Nutrient content and nutrient retention of selected mushrooms

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Abstract

In 2004 Americans consumed 2.6 pounds per capita of fresh mushrooms. While the white button mushroom remains a frequent component of many recipes, other varieties such as shiitake, enoki, maitake, oyster, portabella, and shiitake are also growing in popularity. To improve and expand the data in the USDA National Nutrient Database for Standard Reference, the Mushroom Council and USDA undertook the sampling and analyses of these mushrooms.

Mushroom samples were collected from retail outlets in 12 cities in the US. These were then combined into 4 random composites by type and analyzed under existing contracts and cooperative agreements managed by USDA's Nutrient Data Lab (NDL). All mushrooms were analyzed raw. White mushrooms were also analyzed stir-fried and microwaved, so that retention factors could be developed and used to calculate cooked values for other mushroom varieties.

Results of this study show that mushrooms are a good source of several nutrients. These include total dietary fiber, which ranges from 1.4 g/100g in the white variety to 2.8 g/100g in enoki. Potassium ranged from 204 mg/100g in maiitake to 359 mg/100g in both enoki and white. Niacin ranged from 2.8 mg/100g in white to 7.0 mg/100g in enoki. Enoki contained 52 µg/100g of folate, while other mushrooms contained lower amounts. All minerals and vitamins were well retained (most at 100%) during cooking. Some losses of sodium (due to leaching) and folate and vitamin B6, which are more heat labile, were observed.

These new values for mushrooms enabled USDA to update and expand the data on mushrooms in its databases, which are available on its web site: www.ars.usda.gov/nutrientdata. The Mushroom Council was also able to use the data to promote mushrooms to the public and to provide information on the nutrient content of mushrooms to its members.

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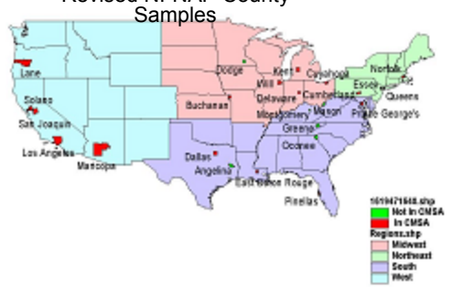
Introduction

In 2003 Americans consumed 2.6 pounds per capita of mushrooms. While the white button mushroom remains a frequent component of many recipes, other varieties such as enoki, oyster, and maitake are also growing in popularity. To improve and expand the data in the USDA National Nutrient Database for Standard Reference, the Mushroom Council and USDA undertook the sampling and analyses of these mushrooms.

Revised NFNAP County Samples



Methods

This study used the infrastructure established by USDA's Nutrient Data Laboratory (NDL) for the National Food and Nutrient Analysis Program (NFNAP). NFNAP incorporates prioritizing foods and nutrients for analysis, statistically valid sampling plans, qualified analytical laboratories, and a rigorous quality control program. Samples of white, maitake, oyster, and enoki mushrooms were collected from 12 retail outlets around the country.

Sampling:

- States where samples were procured were selected proportional to the state population (US Census, 2000)
- Sample counties within states dispersed over the 48 conterminous states, were selected proportional to the county population
- Sample Consolidated Metropolitan Statistical Areas (CMSAs) selected proportional to CMSA population
- Retail outlets with over $2M sales were selected in 12 primary locations (Figure 1)
- Maitake mushrooms were not available in retail outlets identified in the sampling plan, so samples were obtained from two growers; enoki mushrooms were not found in all of the retail outlets, so additional samples were obtained from two growers.

Reference: (Perry *et al*, 2002).

Sample preparation:

- Shipped overnight to the Food Analysis Laboratory Control Center (FALCC) at Virginia Polytechnic Institute and State University in Blacksburg, Virginia where composites were prepared. Composites were analyzed for nutrients based on expected content and priority. Therefore not all composites were analyzed for all nutrients.
- White mushrooms were stir-fried for six minutes over medium heat in a non-stick skillet. No oil was added. White mushrooms were covered loosely with plastic wrap and cooked in a microwave oven on high (100% power) for three minutes.
- Samples were packed under nitrogen and shipped frozen to qualified commercial analytical labs under USDA contracts, for analysis.

Analysis Methods:

The methods used were those of AOAC international as follows:

- Protein was analyzed by Kjeldahl (990.03); fat by acid hydrolysis (954.02), moisture by vacuum oven (934.01) and ash by gravimetric measurement (923.03).
- Dietary fiber was analyzed by the enzymatic-gravimetric method (991.43)
- Minerals were analyzed by ICP (984.27).
- Thiamin and riboflavin were analyzed by the fluorometric method (942.23 and 9700.65, while niacin, pantothenic acid, and vitamin B6 were analyzed by microbiological methods (944.13, 945.74 and 961.15); Folic acid was done by the enzymatic method (992.15).
- Ergosterol was determined by gas chromatography (Phillips *et al*, J Food Lipids 12 (2005) p. 124-140)
- β-glucan was determined by enzymatic spectrophotometric analysis (Megazyme "Mushroom and Yeast Beta Glucan Assay Procedure", 2005)

NDL's quality control panel reviewed results from the labs for both the analytical samples and the quality control materials included in the sample stream. Once approved, the data were migrated into NDL's Nutrient Databank System for processing.

True retention (TR) factors for the various nutrients were calculated by the method of Murphy et al (1975).

$$\% TR = \frac{\text{(nutrient content per g of cooked food X g of food after cooking)}}{\text{(nutrient content per g of raw food X g of food before cooking) X 100}}$$

This formula accounts for changes in weight, due to loss or gain of moisture or fat, as well as nutrient losses during preparation.

Table 1. Proximate content of raw mushrooms (g/100 g, edible portion)

	Enoki (n=3)	Maitake (n=2)	Oyster (n=3)	White (n=3)
Moisture	87.73±0.51[a]	90.53[b]	90.20±0.52[b]	92.18±0.48[b]
Protein	2.66±0.25	1.94	2.75±0.24	3.00±0.22
Fat	0.28±0.08	0.20	0.33±0.04	0.34±0.06
Ash	0.91±0.08[a]	0.52[b]	0.77±0.02[b]	0.79[b]
Carbohydrate (by difference)	8.42	6.81	5.95	3.69
Dietary fiber	2.8±0.21	2.70	2.10	1.45
Ergostrerol (mg/100 g)	37±9.27	59	69	59±4.22
β-glucan	0.62[a]	0.29[b]	0.79±0.06[a]	0.21±0.04[b]

[a,b] means with the same letter are not significantly different (p≤0.05) between types of mushrooms; Mean ± Standard error

Table 2. Mineral content of raw mushrooms (mg/100 g, edible portion)

	Enoki	Maitake (n=2)	Oyster (n=2)	White (n=3)
Calcium	0.4±0.13 (3)[a]	1[b]	1[b]	4±0.89[a]
Copper	0.11±0.02 (3)[a]	0.25[b]	0.12[a]	0.30±0.01[a]
Iron	1.15±0.09 (3)[a]	0.30[b]	0.91[a]	0.22±0.05[b]
Magnesium	16 (2)[a]	10[b]	15 [a]	10±0.42[b]
Manganese	0.08 (3)[a]	0.06[a]	0.10[b]	0.05±0.01[c]
Phosphorus	105 (2)	74	98 [b]	94±8
Potassium	359±19.8 (3)[a]	204[b]	324 [a]	358±15.7[a]
Sodium	3±0.35 (3)	1	6	15±3.51
Zinc	0.65 (2)	0.75	0.77	0.60 ±0.05

[a,b,c] means with the same letter are not significantly different (p≤0.05) between types of mushrooms; Mean ± Standard error (number of samples)

Table 3. Vitamin content of raw mushrooms (mg/100 g, edible portion)

	Enoki	Maitake	Oyster	White
Thiamin	0.22±0.07 (4)	0.15 (2)	0.17±0.04 (3)	0.05±0.02 (4)
Riboflavin	0.20±0.02 (3)	0.24 (2)	0.33 (1)	0.22 (1)
Niacin	7.03±0.86 (4)[a]	6.58 (2)[a]	5.87±0.97 (3)[a]	2.80±0.94 (4)[b]
Pantothenic acid	1.35 (1)	0.27 (1)	1.30 (1)	1.36 (1)
Vitamin B6	0.10±0.02 (4)	0.05 (2)	0.10 (2)	0.05±0.005 (3)
Folic acid (µg/100 g)	52±2 (3)[a]	29 (2) [b]	6 (2)[c]	19 (2)[b]

[a,b,c] means with the same letter are not significantly different (p≤0.05) between types of mushrooms; Mean ± Standard error (number of samples)

White

Oyster

Enoki

Table 4. Nutrient retention for cooked white mushrooms[1]

	Raw	Stir-fried	% Retention	Microwaved	% Retention
Calcium	4	4	90	6	100
Copper	0.3	0.29	80	0.4	100
Iron	0.22	0.25	100	0.33	100
Magnesium	10	11	100	14	100
Manganese	0.05	0.05	80	0.06	100
Phosphorus	94	105	100	126	100
Potassium	358	395	100	488	100
Sodium	15	12	80	17	85
Zinc	0.6	0.57	85	0.7	100
Thiamin	0.05	0.10	100	0.06	100
Riboflavin	0.22	-[2]	-	0.43	100
Niacin	2.80	3.99	100	5.35	100
Pantothenic acid	1.36	1.45	100	1.96	100
Vitamin B6	0.05	0.04	65	0.05	80
Folic acid	19	20	95	16	65

[1] Stir-fried yield 90.69%, Moisture loss –9.58%, fat loss -0.09%
Microwave yield 81.98%, Moisture loss –16.64%, fat loss -0.03%

[2] dashes denote nutrient not analyzed.

Discussion

Proximate and other components: The proximate composition of the raw mushrooms was quite similar for all types (Table 1). Moisture ranged from 87.7 g/100 g in enoki to 92.18 g/100 g in white mushrooms. Protein ranged from 1.94 g/100 g in maitake to 3.00g/100 g in white. The average fat content for all mushrooms was approximately 0.3g/100 g. There is a significant difference (P ≥0.05) between mushrooms for moisture and ash, but no significant difference was observed for protein, fat, and carbohydrates

The β-glucan content of mushrooms varied from 0.02 g/100 g in enoki to 0.79 g/100 g in oyster types. The ergosterol content varied from 37 mg/100 g in enoki to 59 mg/100 in maitake and white types. The ergosterol content is of particular interest as it is precursor to vitamin D and recent research sponsored by the Mushroom Council has shown significant amounts of vitamin D can be produced in mushrooms by exposure to UVB light.

Minerals: More variability was observed in the mineral content of mushrooms (Table 2), with significant differences (p≤0.05) between mushrooms for calcium, copper, iron, magnesium, manganese and potassium. No observable differences were noted for phosphorus, sodium, and zinc. All mushrooms provided a significant amount of copper ranging from 0.1 mg/100 g for enoki to 0.3 mg/100g for white, compared to a RDA of 0.9 mg/day. Sodium values were low, but variable, ranging from 1 mg/100 g in maitake to15 mg/100 g in white.

Vitamins: There is a significant difference (p≤0.05) between mushrooms for niacin and folic acid, but no significant difference were observed for thiamin, riboflavin, pantothenic acid, and vitamin B6 (Table 3). Mushrooms contain significant amounts of niacin, ranging from 2.80 mg/100 g in white mushrooms to 7.0 mg/100 g in enoki, compared to a RDA of 16 mg/day (men and women, 19+). Folate is quite variable ranging from 19 µg/100 g in white mushrooms to 52 µg/100 g in enoki, compared to a RDA of 400 µg/day (men and women, 19+).

Nutrient Retention: Most nutrients were retained at the 100% level in both stir-frying and cooking in a microwave oven (Table 4). Of the minerals, sodium showed the lowest retention, 80% and 85% for stir-frying and microwaving respectively. Sodium losses are typically due to leaching, though neither cooking method is known to have high amounts of nutrient losses due to leaching.

Folic acid retention during stir-frying (95%) was higher than that during microwaving (65%). Conversely, vitamin B_6 was better retained during microwaving (80%) than stir-frying (65%). Other B-vitamins exhibited 100% retention under the cooking conditions used in this study.

These data have been aggregated with other acceptable data on mushrooms obtained by NDL and released in the USDA National Nutrient Database for Standard Reference, which is available on NDL's web site: http://www.ars.usda.gov/nutrientdata. For this reason, the values reported in SR may be slightly different from those reported here.

References

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