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Comparison of Enzyme Activity and Micronutrient Content in Powdered Raw Meal and Powdered Processed Meal

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Abstract

The enzyme activity and the micronutrient content of powdered raw meal (PRM) and powdered processed meal (PPM) were compared. PRM was made of freeze-dried cereals, fruits, and vegetables. PPM was made of the same materials as PRM, but with heat processing such as steaming, roasting and hot air drying. The activity of α-amylase of PRM was higher than that of PPM. However there were no differences of the concentration of proximate components between PRM and PPM. The concentrations of vitamin A, C, folic acid, biotin, calcium, potassium, sodium and iron in PRM were higher than in PPM, but there were no differences in vitamins E, B_1, B_2, phosphorus and zinc. This research demonstrated that PRM retains greater nutritional value because there is higher enzyme activity and less loss of micronutrients during processing in PRM than in PPM.

Key words: powdered raw meal, powdered processed meal, α-amylase activity

INTRODUCTION

Saengsik (dried and powdered raw meal, PRM) is a non-heated, freeze-dried and powdered meal made from raw cereals, vegetables and seaweeds. PRM is a highly nutritious concentrated food that is rich vitamins, minerals, energy nutrients and enzymes. Powdered processed meal (PPM) is a similar powdered meal which has been processed with heat-drying after some type of pre-cooking such as steaming and roasting. Because PRM is a raw powdered meal which has not been heated, many enzymes and nutrients may be retained making PRM useful as a functional food with unique properties not present in its cooked counterpart (1). When food is heated, many nutrients such as vitamins are destroyed, minerals may be leached from the food, and enzymes are often deactivated (2). Recently, there has been increased recognition of the health benefits of raw meal, but only a few studies (3,4) have investigated the benefits or properties of dried and powdered raw meal (mostly for the effects of PRM on obesity and sanitation of powdered raw meals). There is little information on the effect of cooking on the nutritional quality of raw meal. Therefore, we compared the enzyme activity and contents of vitamins and minerals in PRM and PPM to evaluate the health benefits of PRM and facilitate the development of new products using PRM.

MATERIALS AND METHODS

Materials

Commercial saengsik is prepared from 30~40% of PRM and 60~70% of PPM because of the low digestibility, flavors, and smells of PRM. PRM in this study was mixed with 60% PPM. The processing of PRM is illustrated in Fig. 1. PRM was made with brown rice, degermed brown rice, barley, kale, carrot, cabbage, glutinous millet, Indian millet, job's tears, white bean, black bean and strawberry; all of which were freeze-dried and powdered. In order to improve flavor, taste and digestibility, PRM was mixed with roasted black sesame, burdock,

Raw material
↓ Removal of foreign material
Careful selection
↓ Quick freezing at -40°C for 20~24 hours
Freezing
↓ Drying 18~40 hours at 53~58°C in 0.2 torr vacuum
Drying
↓
Crude milling
↓
Main milling
↓
Screening
↓
Powdered raw meal

Fig. 1. Flow diagram illustrating the preparation of powdered raw meal.

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pumpkin, pine needle, duduck (*Condonopsis lanceolata*, a wild plant), shiitake (*Cortimellus shiitake*), laver, kelp, brewer's yeast, yogurt, chlorella, corn, fructo-oligosaccharide, shell calcium, aloe, chitosan, green vegetable extract and green tea extract which were powdered. By comparison, PPM was made with powdered heat-dried foods after being steamed or roasted. The composition of PPM and PRM were 69% cereal and other seeds like soybean and sesame, 8% fruits and vegetables, 1% seaweed, and 22% sweetener and functional ingredients like shell calcium, chitosan, fructo-oligosaccharide, etc. The cereals and vegetables were purchased from domestic products in Korea.

Preparation of PRM and PPM

The 12 raw foods, including brown rice, were freeze-dried (Clean vac 8B, Hanil R & D, Korea) as shown in Fig. 1. Freezing time at -40°C for fruits and vegetables was 30~40 hrs, and 18~20 hr for cereals. All samples were vacuum dried for 30 hr at 0.2 torr and 53~58°C.

PPM was made from dried and powdered cereals after steaming. Fruits, vegetables and seaweeds were powdered after hot-air drying at 80~90°C.

Determination of enzyme activity

The amylase activity was measured using commercial α-amylase from *Rizopus* spp. purchased from Korean Federation of Culture Collections (KFCC) for comparing its activity with those in PRM and PPM. The enzyme activity was measured by the Official Analytic Method of Japanese Tax Office (5). 0.5 mL of enzyme solution was added to 10 mL of 1% soluble starch dissolved in 0.04 M-acetic acid-sodium acetate buffer solution (pH 5.0) at 40°C. During the incubation, iodine was added to the enzyme-starch solution and optical density was measured at 670 nm.

Analysis of proximate component

The proximate analysis was performed by Shin's method (6). The moisture content was measured by the direct air-oven drying method, the ash content by dried ashing, crude protein content by the micro-Kjedahl method, and the crude lipid content by Soxhlet extraction. Crude fiber was analyzed by the AOAC method (7).

Analysis of vitamins and minerals

Vitamin content was analyzed by HPLC (Shisceido Co., nanosace SI-2, Japan) using a UV-detector according to the Korean Food Code (8). The HPLC parameters for each of the vitamins are shown in Table 1.

Mineral content was analyzed by Ion Coupled Plasma (Spectro Co., Deutsch) at each wave length according to Korean Food Code (8).

Table 1. HPLC conditions for measuring the various vitamins

Vitamin	Solution	UV (nm)
A	100% MeOH	325
E	100% MeOH	295
C, B_1, B_2	A : 100% H_2O B : 100% MeOH	270
Pantothenic acid	Triethylamine 0.5% (v/v) Phosphoric acid 0.3% (v/v)	198

The operating conditions of HPLC for column, flow rate and injection volumn were C-18, 1.0 mL/min and 20 μL, respectively.

RESULTS AND DISCUSSION

Enzyme activity

The enormous variety of biochemical reactions that comprise life are nearly all mediated by a series of remarkable biological catalysts known as enzymes (9). The metabolic reaction for maintaining the life of an organism is served by the enzyme whose sole biological purpose is to catalyze its specific reaction like the production of energy, the synthesis of the body composition, and the degradation, digestion and excretion of nutrients. An enzyme is a protein that is synthesized in a living cell and catalyzes or speeds up a thermodynamically possible reaction so that the rate of the reaction is compatible with the biochemical process essential for the maintenance of a cell (10).

Enzyme-catalyzed reactions, like all chemical reactions, have rates that increase with temperature. Because enzymes are proteins, there is a temperature limit beyond which the enzyme becomes vulnerable to denaturation. Thus, every enzyme-catalyzed reaction has an optimum temperature, usually in the range 25°C~40°C. Above or below that temperature, the reaction rate of the enzyme will be lower (11).

The heat processed cereal (HPC) underwent processes like roasting, steaming and hot-air drying; but the freeze-dried cereal (FDC) was prepared by the freeze-drying process only.

The α-amylase activities of each of the cereals are shown in Fig. 2. The enzyme activity of HPC was lower than that of FDC. In the case of brown rice, the α-amylase activity of FDC was 63.5 μ/mL while that of HPC was 13.4 μ/mL. Fig. 2 shows that the enzyme activities of FDC were 3~4 times as high as that of HPC. Therefore, the freeze-drying method was more effective at preserving enzyme activity than the normal heat processing.

Each α-amylase activity of the heat processed vegetables (HPV) and that of freeze-dried vegetables (FDV) is shown in Fig. 3. As with the cereals in Fig. 2, enzyme activity of HPV was lower value than that of FDV. In

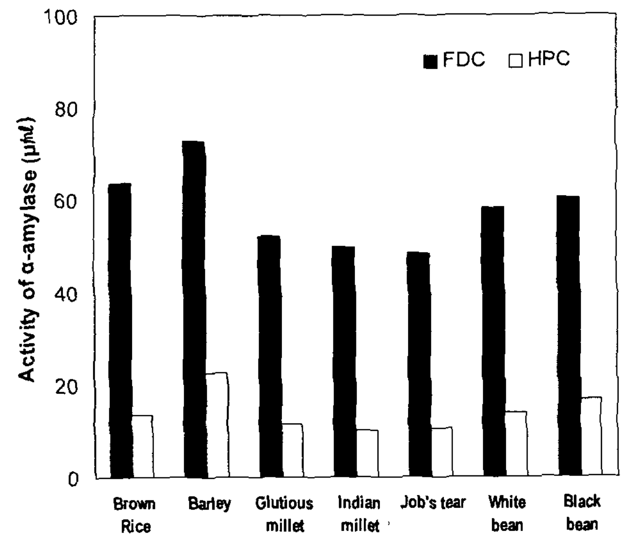

Fig. 2. α-Amylase activity of cereals made from FDC and HPC.
FDC: freeze-dried cereal, HPC: heat processed cereal.

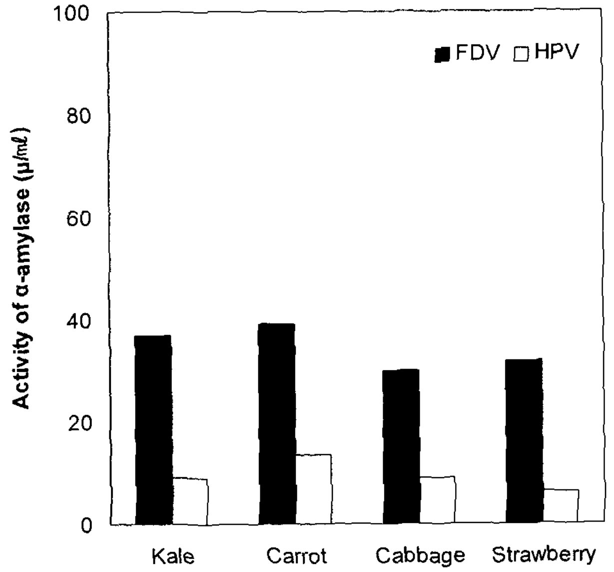

Fig. 3. α-Amylase activity of fruit and vegetables made from FDV and HPV.
FDC: freeze-dried vegetables, HPC: heat processed vegetables.

the case of strawberries, the enzyme activity of FDV was 31.6 μ/mL but that of HPV was 6.4 μ/mL.

The enzyme activity of PRM was measured as 28.6 (μ/mL) and that of PPM was 8.9 (μ/mL) after the each ingredients were mixed to make PRM or PPM. The heat treatment was responsible for the loss of enzyme activity because the enzyme are proteins which can be denatured with heating (11). The enzyme activity of PPM which contained heat-treated cereal, fruits and vegetables was remarkably lower value than that of PRM because the enzymes in PPM were denatured by heating.

Composition of proximate component

The results of the proximate analysis of PPM and PRM are shown in Table 2. There were no differences between the content of crude protein, crude lipid and crude ash of PPM and PRM. So, we recognized that the heating method could not affect the content of these components.

Micronutrient content

Humans require many different micronutrients for optimum health. Among these, vitamins and minerals are essential for maintaining human life, but are required at very low levels.

Plants serve as primary sources of several important vitamins in human diets. Some of the food plants are important dietary sources of one or more vitamins, and of minor importance as sources of other vitamins. Citrus fruits and tomatoes are very important sources of vitamin C, and whole wheat products may make appreciable contributions of iron, niacin, and thiamine to humans (12).

All foods that undergo processing are subject to some degree of loss in vitamin and mineral content, even though the biobenefit of a nutrient is occasionally increased or some anti-nutritional factor is inactivated (13). The greatest loss of nutrients, which is discussed under several headings, was the result extraction into water and by heat damage. Thermal degradation of nutrients has been extensively studied (14). The vitamin content of PRM and PPM is shown in Table 3.

The contents of folic acid, biotin, vitamin C and A of PPM were lower than those of PRM. For example, the content of vitamin C was decreased from 46.1 mg in PRM to 17.8 mg in PPM. The content of vitamins was decreased because they were destroyed during the heat-drying proc-

Table 2. Composition of proximate components in the powdered raw meal (PRM) and powdered processed meal (PPM)

Composition (%)	PRM	PPM
Moisture	6.33±0.31[1)]	5.47±0.27
Crude lipid	2.90±0.12	3.11±0.14
Crude protein	10.15±0.43	10.25±0.56
Crude fiber	3.01±0.08	2.91±0.06
Crude ash	2.27±0.11	2.10±0.09

[1)]Mean value±SD (n = 3).

Table 3. Content of vitamins in the powdered raw meal (PRM) and powdered processed meal (PPM) per 100 g

Content	PRM	PPM
Vitamin C (mg)	46.10±0.26[1)]	17.81±0.22
Pantothenic acid (mg)	17.89±0.15	18.11±0.18
Vitamin E (mg)	1.16±0.09	1.01±0.07
Vitamin B_1 (mg)	0.25±0.04	0.26±0.03
Vitamin B_2 (mg)	0.05±0.002	0.03±0.001
Vitamin A (μg)	270.55±2.36	225.71±2.14
Folic acid (μg)	270.67±1.96	243.32±2.06
Biotin (μg)	74.89±0.86	51.27±0.74

[1)]Mean value±SD (n = 3).

Table 4. Content of minerals in the powdered raw meal (PRM) and powdered processed meal (PPM) per 100 g

Content (mg)	PRM	PPM
Calcium	714.24±2.12[1)]	295.34±0.98
Potassium	459.35±1.18	368.42±1.04
Phosphorus	192.28±0.86	193.61±0.78
Sodium	114.29±0.64	47.38±0.72
Magnesium	99.49±0.38	101.71±0.26
Iron	6.33±0.08	4.48±0.05
Zinc	1.99±0.03	2.13±0.02

[1)]Mean value±SD (n = 3).

ess. Vitamins such as vitamin C, folic acid and biotin are unstable, so these were destroyed by the reaction with oxygen during the heat-drying process, but the content of other vitamins in PPM and PRM was unaffected by the heat-drying process.

Vitamin C (ascorbic acid) is highly sensitive to various modes of degradation. Factors that can influence the nature of the degradative mechanism include temperature, salt and, sugar concentration, pH, oxygens, metal catalysts, initial concentration of ascorbic acid, and the ratio of ascorbic acid to dehydroascorbic acid (15-17). There was substantial loss of vitamin C because it is easily oxidized and is unstable in wet conditions.

The freezing process itself does not affect the vitamin content of the products (12). Therefore, PRM made from fruits and vegetables by the freeze-drying method demonstrated that vitamin loss can be prevented with proper food processing. The losses of mineral salts in processing are solely due to leaching during heat processing (12).

The mineral content of PRM and PPM is shown in Table 4. The content of calcium, potassium, sodium and iron of PPM was lower than that of PRM because the contents of minerals in PPM were reduced during the heating drying process. A similar result was reported by Krehl and Winters (18). They showed losses of 12~40% of the calcium of carrot, beans, cabbage and other vegetables, together with 60% of the potassium. There were hardly any changes in concentrations of phosphorus and zinc during the heating process, because they were not affected by those processes. These results demonstrate that PRM retains greater nutritional value because there were higher enzyme activity and less loss of the micronutrients in PRM than in PPM.

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