5 g	6.5 g
Carbohydrate	9.1 g	9.1 g
Fat	3.7 g	3.6 g
Sodium	315 mg	315 mg

Table 3
Selected Percentage Ingredient Output for Rigatoni Entree

INGREDIENTS	%
Tomatoes, boiled	29.8
Macaroni, enriched, cooked	11.3
Beef, ground, lean, cooked	11.3
Tomatoes, puree	11.3
Water	11.3
Mushrooms, canned, drained	11.3
Tomato puree	3.7
Mozzarella cheese	3.7
Onion, cooked	0.5
Wheat flour	0.4
Onion, dehydrated flakes	0.4

Table 4
Food Formulation
RIGATONI W\MEAT SCE & CHEESE (DIET FROZ 100)

1	11530	Tomato, boiled	3754	29.8
2	82990	Macaroni, Enr., Ck, Firm	0385	11.3
3	13306	Hamburger, Ln, Well Dn	0770	11.3
4	11547	Tomatoes w\Puree	3754	11.3
5	14429	Water		11.3
6	11264	Mushrooms, Cnd, Draind	3788	11.3
7	11547	Tomato Puree, Cnd	3754	3.7
8	01029	Lo H20 Partskim Mozz	0007	3.7
9	11283	Onion, Ckd, Bld, No Slt	3468	0.5
10	11125	Carrots, boiled	3468	0.5
11	11334	Pepper, Swt, Grn, Boild	3788	0.5
12	01038	Romano Cheese	0007	0.5
13	78940	Modified Corn Starch		0.5
14	04518	Oil, Veg, Corn		0.5
15	01032	Parmesan Cheese	0007	0.5
16	92300	Sugars, Granulated		0.5
17	89630	Salt		0.5
18	16122	Hydro. Veg. Pro. (Soy iso)		0.5
19	94390	Wheat Flour, All-Purp	0302	0.4
20	11284	Onion, Dehydra Flakes		0.4

Table 5
Ingredients in Swedish Meatball Meal

Cooked meatballs	Onion powder
Cooked enriched egg noodles	Margarine
Beef stock	Sugar
Chicken stock	Parmesan cheese
Carrots	Vegetable oil
Water	Chicken fat
Sherry wine	Dehydrated chives
Nonfat dry milk	Dehydrated garlic
Modified food starch	Lemon juice concentrate
Wheat flour	Vinegar
Salt	

Table 6
Selected Nutrient Values per 100 grams for Meatball Meal

OPTIMIZATION TECHNIQUE		LABEL
Calories	114	112
Protein	7.9 g	7.9 g
Carbohydrate	12.9 g	12.9 g
Fat	3.3 g	3.3 g
Sodium	270. mg	270. mg

Table 7
Selected Percentage Ingredient Output for Meatball Meal

INGREDIENTS	%
Meatballs	12.1
Noodles	12.1
Beef broth	12.1
Chicken broth	12.1
Carrots	12.1
Water	12.1
Sherry wine	12.1
Nonfat dry milk	9.2
Modified food starch	3.2
Lemon juice concentrate	0.1
Vinegar	0.1

Table 8
Food Formulation
MTBALLS, SWED, SCE, W\NDLS & VEG MED (FRZN 100.0)

1		2154010	MEATBALLS (GRD BF W\TVP)	0070	12.1
2		83780	NOODLES(EGG)ENR., CKD	0385	12.1
3		06008	BEEF BROTH, RTS		12.1
4		06413	CHICKEN BROTH, W\WATR		12.1
5		11125	CARROTS, BOILED	3788	12.1
6		14429	WATER		12.1
7		43471	SHERRY WINE (TABLE, AFTER)		12.1
8		01092	INSTANT NONFATDRYMLK	2152	9.2
9	2	78940	MODIFIED FOOD STARCH		3.2
10		94390	WHEAT FLOUR, ALL-PURP	0301	0.3
11		89630	SALT		0.3
12		02026	ONION POWDER		0.3
13		04132	MARG,HRD,UNSP,W\SALT		0.3
14		92300	SUGARS, GRANULATED		0.3
15		01032	GRATED PARMESAN	0001	0.2
16		04518	OIL, VEG, CORN		0.2
17		04542	FAT, CHICKEN		0.2
18		11156	CHIVES, RAW	3771	0.2
19		02020	GARLIC POWDER		0.2
20	2	09153	LEMON JUICE CONCENTRATE		0.1
21		94060	VINEGAR, CIDER		0.1