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Rheological Properties and Quality Evaluation of Pan Bread and Biscuits Supplemented with Mushroom Micelles Flours

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Abstract: Milled mushroom micelles grown on sorghum grains (MSG) or grown on wheat grains (MWG) as a partial substitute for wheat flour in pan bread and biscuit production were evaluated. The rheological properties of flour dough and baking quality properties (physical, chemical, protein content, color and sensory characteristics in pan bread and biscuit) of wheat flour or milled mushroom micelles (MSG or MWG) and its blends were examined. Wheat flour was partially replaced by milled mushroom micelles grew on sorghum or wheat grains in ratios of 15, 30, and 45% in pan bread and biscuit blends. Water absorption, dough development time (DDT) and dough weakening increased but mixing tolerance index (MTI) and dough stability decreased relatively marginal by milled mushroom micelles at the level of 15 and 30%. Greater effects were observed on the mixing tolerance index values (MTI) in biscuit. It increased in milled mushroom micelles with increasing the level from 15% to 30%. Baking properties, color and sensory evaluation tastes showed that 15% of wheat flour could be replaced with milled mushroom micelles (MSG or MWG) and still providing good quality of pan bread and biscuits. But with 30% of wheat flour could be replaced with milled mushroom micelles (MSG or MWG) exhibited low differences in sensory evaluation when replaced by (MSG) but in (MWG) the appeared better taste while in samples replaced wheat flour with 45% all pan bread samples appeared more significant differences and the taste more better and the color become darker compared to control. But in biscuit samples replace wheat flour with 15 and 30% of (MSG or MWG) while when replaced with 45 % of (MSG or MWG) samples offered slightly differences in organolyptic taste.

Key words: Biscuit, color, bread, flours, oyster mushroom, rheological properties, sensory attributes, wheat, sorghum.

INTRODUCTION

In Egypt, the total production of bread grains does not satisfy the needs of the country. The total production of wheat grains cover only about 55% of the total needs. The way to overcome such problem is through search for the native cereal sources or others which could be used with wheat flour in bread making. Biscuits are convenient food products and are the most popular bakery items consumed nearly by all levels of society in Egypt. Some of the reasons for such wide popularity are low cost among other processed foods (affordable cost), high nutritional quality and availability in different farms, varied taste, easy availability and longer shelf-life. Most of bakery products are used as a source for incorporation with different nutritionally rich ingredients for their diversification (Gandhi *et al*., 2001; Hooda and Jood 2005 and Sudha *et al*., 2007). The enrichment by protein may be achieved through the incorporation of protein–rich non-wheat flours (Gandhi *et al*., 2001 and Sharma and Chauhan, 2002). Oyster mushroom have a great potential, due to their high (24–35%) and good quality-protein, (higher lysine and soluble dietary fiber), but mushrooms have soluble and insoluble dietary fiber especially β-glucan (Fahmey *et al*., 1981; Ulloa *et al*., 1988; Varughese, *et al*.,1996 and Petrovska *et al*., 2002). Therefore, fortification with high protein milled mushroom micelles could provide a good opportunity to improve the nutritional quality of protein consumed by many people. Fortification of wheat flour with non-wheat proteins, also, increases protein quality through improving its amino acid profiles (Stark *et al*., 1975 and Hoover, 1979). Results according to Autio *et al*., (1998) reported that the doughs made from flours of milled mushroom micelles were always softer than doughs made from flours of native grains. Hence, development and consumption of such therapeutic bakery products would help to raise the nutritional status of the population. Information on incorporation of mushroom flour in bakery products and bread is scanty. Thus, the present study was designed to evaluate the suitability of partial replacement of wheat flour using milled mushroom micelles in pan bread making and biscuit manufacture. It was also aimed to evaluate the effects of milled mushroom

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micelles addition at various ratios (15, 30 and 45%) on the rheological properties of dough and on the quality (physical, chemical, protein content, color and sensory characteristics) of wheat pan bread and biscuits.

MATERIAL AND METHODS

Materials:

Wheat flours (72% extraction) were obtained from the North Cairo Mills Company, Egypt. *Pleurotus colombinus* was obtained from the unit of mushroom production, Faculty of Agriculture, Ain Shams University. Sorghum and wheat grains straw were purchased from the Center of Mushroom Services, Agricultural Research Center, Giza, Egypt.

Preparation Methods:

Preparation of Spawn:

Wheat and sorghum grains were washed and boiled for 20 minutes then cooled and spread in the air until the humidity reached 60%. The grains were picked up in plastic bags and plugged, then autoclaved at 121°C for 2 hours. The autoclaved grains were inoculated with pure culture of *Pleurotus colombinus* and incubated at 28°C for 10-15 days. The resulted mushroom micelles were harvested and prepared to use.

Preparations of Mushroom Flour:

The resulted mushrooms micelles were dried in a thermostatically controlled oven with air fan at 45-50°C for 480 min and milled using a Laboratorial disc mill (Quadrumat Junior flour mill, Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) to pass through a 40 mesh/inch sieve, stored at 3-4°C for 2 days until needed for technological studies. The milled mushroom micelles grown on sorghum grains (MGS) and that grown on wheat (MWG).

Preparation of Mushroom Flour and Wheat Flour Blends:

Wheat flour of (72% extraction) was well blended and replaced with specified amounts of mushroom milled mushroom micelles to produce mixtures containing 0, 15, 30 and 30%. All samples were stored in airtight containers and kept at 3–4°C until required.

Pan Bread Making:

Pan bread was prepared by mixing 100g of wheat flour (72% extraction, or its blends with milled mushroom micelles) with 0.5 g of active dry yeast, 1.5 g of sodium chloride and 75–80 ml of water and hand blended for about 6 min to form the dough. The dough was lift to rest for 10 minutes at 30°C and 85% relative humidity and was then divided into 150g pieces. The pieces were booted in metal pans that had been left to ferment for about 45 min at the same temperature and relative humidity according to AACC (2005). And then were baked at 200–240°C for 10–15 min the resulted pan bread was allowed to cool at room temperature for 2 h before being packed in polyethylene bags and stored at room temperature for further analysis.

Biscuits Making:

(blends containing different levels of milled mushroom micelles 0, 15, 30, and 45%). Biscuits were prepared according to the procedure described by AACC (2005) with slight modifications. The ingredients included wheat flour or blends were used as described by Sudha *et al.,* (2007). The formula was contained: 100g wheat flour or its tested blends, 57.77 g sugar, 7.1 ml water, 6 ml fresh orange juice, 28.44 g shortening, 0.93 g salt (sodium chloride), 1.11 g sodium bicarbonate and 14.66 g dextrose. All the previous ingredients were mixed for 15 min using a mixer. The dough was then rolled between sheets of wax coated freezer paper to a uniform thickness of 9 mm and was cut using a circular mould to a diameter of 3.8 cm. Biscuits were baked at 205°C (400°F) for 9-10 min in a conventional air-fan electric oven. After baking, the biscuits were cooled to room temperature, packed in polyethylene pouches and sealed until analysis.

Analytical Methods:

Protein And Crude Fiber Determination:

Standard Association of Official Analytical Chemistry methods, AOAC (2000) were adopted for estimating protein and crude fiber contents.

Dough Characteristics:

The effect of different milled mushroom micelles levels (0, 15, 30 and 45%) on dough rheology was determined by Farinograph (Model Type No: 81010 at 31, 50 and 63 rpm), ©Brabender® OHG, Duisburg, 1979, Germany) according to the standard methods AACC (2005). The measured parameters were water absorption, dough development time, dough stability and mixing tolerance index (MTI). The elastic properties of dough with different levels of flours were measured using Extensograph (Model Type No: 81010 at 31, 50 and 63 rpm,

©Brabender® OHG, Duisburg, 1979, Germany) according to the AACC (2005) standard methods. The studied parameters were resistance to extension (R), extensibility (E), ratio figure (R/E) and energy (Area).

Physical Characteristics of Biscuits:

Diameter (W) was measured by Boclase (HL 474938, STECO, Germany). Volume (V) and thickness (T) of biscuits were also determined according to standard methods AACC (2005). The spread ratio (W/T) was calculated. Percent spread ratio was calculated according to the standard methods AACC (2005) by dividing the average value of diameter (W) by the average value of thickness (T) of biscuits. Analytical methods of protein determination. Protein content of all samples was determined according to the macro Kjeldahl method AACC (2005).

Color Determinations:

Objective evaluation of biscuits surface color and pan bread crust color was measured. Hunter (a*, b* and L*) parameters were measured with a color difference meter using a spectro-colorimeter (Tristimulus Colour Machine) with the CIE lab color scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized (at each time) with a white tile of Hunter Lab Color Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) (Sapers and Douglas, 1987). The Hue (H)*, Chroma (C)* and Browning Index (BI) were calculated according to the method of (Palou *et al*., 1999) as follows:

$$H^* = \tan^{-1} [b^*/a^*] \quad (1)$$

$$C^* = \text{square root of } [a^{2*} + b^{2*}] \quad (2)$$

$$BI = [100 (X-0.31)]/ 0.172 \quad (3)$$

Where:

$$X = (a^* + 1.75L^*) / (5.645L^* + a^* - 3.012b^*)$$

Sensory Characteristics:

The pan bread samples were allowed to cool on racks for about 1h before evaluation. Pan bread loaves were organoleptically evaluated for general appearance, crust color, taste, odor, crumb color, structure by 12 trained panelists of Food Science Department, National Research Center Stuff according to Gujral *et al*. (2004).

Sensory characteristics of biscuits were evaluated according to Zabik and Hoojjat (1984) with some modifications. However, the sensory characteristics of biscuits were determined, using a taste panel, consisting of 12 trained judges. The panelists were asked to evaluate the surface color, taste, odor, shape, texture and structure of the tasted samples.

Statistical Analysis:

The obtained results of sensory evaluation were statistically analysed using SPSS statistical package (Version 9.05) according to Rattanathanalerk *et al*., (2005), analysis of variance (ANOVA), Duncan's multiple range test and least significant difference (LSD) was chosen to determine any significant difference among various treatments at $p<0.05$.

RESULTS AND DISCUSSION

Influence of Milled Mushroom Micelles on the Farinograph Measurements Properties of the Dough:

Variation in blending ratios (0, 15, 30 and 45%) of milled mushroom micelles (MSG or MWG) on dough mixing properties (Farinograph) with wheat flour (72% extraction) showed differences in dough mixing properties. The results are obvious mentioned indicated in Table (1).

Table 1: Farinograph measurement properties of milled mushroom micelles (MSG or MWG) and their blends.

Samples	Water absorption %	Arrival time (min.)	Mixing time (min.) (DDT)	Dough stability (min.)	Weakening value (B.U.)
Control	57.0	2.0	3.5	4.00	40
15 % MSG + 85% wheat flour	60.3	2.5	5.0	13.5	80
30 % MSG + 70% wheat flour	62.8	3.5	8.0	25.0	100
45 % MSG + 55% wheat flour	65.2	4.0	7.0	37.0	120
15% MWG + 85% wheat flour	60.8	2.5	4.0	11.0	80
30% MWG + 70% wheat flour	66.2	3.0	5.0	12.5	120
45% MWG + 55% wheat flour	68.8	3.0	5.0	--	--

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

Addition of both types of milled mushroom micelles mainly increased the water absorption. By increasing the sample level from 15% to 45% the highest increase in water absorption was found with the addition of 45%

of both types (MSG or MWG) of milled mushroom micelles (65.2 and 68.8% respectively). The increase in the water absorption in the case of milled mushroom micelles was marginal. Similar effects on water absorption were observed by Essa *et al*. (2007) and Abou-Zaid (2011) when wheat bran or rice bran or resistant rice starch was added. Abou-Zaid *et al*. (2011) reported that the differences in water absorption are mainly caused by the greater number of hydroxyl groups which exist in the fiber, sugars, higher protein content and structure which retaine more water and allow more water interactions through hydrogen bonding. The extent of increase in arrival time or dough development time (DDT) was increased by milled mushroom micelles increasing to be 7 min in (MSG) and 5 min in (MWG) compared to 3.5 min in control sample. Dough stability which indicates the dough strength, increased up to 37 and more than 40 in MSG and MWG samples respectively compared to 4 min in control at the level of 15 and 30%. Greater effects were observed on the mixing tolerance index values (MTI). It increased in the case of milled mushroom micelles, with increasing the supplementation level from 15% to 45%. It is due to that with increasing of dietary fiber and protein (by ratio increasing of both types of milled mushroom micelles, more molecules of water were binding led to an increasing in DDT), dough stability and mixing tolerance index. Similar results were reported by Abou-Zaid (2011) for the addition of resistant rice starch to the blends. The results showed the weakening of dough with the increasing level from 15% to45% of both milled mushroom micelles. It is due to that with all milled mushroom micelles increased, the net work proteins was diluted and cussed an increase in weakening values, as reported by Abou-Zaid (2011).

Influence of Milled Mushroom Micelles on the Extensograph Measurement Properties of the Dough:

The effect of incorporation of milled mushroom micelles at varying levels on extensible properties is illustrated in Table (2). The resistance to extension values were gradually decreased with increasing the level of milled mushroom micelles addition.

Table 2: Influence of milled mushroom micelles types on the Extensograph measurement properties of the dough:

Samples	Dough resistance to extension R (B.U.)	Dough extensibility (E) (mm.)	Proportion number D=R/E	Dough Energy (cm^2)
Control	140	70.0	2.00	22.5
15% (MSG) + 85% wheat flour	120	60.0	2.00	17.0
30% (MSG)+ 70% wheat flour	100	40.5	2.22	10.5
45% (MSG)+ 55% wheat flour	80	30.0	2.67	6.00
15% (MWG)+ 85% wheat flour	120	60.0	2.00	18.0
30% (MWG)+ 70% wheat flour	110	50.0	2.20	12.0
45% (MWG)+ 55% wheat flour	85	30.5	2.43	6.50

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

This may be due to the interaction between polysaccharides and proteins of wheat and mushroom flours as earlier reported by Jones and Erlander (1967) and Essa *et al*., (2007). The extensibility values were greatly reduced by increasing the addition of milled mushroom micelles. The ratio between dough resistance to extension and dough extensibility (D=R/E) was increased by increasing the milled mushroom micelles addition. Such results indicating that the dough became more harder in the presence of milled mushroom micelles. The R/E ratio values increased to a greater extent in the case of milled mushroom micelles. Were such in general, extensogram measurements of blends contained milled mushroom micelles indicated that the dough was softer and weaker than the control (wheat flour dough) sample (Table 2). All samples containing both types of milled mushroom micelles have less extensibility and lowest dough energy than wheat flour dough (control). The substitution of wheat flour by both types of milled mushroom micelles at all the different levels minimized the extensibility. This decrement may be due to the deficiency of gliadin and glutenin in all samples containing both milled mushroom micelles protein. The proportional number increased as the percentage of milled mushroom micelles increased. These results are in agreement with those obtained by Essa *et al*., (2007) as well as by Naeem *et al*., (2002). Areas under the curve (dough energy) were decreased with the increase in the level of milled mushroom micelles.

Influence of Milled Mushroom Micelles on Physical Characteristics of Biscuits and Pan Bread:

Physical characteristics of biscuits, such as thickness, diameter and spread ratio were affected by the substitution increment of the level of milled mushroom micelles (Table 3).

The changes in diameter and thickness reflected the spread ratio which was consistently increased to from 7.30 in MSG and to 7.33 in MWG as result of 45% levels substitution. These results indicated that the addition of milled mushroom micelles adversely affected the thickness. It's due to that the gluten network was weakened. Cookies having higher spread ratios are considered most desirable (Kirssel and Prentice, 1979). Other research workers also reported that the thickness of supplemented biscuits were decreased, whereas, diameter and spread ratio of biscuits increased with increasing the level of resistant rice starch blends (Sudha *et al*., 2007 and Abou-Zaid 2011).

Table 3: Physical characteristics of the tested biscuits samples.

Samples	Thickness. (mm)	Diameter. (mm)	Spread ratio	Weight (g)	Volume (cm^3)	Density (g/cm^3)
Control	10.0	64.5	6.45	91.61	140	0.65
15% (MSG) + 85% wheat flour	10.0	65.0	6.50	83.46	110	0.76
30% (MSG)+ 70% wheat flour	9.50	65.0	6.84	92.72	150	0.62
45% (MSG)+ 55% wheat flour	9.00	66.0	7.30	90.69	150	0.61
15% (MWG)+ 85% wheat flour	10.0	65.0	6.50	86.25	115	0.75
30% (MWG)+ 70% wheat flour	9.00	65.5	7.27	91.35	145	0.63
45% (MWG)+ 55% wheat flour	9.00	66.0	7.33	93.01	150	0.62

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

Physical characteristics (volume, weight and density) of pan bread were also affected by the increase in the level of milled mushroom micelles (Table 4). It was found that by increasing of the milled mushroom micelles to 15% the loaf volume was increased to 320 cm^3 in MSG and 300 cm^3 in MWG compared to 280 cm^3 in the control. It may be due to that at 15%, milled mushroom micelles the gluten network loss some of its strength but still kept ear in the dough. But more than 15%, milled mushroom micelles let the network be became weakened and it cannot keep the ear of leavening agents, as reported by Abou-Zaid (2011).

Table 4: Physical characteristics of the tested pan bread samples.

Samples	Volume (cm^3)	Weight (g)	Density (g/cm^3)
Control	280	130.72	0.47
15% (MSG) + 85% wheat flour	320	128.91	0.41
30% (MSG)+ 70% wheat flour	260	136.05	0.52
45% (MSG)+ 55% wheat flour	230	129.11	0.56
15% (MWG)+ 85% wheat flour	300	131.62	0.44
30% (MWG)+ 70% wheat flour	250	135.97	0.54
45% (MWG)+ 55% wheat flour	220	133.66	0.61

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

Influence of Milled Mushroom Micelles on Protein Content (g/100 g) of Pan Bread and Biscuits:

Tables (5) show that protein content increased with increasing both types of milled mushroom micelles in the blends. Control pan bread and biscuits had 12.5 and 9.2% protein content, respectively. In the case of supplemented biscuits by 15 to 45%, it ranged from 10.3 to 12.8% respectively, in MSG milled mushroom micelles, and ranged in corresponding samples from 10.5 to 12.9% in MWG milled mushroom micelles.

Table 5: Effect of supplementation of wheat flour with different levels of (MSG) and (MWG) on protein and dietary fiber contents (g/100 g).

Samples	Protein content		dietary fiber content	
	Biscuits	Pan bread	Biscuits	Pan bread
Control	9.2	12.5	0.82	1.20
15% (MSG) + 85% wheat flour	10.3	15.4	1.02	1.42
30% (MSG)+ 70% wheat flour	11.6	17.6	1.21	1.60
45% (MSG)+ 55% wheat flour	12.8	20.0	1.32	1.72
15% (MWG)+ 85% wheat flour	10.5	15.5	1.00	1.41
30% (MWG)+ 70% wheat flour	11.8	17.9	1.19	1.60
45% (MWG)+ 55% wheat flour	12.9	19.8	1.30	1.74

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

In case of the supplemented pan bread, it ranged from 15.4 to 20.0 % in MSG and ranged from 15.5 to 19.8% in MWG. The increase in protein content of milled mushroom micelles supplemented pan bread and biscuits may be due to the appreciably higher protein content of milled mushroom micelles. These results are confirmed by the results of Essa *et al*., (2007) they reported that a higher protein content was found in biscuits prepared from blends of wheat-raw and germinated mushroom powder. From the same Table, it could be noticed that total protein content in pan bread was increased by increase the milled mushroom micelles.

The same table showed that dietary fiber content was increased with increasing both types of milled mushroom micelles. Control pan bread and biscuits had 1.2 and 0.82% dietary fiber content, respectively. In the case of supplemented biscuits, it ranged from 1.02 to 1.32% in MSG and ranged from 1.00 to 1.30% in MWG. Also, in the case of supplemented pan bread, it ranged from 1.42 to 1.72% in (MSG) milled mushroom micelles, and ranged from 1.41 to 1.74% in (MWG) milled mushroom micelles. The increase in dietary fiber content of milled mushroom micelles supplemented pan bread and biscuits might be as a result of the appreciably higher dietary fiber content of all types of milled mushroom micelles. The results are in agreement with that obtained by El-Hadidi (2006) who found that addition resistant starches to wheat flour led to produce biscuits contained higher dietary fiber than control in a linear relation.

Color Characteristics:

Color characteristic is a major criterion that affects the quality of the final product. The fortified flours blends showed a difference in color compared to the control (100% wheat flour). The slight improvement in color was interpreted as an intense color and it was dependant on the fortification level. Mean color values of biscuit and pan bread of different treatments are recorded in Tables (6, 7 and 8).

Table 6: Color characteristics of biscuit samples.

Samples	*L*	*a*	*b*	C*	H*
Control	54.40	11.48	20.54	23.53	60.80
15% (MSG) + 85% wheat flour	50.88	11.71	18.66	22.03	57.89
30% (MSG)+ 70% wheat flour	48.55	11.98	16.42	20.33	53.88
45% (MSG)+ 55% wheat flour	44.84	12.22	14.56	19.01	49.99
15% (MWG)+ 85% wheat flour	50.25	11.75	18.84	22.20	58.05
30% (MWG)+ 70% wheat flour	48.24	12.03	16.73	20.61	54.28
45% (MWG)+ 55% wheat flour	45.02	12.51	13.00	18.04	46.10

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

Tables (7 and 8) shows Hunter values of whiteness (L), redness (a) and Yellow (b) measured for crumb and crust colors. All fortified samples had slightly lower L values for crust than the control and therefore a slightly darker crumb color. All breads incorporating milled mushroom micelles, had lower crust L values than the control, indicating darker color, its due to dietary fiber level increased. There results are in coincidence and confirmed with that obtained by Kenny *et al*., (2000); Saricoban and Yilmaz (2010).

Table 7: Color characteristics of pan bread crust samples.

Samples	L	A	B	C*	H*
Control	58.26	4.48	16.75	17.34	75.03
15% (MSG) + 85% wheat flour	50.18	8.64	17.37	19.40	63.55
30% (MSG)+ 70% wheat flour	53.77	8.80	18.21	20.22	64.21
45% (MSG)+ 55% wheat flour	50.10	6.33	16.10	17.30	68.54
15% (MWG)+ 85% wheat flour	46.75	6.64	15.81	17.15	67.22
30% (MWG)+ 70% wheat flour	40.95	9.70	16.04	18.75	58.84
45% (MWG)+ 55% wheat flour	34.34	10.45	14.63	17.97	54.46

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

Table 8: Color characteristics of pan bread crumb samples.

Samples	L	A	B	C*	H*
Control	68.35	2.32	15.63	15.80	81.56
15% (MSG) + 85% wheat flour	52.72	4.16	13.96	14.57	73.03
30% (MSG)+ 70% wheat flour	55.24	5.53	16.09	17.02	71.04
45% (MSG)+ 55% wheat flour	49.64	4.87	13.40	14.26	70.02
15% (MWG)+ 85% wheat flour	46.81	5.27	13.09	14.11	68.07
30% (MWG)+ 70% wheat flour	45.37	6.67	15.01	16.43	66.04
45% (MWG)+ 55% wheat flour	43.31	6.45	14.17	15.57	65.53

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains.

Increasing the percentage of added milled mushroom micelles to wheat flours, led the values of whiteness (L), redness (a), Yellow (b), chroma (C*) and hue angle (H*) to be slightly increased in all fortified samples. Subjective evaluations confirmed that the milled mushroom micelles biscuits and bread samples were darker, more red (a-values) than control samples. The results showed that the a-values (redness) increased in the fortified biscuit samples with the increasing of milled mushroom micelles level from 15% to 45% (Table 6, 7 and 8). The results are consistent with that obtained by Ahmed (1999) and Kenny *et al*., (2000).

Sensory Evaluation:

Sensory Characteristics of Biscuit:

The effects of mushroom micelles supplementation on the sensory characteristics of biscuits are presented in Table (9). With the increase in the level of mushroom micelles in the formulation, the sensory scores for color, shape, odor, taste and texture of biscuits decreased and increased sharply. Replacement of wheat flour with 15% and 45% of both types of milled mushroom micelles impaired the taste of biscuits (control samples had 9.5 score), which significantly decreased from 8.5 to 6.4 in MSG and from 8.2 – 5.9 in MWG, respectively. It may be due to the bitter taste of samples contained the tested milled mushroom micelles over 15% level. The control samples had maximum shape and color acceptability, whereas biscuits containing 15% addition of milled mushroom micelles were found to be unacceptable to the panelists in terms of color, shape, odor, taste and texture. The shape, color, taste and odor attributes score for control sample was 9.3, 9.8, 9.5, 10.0, and 9.8, respectively, on a 10-point hedonic scale. Biscuits made from blends containing 15% level of all types of milled mushroom micelles were in significantly ($p<0.05$) differ than the control. The color, odor, taste and texture of the 45% levels substitution was rated as poor and was significant differed then the control sample. Similar observations were also reported with supplementation of mushroom flour blends flour with wheat flour as reported by Essa, *et al*., (2007). Biscuits made from blends containing 30% level of milled mushroom micelles slightly difference at ($p<0.05$) compared to control. At 45% levels of substitution, the color, shape, odor, taste and texture acceptability was rated significantly poor. The milled mushroom micelles supplemented biscuits with 15 and 30% performed better in distribution of cell resemble the control. From the sensory acceptability rating, it was concluded that milled mushroom micelles could be incorporated up to 30% level in the formation of biscuits without affecting their sensory quality.

Table 9: Sensory evaluation of biscuit as affected by different levels of milled mushroom micelles flours.

Samples	Color	Shape	Taste	Odor	Texture	Cell distribution
Control	9.3^{a}	9.8^{a}	9.5^{a}	10.0^{a}	9.8^{a}	9.6^{a}
15% (MSG) + 85% wheat flour	8.9^{a}	9.5^{a}	8.5^{b}	9.5^{a}	9.4^{a}	9.4^{a}
30% (MSG)+ 70% wheat flour	8.0^{b}	9.4^{a}	7.2^{c}	9.1^{ab}	9.0^{b}	9.4^{a}
45% (MSG)+ 55% wheat flour	7.6^{bc}	9.4^{a}	6.4^{d}	8.0^{b}	8.5^{c}	9.2^{b}
15% (MWG)+ 85% wheat flour	8.8^{a}	9.6^{a}	8.2^{b}	9.4^{a}	9.5^{a}	9.5^{a}
30% (MWG)+ 70% wheat flour	7.8^{b}	9.5^{a}	6.9^{c}	9.1^{ab}	9.1^{b}	9.4^{a}
45% (MWG)+ 55% wheat flour	7.3^{bc}	9.2^{b}	5.9^{d}	7.8^{c}	8.4^{c}	9.1^{b}
L.S.D.	0.5	0.4	0.7	0.6	0.5	0.3

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains. Values in the same column followed by the same letter are not significant different at $P\leq0.05$.

Sensory Characteristics of Pan Bread:

The crust color, crumb color, general appearance, taste, odor, texture and cell distribution of pan bread loafs containing (MSG) and (MWG) milled mushroom micelles up to 15% were exhibited slightly differences than the control sample (table 10).

Table 10: Sensory evaluation of pan bread as affected by different levels of milled mushroom micelles flours.

Samples	Crust color	Crumb color	general Appearance	Taste	Odor	Texture	Cell distribution
Control	9.5^{a}	9.4^{a}	9.8^{a}	9.5^{a}	9.8^{a}	9.7^{a}	9.8^{a}
15% (MSG) + 85% wheat flour	9.1^{a}	9.2^{a}	9.5^{a}	9.0^{b}	9.2^{a}	9.5^{a}	9.5^{a}
30% (MSG)+ 70% wheat flour	8.6^{b}	7.5^{b}	9.2^{a}	7.9^{c}	8.2^{b}	8.5^{b}	9.6^{a}
45% (MSG)+ 55% wheat flour	7.5^{c}	6.0^{c}	8.0^{b}	5.5^{d}	7.0^{c}	6.5^{c}	8.5^{b}
15% (MWG)+ 85% wheat flour	9.0^{a}	9.1^{a}	9.6^{a}	8.9^{b}	9.1^{a}	9.5^{a}	9.6^{a}
30% (MWG)+ 70% wheat flour	8.3^{b}	7.4^{b}	9.1^{a}	7.5^{c}	7.9^{b}	8.6^{b}	9.3^{a}
45% (MWG)+ 55% wheat flour	7.4^{c}	5.8^{c}	7.9^{b}	4.9^{d}	6.8^{c}	6.1^{c}	8.0^{b}
L.S.D.	0.6	0.7	0.6	0.4	0.6	0.7	0.5

Where: (MSG) = Milled mushroom micelles grown on sorghum grains, (MWG) = Milled mushroom micelles grown on wheat grains. Values in the same column followed by the same letter are not significant different at $P\leq0.05$.

The sensory evaluation data demonstrated that wheat flour could be replaced up to 30% by both types of milled mushroom micelles to produce loaves had lower differences compared to control agreed with that found by Pena and Amaya, (1993); Doxastakis *et al*., (2002) and Naeem *et al*., (2002). There was a highly significant difference in all sensory properties of pan bread score between the control sample and those blends contained milled mushroom micelles up to 45% level. Pan bread prepared with both types of milled mushroom micelles at any level up to 30% addition received significantly higher scores for crust color, general appearance, taste, odor, texture and cell distribution with meanable acceptability. The obtained results indicated that mushroom micelles could constitute a good alternative for pan bread manufacture at a level of 15%.

Conclusions:

The results obtained indicated that milled mushroom micelles may be blended with wheat flour at levels as high as 15% without adversely affecting baking performance of pan bread, but with 30% of (MSG) or (MWG) samples were acceptable with slightly differences compared to control sample. While by addition of (MSG) or (MWG) to biscuits resulted in acceptable samples with slightly differences at 30% addition. However, the addition of milled mushroom micelles as a source of protein and dietary fibers to wheat flour affected the rheological, color and sensory characteristics of pan bread and biscuits in various ways. Pan bread and biscuits containing milled mushroom micelles (30%) were high in protein, dietary fibers and acceptable. The protein and dietary fibers composition of these samples showed that protein, which plays a very important role in improving rheological, technological and sensory properties of baking products, could be used for enriching the protein content of pan bread and biscuits. These studies have shown the potential for developing protein and dietary fibers-rich pan bread and biscuits.

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