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Quality Characteristics of Processed Mushroom Products Using *Pleurotus ostreatus, Agaricus bisporus* and *Flammulina velutipes*

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ABSTRACT This study examined the effects of adding *Pleurotus ostreatus, Agaricus bisporus and Flammulina velutipes* on the quality characteristics of cookies and multiple purposes of wheat powders. The water content, crude protein content, mineral content, color value and sensory evaluation of mushroom cookies and multiple purposes of wheat powders were measured. In the case of cookies, the water content was 1.10-1.24% and crude protein content was 8.20-9.80%. General preferences, such as appearance, color, taste and texture, increased when mushroom was added to the cookies, especially flavor, which showed a much higher preference. In the studies where mushroom was added to wheat powders, the water content was 0.57-0.92% and crude protein content was 11.90-12.80%. The addition of mushroom to both of the cookies and multiple purposes of wheat powders resulted in a remarkable increase in the mineral content, especially Fe, K. In addition, an increase in the amount of added mushrooms resulted in an increase in the hunter L and a values; however, this also resulted in a decrease in the b value.

KEYWORDS: mushroom, processing, quality, cookies, powder

INTRODUCTION

In recent years, the demand by consumers for functional food products to promote good health has been increasing. Therefore, many current research projects have focused on finding natural bioactive compounds from natural plants. As a results of this effort, many functional foods have been developed by several industries that meet the consumers' needs (Hong et al 2003).

Pleurotus ostreatus, Agaricus bisporus and *Flammulina velutipes* have been used as a healthy food source because it contains high quantities of protein, vitamins and minerals (Manzi et al 1999; Manzi et al 2000; Yang et al 2001). Large quantities of mushrooms are produced in Korea all year round. The consumption of mushrooms, however, is limited because fresh mushroom contain several different enzymes. Therefore, the development of processed foods with mushrooms containing physiologically active compounds may be the best way to increase the consumption of mushrooms (Hong et al 2003).

Cookies are widely consumed baked products that can be served from breakfast to bedtime. Cookies are appreciated for their taste, aroma, convenience and long shelf stability due to their low moisture content (Chung 2007). Different types of cookies containig diverse functional ingredients have been developed. For example, bamboo leaf powder (Lee et al 2006), dried red ginseng powder (Lee et al 2006), *Angelica* plant powder (Jeon et al 2006), soybean pasts powder (Yoon et al 2005), *Lycii* fructus powder (Park et al 2005), barely bran (Kim et al 2004), potato peel (Han 2004), hot water extract of roasted safflower (Kwak et al 2002), garlics (Kim et al 2002), and barley germ (Kim et al 2002) were used as cookie ingredients and the quality characteristics of cookies made with these ingredients have been investigated.

The addition of mushroom powders to various types of food products will contribute to the development of value added foods with high consumer acceptance. The objective of this study was to evaluate the effects of mushroom powders on the quality characteristics of cookies. The physicochemical and sensory properties of cookies and wheat powders containing 20% mushroom powder were investigated.

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MATERIALS AND METHODS

Materials

Fresh mushrooms (*Pleurotus ostreatus, Agaricus bisporus* and *Flammulina velutipes*) were purchased from a wholesale market. Ingredients for cookies such as wheat powder (CJ Co., Korea), milk (Maeilmilk Co., Korea), sugar (CJ Co., Korea), butter (Seoulmilk Co., Korea) and egg were purchased from a wholesale market. Each Mushrooms that were used in preparing the cookies were cut by dicing type and then frozen dried.

Cookies making

Egg, butter and sugar were creamed for 2 min. Flour, diced mushrooms (20%) and baking powder were sifted and added to the liquid ingredients and mixed for 30 sec. The dough was wrapped in plastic wrap and refrigerated for 1 hr until it set. The firm dough was then sheeted to a thickness of 5 mm thick with a roller and cut with a cookie cutter of 50 mm in diameter. The cookies were then transferred to a lightly greased baking tray and baked in an oven (GOR-4200VR, Dongyang Magic, Korea) at an upper heating temperature of 170°C and lower temperature of 140°C for 14 min. The baked cookies were removed from the baking pan, cooled to room temperature for 1 hr before analysis.

Wheat flours of Multiple purposes

Mushrooms were frozen dried and then ground with a blender (MCH-602, Dongyang Magic, Korea). 80% wheat flour and 20% mushrooms powder were mixed.

Physicochemical analysis

Moisture, crude protein and mineral content was determined using the AOAC method (AOAC 1995).

Color measurement

The surface color of cookies and multiple purposes of wheat powders were characterized by measuring Hunter L, a, b values with colorimeter (Minolta Spectrophotometer CM-508i, Japan).

Texture measurement

The textural characteristics of the cookies were determined using a rheometer (Compac-100, Sun rheometer, Japan). The textural variables were hardness, strength, sharing and cutting.

Sensory evaluation

Sensory evaluation was conducted after cooling the cookies for 1 hr at room temperature. Cookies were placed on a plastic dish coded by a three-digit random number and offered to 9 trained panelists in an individual booth with lighting. Appearance, flavor, texture and overall acceptability were evaluated using the 9-point hedonic scale with 9 indication strong attributes.

Statistical analysis

The statistical analysis was performed using the SPSS Win Program (Version 14.0). All data were recorded as mean±standard deviation of at least triplicate measurements. Means were compared with Duncan's multiple range test with p=0.05 and pearson correlations were performed.

RESULTS AND DISCUSSION

Physicochemical properties

The moisture, crude protein and mineral contents of the processed mushroom products are presented in Table 1, Table 2 and Table 3. In the case of cookies, the moisture content of the control was 1.48% and the moisture content of the cookies containing mushrooms ranged from 1.10-1.24%. The crude protein content of the cookies containing mushrooms varied from 3.8-9.3% and the crude protein content of cookies containing *Agaricus bisporus* was the most lowest. The mineral content of the cookies containing mushrooms were remarkably increased relative to the control, especially Fe and K. The Fe value of cookies containing mushrooms ranged from 1.55-2.06 mg/100 g.

Table 1. Moisture content of processed mushroom products

Samples		Moisture content (%)
Cookies (Diced frozen-dried mushrooms)	Control	1.48$^{b1)}$
	Pleurotus ostreatus	1.24^{a}
	Agaricus bisporus	1.10^{a}
	Flammulina velutipes	1.20^{a}
Multi purpose functional wheat powders (Frozen-dried mushroom powders)	Control	1.39^{d}
	Pleurotus ostreatus	0.92^{c}
	Agaricus bisporus	0.57^{a}
	Flammulina velutipes	0.83^{b}

[1)]Means were compared using Duncan's multiple range test at the significant level of p<0.05.

Table 2. Crude protein content of processed mushroom products

Samples		Crude protein content (%)
Cookies (Diced frozen-dried mushrooms)	Control	6.5$^{b1)}$
	Pleurotus ostreatus	8.2^{c}
	Agaricus bisporus	3.8^{a}
	Flammulina velutipes	9.3^{d}
Multi purpose functional wheat powders (Frozen-dried mushroom powders)	Control	10.2^{a}
	Pleurotus ostreatus	11.9^{b}
	Agaricus bisporus	15.3^{d}
	Flammulina velutipes	12.8^{c}

[1)]Means were compared using Duncan's multiple range test at the significant level of p<0.05.

Table 3. Mineral content of processed mushroom products (Unit: mg/100g)

Samples		Ca	Fe	Na	K
Cookies (Diced frozen-dried mushrooms)	Control	23.26$^{d1)}$	0.89^{a}	70.11^{b}	116.46^{a}
	Pleurotus ostreatus	21.70^{a}	1.55^{b}	71.93^{c}	300.43^{b}
	Agaricus bisporus	22.26^{c}	2.06^{d}	77.35^{d}	386.32^{d}
	Flammulina velutipes	21.80^{b}	2.03^{c}	69.79^{a}	314.85^{c}
Multi purpose functional wheat powders (Frozen-dried mushroom powders)	Control	18.02^{d}	0.58^{a}	2.66^{a}	133.26^{a}
	Pleurotus ostreatus	14.40^{b}	1.85^{c}	4.63^{c}	752.11^{b}
	Agaricus bisporus	15.47^{c}	1.64^{b}	19.70^{b}	1,358.05^{d}
	Flammulina velutipes	13.55^{a}	2.63^{d}	5.19^{d}	833.78^{c}

[1)]Means were compared using Duncan's multiple range test at the significant level of $p<0.05$.

Table 4. Hunter color value of processed mushroom products

Samples		L	a	b
Cookies (Diced frozen-dried mushrooms)	Control	87.37$^{d1)}$	7.45^{a}	25.02^{c}
	Pleurotus ostreatus	78.91^{b}	8.68^{b}	21.66^{a}
	Agaricus bisporus	72.78^{a}	8.76^{b}	21.58^{a}
	Flammulina velutipes	80.97^{c}	8.83^{b}	24.46^{b}
Multi purpose functional wheat powder (Frozen-dried mushroom powders)	Control	96.08^{d}	1.71^{a}	8.31^{a}
	Pleurotus ostreatus	90.09^{b}	1.98^{b}	10.90^{d}
	Agaricus bisporus	87.81^{a}	3.02^{d}	8.98^{b}
	Flammulina velutipes	94.10^{c}	2.26^{c}	10.10^{c}

[1)]Means were compared using Duncan's multiple range test at the significant level of $p<0.05$.

Table 5. Texture analysis of cookies containing pre-treated mushrooms

Samples		MaxG (g)	Distance (mm)	Hardness (Dyne/cm^2)
Control	-	1,109	4.6	10,933,582.8$^{b1)}$
Pleurotus ostreatus	Frozen-dried powder	3,000	8.4	38,629,356.0^{f}
	Diced fried mushroom	4,210	3.4	18,444,060.9^{e}
Agaricus bisporus	Diced fresh mushroom	3,008	8.4	10,731,011.3^{a}
	Diced frozen-dried mushroom	4,300	10.1	16,099,901.4^{d}
Flammulina elutipes	Diced fresh mushrooms	4,834	6.0	15,023,415.8^{c}

[1)]Means were compared using Duncan's multiple range test at the significant level of $p<0.05$.

In the case of multiple purposes of wheat powders, the moisture content of the control was 1.39% and the moisture content of the cookies containing mushrooms ranged from 0.57-0.92%. The crude protein content of multiple purposes of wheat powders containing mushrooms ranged from 11.9-15.3% and the Fe value varied from 1.85-2.63 mg/100 g and the multiple purposes of wheat powders containing *Flammulina velutipes* was the highest.

Color measurement

The Hunter L, a, b values of cookies and multiple purposes of wheat powders are shown in Table 4. The L value of the control cookie was 83.37 and those of the cookies containing mushrooms ranged from 72.28 to 80.97. The a value of the control cookie was 7.45 and those containing mushrooms ranged from 8.68-8.83. The b value of the control was 25.02. Kim et al (2002) reported that the color of sugar-snap cookies became darker and more red and yellow as the amount of barley germ increased.

In case of multiple purposes of wheat powders, the L value of the control was 96.08 and the L value of multiple purposes of wheat powders containing mushrooms ranged from 87.81 to 94.10. The a value of the control was 1.70, which was significantly different from those containing mushrooms (1.98-3.02.). The b value of the control was 8.31. Singh et al (2004) reported that lightness value decreased while redness and yellowness values increased as the substitution level of both corn flour and potato flour increased.

Texture measurement

The results from the texture analysis are shown in Table 5. The hardness value of the control cookie was 10,922,582.8 dyne/cm^2. The degree of hardness of cookies containing mushrooms slightly increased relative to the control regardless of mushroom type. The hardness of the cookie

Table 6. Sensory evaluation of cookies containing pre-treated mushrooms

Contents	Control	*Pleurotus ostreatus*		*Agaricus bisporus*			*Flammulina velutipes*
		Frozen-dried mushroom powder	Diced-fried mushroom	Diced fresh mushroom	Diced frozen-dried mushroom	Diced fried mushroom	Diced fresh mushroom
Appearance	6.8±5.4$^{d1)}$	7.3±1.9^{e}	6.3±1.3^{c}	6.2±1.7^{b}	6.1±0.9^{a}	6.1±1.6^{a}	7.3±1.9^{e}
Flavor	3.8±3.1^{a}	6.1±2.0^{d}	6.0±1.9^{c}	6.1±1.1^{d}	5.8±1.6^{b}	6.4±1.7^{f}	6.3±1.9^{e}
Texture	6.0±4.7^{d}	7.6±1.3^{g}	4.6±1.1^{a}	6.4±1.9^{e}	4.7±1.8^{b}	6.6±1.3^{f}	5.2±2.2^{c}
Overall acceptability	3.3±2.9^{a}	7.4±1.3^{g}	4.6±1.0^{b}	5.7±1.4^{e}	5.4±1.6^{d}	6.6±1.6^{f}	4.8±1.5^{c}

[1)]Means were compared using Duncan's multiple range test at the significant level of $p<0.05$.

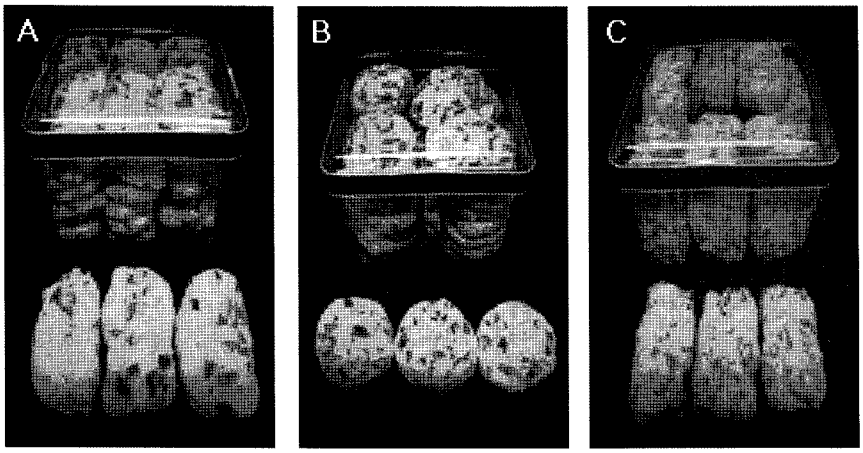

Fig. 1. Cookies containing mushrooms (A: *Pleurotus ostreatus*, B: *Agaricus bisporus*, C: *Flammulina velutipes*).

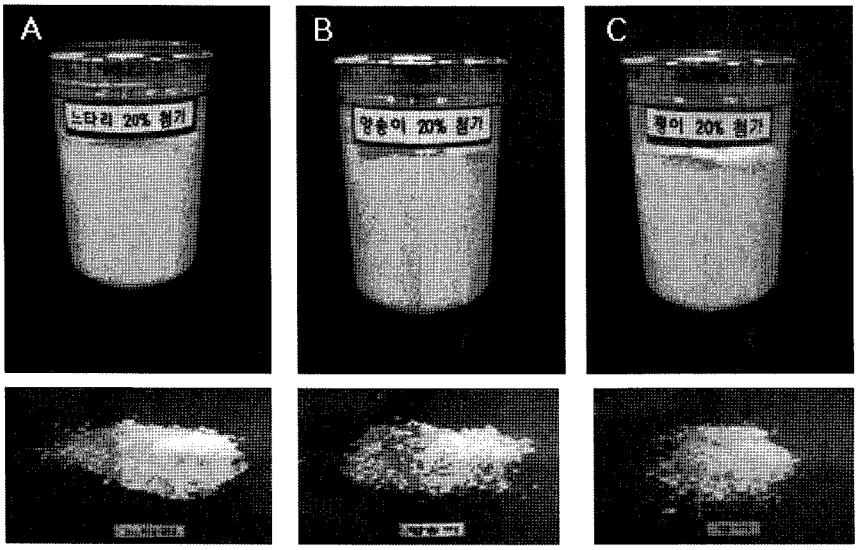

Fig. 2. Multi purpose functional wheat powders containing mushrooms (A: *Pleurotus ostreatus*, B: *Agaricus bisporus*, C: *Flammulina velutipes*).

containing *Pleurotus ostreatus*, especially the frozen dried powder type, was the highest and the cookie containing *Agricus bisphorus* was the lowest. Lee and Oh (2006) reported that cookies made with brown rice flour exhibited increased hardness but decreased crispness values compared to control cookies.

Sensory evaluation

Table 6 shows the result of the sensory evaluation in regards to appearance, flavor, texture and overall preference of the control and mushroom added cookie. Figure 1 and Figure 2 show the cookies and multiple purposes of wheat powders containing mushrooms. The flavor score ranged from 3.8 for the control to 6.4 for the mushroom added cookie. The appearance of the mushroom added cookies were significantly different from that of the control. The general preference for cookies containing each mushrooms was higher than the control, especially in flavor, because the mushroom gave the cookie a characteristic flavor.

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