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Quality Characteristics of Bread Added with Oat Flours

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ABSTRACT Oat flour was purchased and investigated for quality characteristics of oat bread. Antioxidant and flour pasting properties of oat flour, and water content, weight, volume, Hunter color value, texture of bread were measured. DPPH radical scavenging capacity (%) of oat extract was 68.49%. Pasting temperature of oat flour ranged between 66.60℃ and 70.93℃. Flour pasting properties of sample added with 10 and 30% oat flour was shown similar results compared with wheat flour. Final viscosity of sample was increased by adding concentration of oat flour (up to 311.65 RVA). Water content (%) of bread was shown increasing trend by adding oat flour. Weight of bread loaf with 100% oat flour was shown higher score than other samples. Volume of loaf by adding oat flour of 10, 30, and 50 % ratio was 550, 450, and 388 mL, respectively. The Hunter color L* values of bread by adding oat flour was dark compared with wheat bread. Color value of bread added 10% oat flour was similar results with L* values of bread with wheat flour. The bread added with 20 and 30% oat flours had the higher hardness, gumminess, and chewiness compared with other samples. Cohesiveness of the bread with wheat flour showed higher than that of bread added with oat flour and increased by storage period. The growth of total viable cell was inhibited depending on the concentration of oat flour during storage.

Keywords : oat flour, bread quality, antioxidant, storage stability

From the mid-20th century, an emphasis on the concept of diet was placed on maintaining or enhancing good health due to global health concerns, high health care costs, and increasingly aging population, and so on (Arvanitoyannis *et al.*, 2005). Health authorities, world-wide, recommend a decrease in the consumption of animal fats and protein, and an increase of cereal intake, which is and important source such as dietary fibre and phenolic compounds (Wang *et al.*, 2002).

Oat (*Avena sativa* L.) is one of the most adventurous cereal grains for human diet since it contains naturally high amounts of valuable nutrients such as soluble fibres, proteins, unsaturated fatty acids, vitamins, minerals and phytochemicals (Flander *et al.*, 2008). The main component of soluble fiber in oats is the mixed-linkage polysaccharide (1→3),(1→4)-β-D-glucan, referred to as β-D-glucan. The consumption of oats, oatmeal, and oat bran has been shown in most studies to reduce total plasma cholesterol and low-density lipoprotein (LDL) cholesterol levels, the main risk factors for CHD (Truswell AS, 2002). In addition to their cholesterol lowering effect, oats have recently been shown to improve endothelial function (Katz *et al.*, 2001) and blood pressure (Keenan *et al.*, 2002; Saltzman *et al.*, 2001), potentially through modulation of blood cholesterol and vascular endothelium production of nitric oxide (NO) (Nie *et al.*, 2006). Oats, in addition to containing soluble fibers, are a rich source of many nutrient and antioxidants including vitamin E, phytic acid, and unique polyphenols, avenanthramides (Collins *et al.*, 1989).

Bread can be enriched with dietary fibre or functional ingredient such as antioxidant including wheat bran, gums, such as modified cellulosed, and β-glucan (Wang *et al.*, 2002). However, the addition of these fibre or functional ingredient causes a neglected effect of the final bread quality and storage stability. The objective of this study was to investigate the quality characteristics and storage stability of bread by addition oat flour as functional ingredient.

MATERIALS AND METHODS

Sample preparation

Oat flour was purchased and used from the Hamyang

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region in Gyeongnam province, Korea. Moisture of oat flours was 7.71%. Extraction in which sample and solvent ratio was 1:40 (w/v) was performed by using a 70% ethanol solution for 72 h at room temperature with 5 times of agitations. The extracts were filtered through a filter paper twice.

Breadmaking process

A straight dough breadmaking process was performed. Basic recipe consisted in oat flour, compressed yeast (4%, flour basis), salt (2%, flour basis), sugar (5%), butter (4%), powdered milk (3%), and water was used in this study. Ingredients were mixed. Dough was fermented at 30℃ and 75-80% relative humidity for 115 min and then it was mechanically sheeted and rolled. Baking was performed at 200℃ for 25 min and finally bread was cooled at room temperature for 110 min. The weight and volume of loaf was measured. For the storage stability study, bread was packed in polypropylene bags and stored at room temperature. All baking trials were done in triplicate.

Scavenging effects of 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical

Free radical scavenging effect was estimated according to the method of Blois (1958) with some modification. The sample dissolved in 70% ethanol (500 ppm, 1 mL) was added into the 0.2 mM DPPH radical solution (1 mL) and vortexed. The mixture was reacted for 30 min at room temperature and the absorbance was measured at 517 nm with a spectrophotometer. The scavenging activity of the DPPH radicals in percentage points was calculated by the following equation: Scavenging activity (%) = $(1-A_1/A_0) \times 100$, where A_0 is the absorbance of the blank and A_1 is the absorbance of the sample.

Flour pasting properties

A rapid visco analyzer (RVA) was used to determine the pasting properties of flours. Analysis was performed according to the standard Newport Scientific Rice Method. The temperature profile used was holding at 50℃ for 1 min, the heating to 95℃ over 4.48 min and holding at 95℃ for 7.18 min, and finally cooling to 50℃ over 11.1 min. The paddle speed was 960 rpm for the first 7 sec and then adjusted to 160 rpm. Analyses were performed in triplicate.

Texture profile analysis

The texture analysis for the sample was performed by using a texture analyzer (Model TA-XT 2i, Stablemicro systems Ltd., Surrey, UK). Two bite test of the bread was performed. A bread slice of 2 cm thickness was compressed up to 70% of its original height at a crosshead speed of 1 mm/s with a cylindrical stainless steel probe (diameter 35 mm). Values were the mean of three replicates.

Color measurement

Color of sample was measured by a color difference meter (Color JS 55; Color Technology System Co., Japan). The color was measured 3 times for each samples and then averaged. The numerical value of the color was expressed by Hunter L*, a*, and b* values.

Microbial analysis

A sample (10 g) was aseptically homogenized for 30 seconds in a sterile stomacher bag containing 90 mL of sterile 0.1% peptone water by using a bag mixer (Nasco Co, USA). Media for an enumeration of total viable cell count of sample was prepared by a plate count agar (Difco, USA). Plates were incubated at 37℃ of the bacteria for 72 hr and the number of colony forming units (CFU) per gram was counted at a dilution of 30 to 300 CFU per plate.

Statistical analysis

Analysis of variance and Duncan's multiple range tests were performed to analyze the results using a SAS software (version 9.2; SAS Institute, Cary, NC, USA). Mean values and standard deviation were reported and the significance was defined at $p<0.05$.

RESULTS AND DISCUSSION

Free radical scavenging activity of oat extracts

The DPPH radical scavenging activity of the oat extract was shown in Table 1. DPPH radical scavenging capacity (%) of oat extract was 68.49%. In this study, oat extracts was shown higher antioxidant activity proportion to dilution factor. Fagerlund *et al.*, (2009) reported that lipid oxidation is one of the major causes of spoilage of various materials including food. The viatamin E (tocols), phytic acid, phenolic compounds, and avenanthramides are the most abundant antioxidant in oat (Peterson, 2001). Hammond (1983) confirmed that extracts of oat had antioxidant properties when added to lard. Holtekjølen *et al.*, (2008) reported that the incorporation of cereal such as barley increased the antioxidant properties of the breads and the measurement antioxidant activities (FRAP-S and FRAP-IS) of barley flour were relatively stable during the baking process.

Flour pasting properties

Rapid visco analyzer was used to determine the pasting properties of oat and wheat flour by different concentration (Table 2). Pasting temperature of the samples ranged between 66.60℃ and 70.93℃. Flour pasting properties of sample added with 10 and 30% oat flour was shown similar results compared with wheat flour. Final viscosity of sample was increased by addition concentration of oat flour (up to 311.65 RVA). The higher-amylose starches of cassava, sorghum and *Curuma zedoaria* had low viscosities and very small differences between the peak and final viscosities (Blennow *et al.*, 2001). Hüttner *et al.*, (2010) reported that final viscosity of commercial wholegrain oat flour, WGO Fi, WGO IrI, WGO SW, was 402.14, 328.20, and 397.08 RUV, respectively.

Bread characteristics

Table 3 represents the impact of applied additives on the water content, weight and volume of bread. Water content (%) of bread was shown increasing trend by addition of oat flour. Weight of bread loaf with 100% oat flour was shown higher score than other samples. Volume of loaf by adding oat flour with 10, 30, and 50 % ratio was 550, 450, and 388 mL, respectively. Wang *et al.*, (2002) reported that fiber rich breads have higher moisture contents than the control and loaf volume was shown decreasing trend.

The Hunter color value changes of the bread added with oat flour are shown in Table 4. The Hunter color L* values of bread by adding oat flour was dark compared with wheat bread. Color value of bread added with 10% oat flour was similar results with L* values of bread with wheat bread. Holuín-Acuña *et al.*, (2008) reported that Hunter colour L* value decreased as more fiber was added.

Table 1. DPPH radical scavenging activity of oat extracts by water-solvent extract system.

Samples	Dilution	DPPH radical scavenging activity (%)
Oat extracts	10 fold	68.49±1.05
	100 fold	15.29±1.01

Table 2. Flour pasting properties of oat flour with different concentration by rapid visco analyzer.

Samples	Con. (%)	Amylogram (RUV)				
		Pasting Temp.	Final Visc.	Breakdown	Setback	Peak Time
Oat flour	10	65.73±2.33	169.43±4.00	51.57±.06	26.00±0.77	6.20±0.07
	30	66.75±3.11	200.19±1.56	47.26±0.52	46.98±2.96	6.27±0.12
	50	69.45±1.56	224.65±4.27	41.32±1.37	68.37±1.49	6.24±0.14
Wheat flour		66.60±0.83	152.38±6.01	40.52±4.00	28.36±1.32	6.11±0.17

Table 3. Water content, weight and volume of bread according to addition concentration of oat flour.

Samples	Con. (%)	Water content (%)	Weight of loaf (g)	Volume of loaf (ml)
Oat flour	10	38.85±2.26	164.83±0.01	786±0.71
	30	40.15±1.35	164.93±1.45	550±35.36
	50	39.84±0.90	166.79±0.04	450±7.07
	100	45.13±0.79	180.12±0.83	388±17.68
Wheat flour		40.49±0.22	164.52±0.06	838±17.68

Table 4. Hunter color values of bread according to addition concentration of oat flour.

Samples	Con. (%)	Hunter color values		
		L*	a*	b*
Oat flour	10	77.93±0.88	-1.47±0.10	19.96±0.94
	30	71.07±0.31	0.05±0.05	23.39±0.13
	50	65.57±0.89	1.40±0.22	23.79±0.14
	100	61.76±0.40	1.81±0.06	21.94±0.33
Wheat flour		80.67±0.64	2.42±0.04	18.28±0.79

Table 5. Texture profiles of brad according to addition concentration of oat flour.

Samples	Con. (%)	Texture profile				
		Hardness	Springiness	Cohesiveness	Gumminess	Chewiness
0 day						
Oat flour	10	2072.99±103.56	0.81±0.15	0.71±0.02	1468.26±37.55	1168.19±183.20
	30	12271.79±1471.63	0.84±0.05	0.59±0.02	7224.75±1155.04	057.20±1311.06
	50	10384.45±160.22	0.52±0.01	0.39±0.01	4036.12±39.49	2102.81±14.84
	100	8468.03±298.22	0.43±0.03	0.18±0.01	1559.68±124.59	672.01±7.19
Wheat flour		1722.62±193.12	0.95±0.01	0.78±0.01	1339.88±138.13	1276.27±132.46
3 day						
Oat flour	10	2399.76±46.38	0.66±0.02	0.65±0.01	1555.38±92.32	1018.07±25.33
	30	9749.45±470.43	0.56±0.02	0.48±0.01	4698.71±92.32	2616.97±74.57
	50	15299.10±1752.08	0.49±0.01	0.37±0.02	5724.84±996.33	2772.81±458.48
	100	9539.72±667.39	1.33±0.56	0.63±0.01	1983.50±322.69	985.82±50.55
Wheat flour		3534.13±203.81	1.33±0.56	0.63±0.01	2215.72±169.33	2990.48±1467.70

The bread made by addition of 20 and 30% oat flours had the higher hardness, gumminess, and chewiness compared with other samples, respectively (Table 5). Cohesiveness of the wheat bread showed higher than that of bread added with oat flour and increased by storage period. Extruded breakfast cereal with little maize bran presented a high breaking strength, due to the low expansion capacity of oat (Holuín-Acuña *et al.*, 2008). Fibre such as carob fiber, inulin, pea fibre addition increased hardness of bread (Wang *et al.*, 2002). Hüttner *et al.*, (2010) reported that starch amount and starch damage rather than pasting properties influence the bread making properties of oat flours and difference in protein content were also found to influence bred making properties of oat flour.

Microbial safety of bread during storage

The microbial safety of bread by addition of oat flour during storage was shown in Table 6 and Figure 1. The number of viable cell count of wheat bread was 1.39 log_{10} CFU/g at the initial stage and shown increase about 5 log cycle after 6 days later. The total viable cell count of bread added with 10, 30, 50, and 100% oat flour was 2.39, 3.45, 4.25, and 4.64 log_{10} CFU/g, respectively. The growth of total viable cell was inhibited depending on the concentration of oat flour during storage. Initial total microbial counts of bread added with oat flour were higher than wheat bread. However, total viable cell counts of bread with the addition of 30 and 50% oat flour was not increased after 3 day. Rosenkvist and Hansen, (1995) reported that oat products contained low levels (10^0-10^2 cfu/g) of *Bacillus* spores, surviving a heat treatment (100℃, 10 min) corresponding to a baking process. Several studies were confirmed that addition of functional ingredients such as antioxidant, antimicrobial component was prolonged shelf life of

Table 4. Hunter color values of bread according to addition concentration of oat flour.

Samples	Con. (%)	Viable cell count (Log_{10} CFU/g)		
		0 day	3 day	6 day
Oat flour	10	2.39±0.12	2.66±0.26	6.38±0.05
	30	3..45±0.21	3.59±0.16	6.98±0.04
	50	4.25±0.07	4.43±0.10	6.97±0.09
	100	4.64±0.01	4.90±0.11	7.24±0.09
Wheat flour		1.39±0.12	3.53±0.32	6.35±0.07

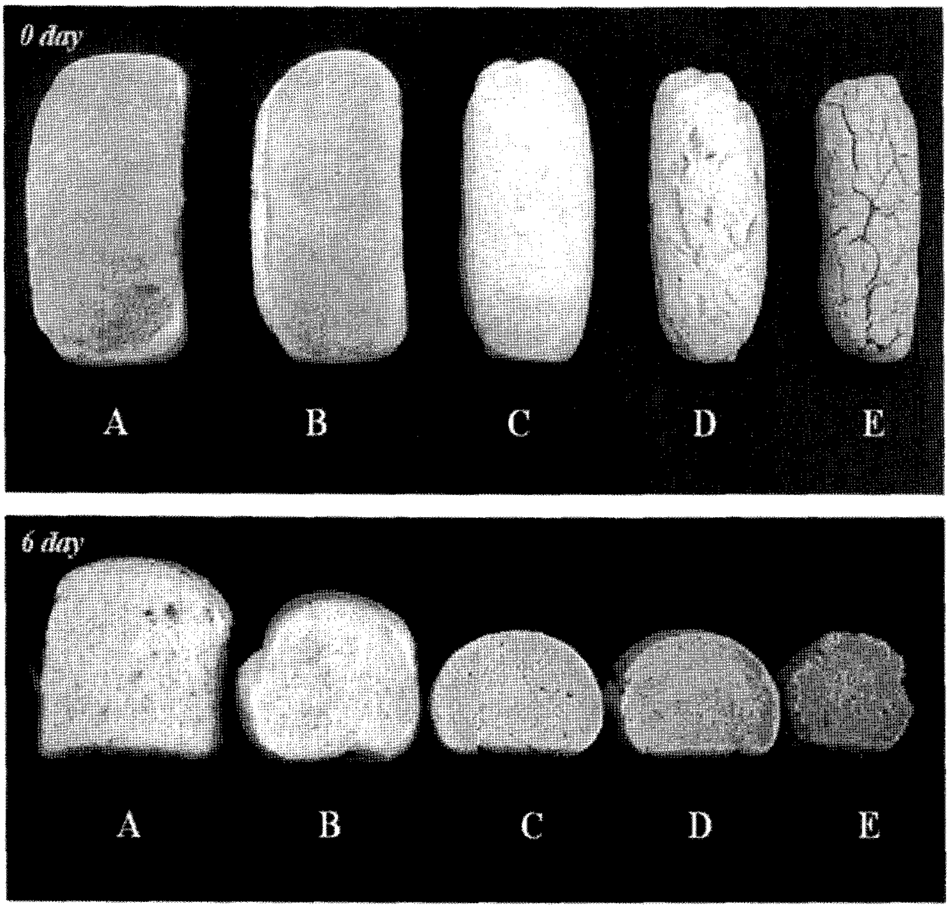

Fig. 1. Pictures of breads made from (A) wheat flour 100%, (B) wheat flour with addition of oat flour 10%, (C) wheat flour with addition of oat flour 30%, (D) wheat flour with addition of oat flour 50%, and (E) oat flour 100%.

products, significantly. Park *et al.*, (2008) reported that the treatment barley sprout powder had a higher total microbial count for aerobes at the beginning of storage. However, as the storage period, the control had greater microbial levels. Kim *et al.*, (1998) confirmed that when various amounts of freeze-dried mugwort powder were added in *Sulgis* (steamed rice cake), 3% *Ssooksulgi* (mugwort powder added sulgi) had quite lower level of total bacterial count (5.5×10^5 CFU/g) compared with the control group (5.5×10^7 CFU/g) at ambient temperature (30℃±1℃) after 72 hr. In conclusion, oat flour as functional ingredients has a positive effect on quality characteristics of wheat bread during storage.

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