Retention and Yield Factors

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Introduction

Many items in Human Nutrition Information Service (HNIS) nutrient data bases are cooked forms of the corresponding raw food. When analytical data for the cooked food are lacking, the nutrient content is calculated from the raw form using true retention values as factors. True retention values are also needed to expand and monitor published values and to validate the HNIS Nutrient Data Bank recipe program used in the U.S. Department of Agriculture's Nationwide Food Consumption Surveys and the U.S. Department of Health and Human Services' Health and Nutrition Examination Survey.

This paper reviews derived retention and yield factors for selected plant and animal products. Some queries that are often asked about retention and yield will also be addressed.

For the derivation of yield and retention factors, nutrient data on raw and cooked foods were compiled from published and unpublished sources. Published scientific and technical literature from the United States and other countries were searched for data. Trade associations and industry were generous in providing unpublished data on yield. Much of the new information on yield and retention factors, however, was provided by research resulting from HNIS contracts.

Calculating true retention requires data on the nutrient content of paired samples of raw and cooked foods and on yield (see Table 1). The first part of the calculation (Murphy et al., 1975) gives the nutrient content of the paired samples of raw and cooked food per gram of food. Nutrient content of the paired samples can, however, be expressed in another unit of weight. In the HNIS Nutrient Data Research Branch, we routinely express the nutrient content of the paired raw and cooked samples as amount per 100 gram of food. The second part of the calculation measures the yield expressed as a ratio of the weight of the cooked sample to the weight of the raw sample.

In addition to yield values for cooked foods, yield data of a food can be directly determined at several different preparation steps. As an example of this, yield data on raw shelled peas and boiled peas (U.S. Department of Agriculture, 1975) are reported in Table 2. The yield of boiled peas prepared from raw shelled peas (95 percent) is in close agreement with the yield of boiled peas prepared from frozen peas (93 percent).

Yield can also be determined indirectly from a published yield table. In Table 3, data on boiled green peas prepared from green peas in pod have been determined from yield values published by the U.S. Department of Agriculture (1975). This kind of information is especially useful to researchers who work on food plans and need yield data for food items from the as-purchased to the as-fed state.

Percentage yield is always reported as it is calculated. True retention values, however, are always reported to the nearest 5 percent. Calculated true retention values above 100 percent are also adjusted down to 100 percent.

Vegetables and Fruits

Table 4 shows retention values for ascorbic acid, vitamin A, folate, and potassium for three types of boiled vegetables (U.S. Department of Agriculture, 1984). Beet greens, chinese cabbage, collards, kale, mustard greens, spinach, swiss chard, and turnip greens are examples of dark-green leafy vegetables. Root/bulb/high-starch vegetables include carrots, beets, green peas, onions, parsnips, rutabaga, squash, sweet corn, turnips, and immature legume seeds (but not potatoes or sweet potatoes, which are listed separately). In the category of other vegetables are asparagus, bean sprouts, broccoli, brussels sprouts, cabbage, cauliflower, eggplant, okra, snap beans, and sweet peppers.

Boiled vegetables generally have the same retention values whether prepared from raw or from frozen. Only the folate retention of dark green leafy vegetables is somewhat higher when prepared from raw vegetables (65 percent) than when prepared from frozen vegetables (55 percent).

Vitamin A and potassium retentions are about 90 percent for all vegetables. Ascorbic acid retention values range from 60 percent for the dark green leafy vegetables to 80 percent in the other vegetables. Average folate retentions are lower for the dark green leafy vegetables (60 percent) than for the other two categories of vegetables (70 percent).

We are often asked to compare the retentions of microwave-cooked foods with foods cooked by another method. Since microwave-cooking is a form of steaming, vegetables as well as fruits lend themselves well to this cooking method.

Table 5, which is based on a limited amount of data from an HNIS contract (Dudek et al., 1982), contains yield and retention data on boiled and microwave-cooked peas. Although boiled green peas have only a slightly higher yield (95 percent) microwave-cooked green peas (91 percent), both of the cooked peas retain 100 percent of their ascorbic acid, vitamin A, folate, and potassium.

Yield and retention data of boiled apples and microwave-cooked apples from the same HNIS contract are given in Table 6. Both cooked apples have about the same yield (96 percent), but retentions vary. All of the vitamin A, folate, and zinc are retained by the boiled apples (100 percent). Microwave-cooked apples also retain 100 percent of their folate but less of vitamin A (85 percent) and zinc (75 percent). Average zinc retention for boiled and microwave-cooked apples is about 90 percent.

Table 7 gives another example of a yield calculation, data on potatoes from another HNIS contract (Hazleton Laboratories America, Inc., 1991). The yield of cooked flesh of potatoes must first be indirectly determined from the yield of peeled raw potatoes. Then the yield of raw peeled potatoes is applied to that paired sample of raw potato which will be boiled in the skin. Finally, the yield of the flesh of boiled potatoes is derived from the ratio of the weight of boiled peeled potatoes to the weight of raw peeled potatoes.

Although statistical data on yield and true retention are not reported in "Food Yields Summarized by Different Stages of Preparation" (U.S. Department of Agriculture, 1975) or in the "Provisional Table on Percent Retention of Nutrients in Food Preparation" (U.S. Department of Agriculture, 1984), statistical operations are taken into account when revisions are made. Estimates of variance and statistical tests are applied to compare differences in yield values and true retention values.

Uncorrected nutrient retention values for boiled and microwave-cooked potatoes are given in Table 8. Ascorbic acid, thiamin, vitamin B-6, and potassium retentions were selected, because retention values for these nutrients had large ranges. Despite these large ranges, the coefficients of variation are acceptable. In this study, boiled potatoes had higher nutrient retentions than microwave-cooked potatoes. The highest coefficient of variation is shown for ascorbic acid in boiled potatoes (16.89) and the smallest coefficient of variation is shown by vitamin B-6 in boiled potatoes (3.01).

Bread

What happens to the nutrients in bread when it is baked? To answer this question yeast bread was baked from raw dough and frozen dough. Yeast bread for this study was prepared from a recipe with enriched flour, yeast, salt, and water as ingredients. With the exception of thiamin, folate, and copper (see Table 9), retentions for minerals and vitamins were retained at the 100 percent level. For both kinds of bread, thiamin retention was 90 percent and copper retention was 95 percent. In this study, however, yeast bread baked from frozen dough retained 100 percent of its folate while less (80 percent) was retained by yeast bread baked from raw dough.

Meat and Poultry

True retentions for homogeneous mixtures of meat or poultry, such as chopped beef, are determined by the formula earlier given in Table 1. When the carcass of meat or poultry is used as the basis of paired samples, however, the formula for true retention must be modified.

Table 10 gives the formula for determining true retention of meat and poultry. A factor for anatomically paired cuts based on the ratio of raw weight of analyzed raw meat or poultry cut to raw weight of analyzed cooked meat or poultry cut has been derived. The raw weight of the meat includes refuse, while the raw weight of poultry includes bone.

The original true retention formula is now multiplied by the correction factor derived for the anatomically paired cuts. This correction factor is needed in order to account for any weight differences in the raw cuts before analysis. Again, as in the original formula, the Nutrient Data Research Branch routinely expresses the nutrient content of the paired raw and cooked samples as per 100 gram of food. As an example of retentions in meat and poultry, data on roasted beef, veal, lamb, pork, and poultry are given in Table 11 (U.S. Department of Agriculture 1979, 1983, 1989, 1990). These values are for the lean-only portion of meat or the flesh-only portion of poultry.

Retentions for thiamin, riboflavin, niacin, and vitamin B-6 do not follow a pattern. Thiamin, niacin, and vitamin B-6 retentions for poultry range from 70 percent to 85 percent, while the average thiamin, niacin, and vitamin B-6 retentions for meat range from 60 percent to 80 percent. The average riboflavin retention for meat, however, is 95 percent compared with 85 percent riboflavin retention for poultry.

Summary

Retention and yield factors used in HNIS nutrient data bases have been reviewed. When analytical data for a cooked food are lacking in the HNIS nutrient data bases, the nutrient value of the cooked food is calculated from the raw food using true retention factors. The basic formula for true retention derived from data on the nutrient content of paired samples of raw and cooked food and data on yield expressed as a ratio of the weight of the cooked sample to the weight of the raw sample was given. When the carcass of meat or poultry is used as the basis of paired samples, the formula for true retention is modified to include a correction factor which accounts for any weight differences in the raw cuts before analysis.

Retention values for boiled vegetables are generally the same when prepared from raw or frozen vegetables. Dark green leafy vegetables, however, had a slightly higher folate retention when prepared from raw vegetables. Both boiled and microwave-cooked immature green peas retained all of their ascorbic acid, vitamin A,

folate, and potassium. Boiled apples retained 100 percent of their vitamin A, folate and zinc, while microwave-cooked apples also retained 100 percent folate but less vitamin A (85 percent) and zinc (75 percent). Coefficients of variation of uncorrected ascorbic acid, thiamin, vitamin B-6, and potassium retention values for boiled and microwave-cooked potatoes are in an acceptable range.

Yeast bread baked from raw dough and frozen dough retained 90 percent thiamin and 95 percent copper. Although yeast bread baked from frozen dough retained 100 percent folate, less folate (80 percent) was retained by yeast bread baked from raw dough.

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Table 1
CALCULATION OF TRUE RETENTION[1]

% TRUE RETENTION (TR) =

$$\frac{\text{(Nutrient content per g cooked food) X (g cooked food)}}{\text{(Nutrient content per g raw food) X (g raw food)}} \text{ X } 100$$

1
Murphy et al. (1975).

Table 2
YIELD OF GREEN PEAS[1,2]

Description		Average Yield
Before Preparation	After Preparation	%
In Pods	Shelled	38
Shelled	Boiled	95
Frozen	Boiled	93

[1] Immature.
[2] U.S. Department of Agriculture (1975).

Table 3
YIELD OF BOILED GREEN PEAS FROM GREEN PEAS, IN PODS[1,2]

Description of Peas	Yield at Specified Step in Preparation		
Before Preparation	In Pods %	Shelled %	Boiled %
In pods	100	38	36 (38 x 95)
Shelled	--	100	95

[1] Immature green peas.
[2] U.S. Department of Agriculture (1975). Underlined values given in table 1.

Table 4
ASCORBIC ACID, VITAMIN A, FOLATE, AND POTASSIUM RETENTION OF BOILED VEGETABLES[1]

Vegetables, Boiled, Drained	Retention			
	Ascorbic Acid %	Vitamin A %	Folate %	Potassium %
Dark green, leafy, vegetables:[1]				
Prepared from raw	60	95	65	90
Prepared from frozen	60	95	55	90
Root/bulb/high-starch vegetables:[2]				
Prepared from raw	70	90	70	90
Prepared from frozen	70	90	70	90
Other vegetables:				
Prepared from raw	80	90	70	90
Prepared from frozen	80	90	70	90

[1] U.S. Department of Agriculture (1984).
[2] Potatoes and Sweet Potatoes not included.

Table 5
YIELD AND RETENTION OF COOKED GREEN PEAS[1,2]

	Yield	Retention			
		Ascorbic Acid	Vitamin A	Folate	Potassium
	%	%	%	%	%
Boiled	95	100	100	100	100
Microwave-cooked	91	100	100	100	100

[1] Immature.
[2] Dudek et al. (1982).

Table 6
YIELD AND RETENTION OF COOKED APPLES[1,2]

	Yield	Retention			
		Folate	Vitamin A	Potassium	Zinc
	%	%	%	%	%
Boiled	95	100	100	85	100
Microwave-cooked	96	100	85	90	75

[1] Prepared from raw apples.
[2] Dudek et al. (1982).

TABLE 7

AVERAGE YIELD FOR POTATOES[1,2]

Potatoes raw, peeled:

$$\text{Yield (\%)} = \frac{\text{Raw Peeled Potatoes (g)}}{\text{Raw Unpeeled Potatoes (g)}} \times 100$$

$$= \frac{780.2\ \text{g}}{890.0\ \text{g}} \times 100$$

$$= 88\ \%$$

Potatoes boiled in skin = boiled, flesh only:

Raw potatoes unpeeled = 1,525.5 g

Raw potatoes peeled = 1,525.5 g X 0.88

= 1,342.4 g

Cooked potatoes peeled = 1,503.9 g

$$\text{Yield (\%)} = \frac{\text{Boiled Peeled Potatoes}}{\text{Raw Peeled Potatoes}} \times 100$$

$$= \frac{1{,}503.9\ \text{g}}{1{,}342.4\ \text{g}} \times 100$$

$$= 112\ \%$$

[1] Hazleton Laboratories America, Inc. (1991).
[2] Lot 1.

TABLE 8

RETENTION OF BOILED AND MICROWAVE-COOKED POTATOES[1]

Nutrients	Number of Values	Mean	Standard Error	Coefficient of Variation
		%	%	%
Ascorbic acid, total:				
Boiled	3	96.33	16.27	16.89
Microwave-cooked	3	86.67	6.33	7.31
Thiamin:				
Boiled	3	89.00	3.61	4.05
Microwave-cooked	3	88.00	3.22	3.65
Vitamin B_6:				
Boiled	3	96.67	2.91	3.01
Microwave-cooked	3	79.67	6.12	7.68
Potassium:				
Boiled	3	100.33	4.67	4.65
Microwave-cooked	3	93.33	4.33	4.64

[1]Based on data from HNIS contract with Hazleton Laboratories America, Inc. (1991).

TABLE 9
YIELD AND RETENTION OF YEAST BREAD[1]

	Yield	Retention		
		Thiamin	Folate	Copper
	%	%	%	%
Baked from raw dough	90	90	80	95
Baked from frozen dough	90	90	100	95

[1] Hazleton Laboratories America, Inc. (1991).

TABLE 10
TRUE RETENTION OF MEAT AND POULTRY[1,2]

$$\%TR = \frac{F \times Nc \times Wc \times 100}{Nr \times Wr}$$

Where:

$$F\ (meat) = \frac{\text{Raw weight (with refuse) of analyzed raw meat cut}}{\text{Raw weight (with refuse) of analyzed cooked meat cut}}$$

$$F\ (poultry) = \frac{\text{Raw weight (with bone) of analyzed raw poultry cut}}{\text{Raw weight (with bone) of analyzed cooked poultry cut}}$$

Nc = Nutrient content per g cooked food

Wc = g cooked food

Nr = Nutrient content per g raw food

Wr = g raw food

[1] Anatomically paired cuts.
[2] U.S. Department of Agriculture (1979, 1990).

TABLE 11
VITAMIN RETENTION OF ROASTED MEAT AND POULTRY[1]

	Retention			
	Thiamin %	Riboflavin %	Niacin %	Vitamin B_6 %
Meat, lean:				
Beef	60	100	75	65
Veal	60	90	80	50
Lamb	60	90	80	75
Pork	60	95	85	65
Poultry[2]	70	85	85	75

[1] U.S. Department of Agriculture (1979, 1983, 1989, 1990).
[2] Poultry cooked without removal of skin. Retention values of chicken and turkey for meat only.