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THE EFFECT OF MICROWAVE, AUTOCLAVE AND HOT AIR OVEN STABILIZED WHEAT BRAN SUBSTITUTION ON NUTRITIONAL AND SENSORIAL PROPERTIES OF FLAT BREADS

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Abstract:

The influence of stabilized wheat bran enrichment on the nutritional and sensorial properties of leavened and unleavened flat bread was studied. Wheat bran was stabilized with three applications (hot air oven, microwave and autoclave). The stabilization methods affected the physical characteristics of bazlama (thickness, spread factor) and yufka (diameter, thickness, spread factor) samples. In bazlama samples, substitution of stabilized wheat bran (SWB) lead to significant decrease in L* and increase in a* and b* values compared to the control bazlama. While autoclave and microwave stabilization methods are the most effective methods to decrease the phytic acid content for bazlama samples, for yufka samples; autoclave stabilization is the best. The mineral content (Ca, K, Mg, Mn, P, Fe and Zn) of bazlama and yufka samples significantly ($p<0.05$) increased with SWB substitution. Thus, autoclave stabilization could be used for wheat bran stabilization to improve the nutritional quality of bazlama and yufka samples.

Keywords: Stabilization, Wheat bran, Autoclave, Microwave, Flat bread

Introduction

Flat bread, the most widely consumed bread type in the world, made with flour, water and salt. Bazlama and yufka are two types of flat bread; bazlama is different from yufka because it is leavened and thicker and also have smaller diameter and shorter shelf life. Qarooni (1996) classified flat breads into two groups as single layered and double layered (pita, baladi, etc.), also single layered flat breads is consisted of two class as leavened (lavas, pide, barbari etc.) and unleavened (yufka, parotta, etc.). There are a lot of flat bread type studied like chapati, roti and taftoon (Iranian flat bread), two layered or single layered flat bread, bazari, leavened and unleavened flat bread, sangak, tanok and lavosh. (Reinhold, 1971; Başman and Köksel, 1999; Hariri et al., 2000; Nandini and Salimath 2001; Azizi et al., 2003; Brathen and Knutsen 2005; Izydorczyk et al., 2008). There has been considerable attention to a bread fortification all over the world. Fiber rich fractions used for the fortification of breads and flat breads (Izydorczyk et al., 2008; Izydorczyk and Mcmillan, 2011; Noort et al., 2010; Phimolsiripol et al., 2012; Wang et al., 2002). Flat breads is more suitable for fortification with fiber than pan breads because of more modest flour quality requirements (Qarooni et al., 1992). Wheat germ and bran substitution in flour is important to make flat bread processes especially dough rheology and sheeting of flat bread. The flat bread quality improves with flour extraction rate up to an optimum level of 82%, and also particle size of wheat bran is important paramater, therefore finest bran particles gave superior softness and smoother crust of flat bread (Qarooni, 1996).

Wheat bran, a by-product of dry milling of wheat grains for the production of white flour, is an important source of vitamins, good quality proteins (albumins and globulins) minerals (Ca, Fe, Zn, etc.), antioxidants and dietary fibre (Dexter et al., 1994a; 1994b). During the storage, rancidification can reduce the nutritional value of food (Waldemar, 1990; Thomas, 2005), and cause some quality changes, involving flavor, texture, and appearance (Eriksson, 1987). Due to the possibility of rapid rancidity there is a necessity for stabilization. For this purpose, microwave, autoclaving steaming, roasting, toasting, infrared heating, packaging and antioxidant treatment were applied (Allen and Hamilton, 1989; Frankel, 1995; Gardner, 1995; Srivastava et al., 2007). In our previous study, effect of stabilization treatments (microwave, infra-red and ultraviolet) to wheat kernel on the storage stability and qualitative properties of whole wheat flours were investigated**.** For this purpose, thio-barbituric acid (TBA) test was performed to indicate the extent of oxidative rancidity of the samples. In inhibition of rancid development of whole wheat flour, microwave treatment was found the most effective method (Elgün et al. 2012). In our other previous study, microwave heating and autoclaving of fine branny fractions into remixed whole wheat flours gave satisfactory storage stability, flour and bread qualities for 90 days' storage time compared with the untreated whole wheat flour (Elgün et al., 2011).

In this study the effects of addition different stabilization process applied wheat bran on nutritional and sensorial quality of leavened (bazlama) and unleavened flat bread (yufka) is determined.

Materials and Methods

Materials

Wheat bran was obtained from Altınapa Milling Trade Inc, Turkey, and then three different stabilization applications were applied to it. For using in bazlama and yufka production, wheat flour (ash: 0.57%, protein: 13.5%, Farinograph parameters; water absorption: 60%, development time: 6 min., stability: 10 min., softening degree 60 B.U., L*: 94.91; a*: -0.68; b*: 8.52), whole wheat flour (ash: 1.47% protein: 15.25%, Farinograph parameters; water absorption: 65.1%, development time: 7.1 min., stability: 4.6 min., softening degree 71 B.U., L*: 86.22; a*: 0.61; b*: 10.12), powder sugar, salt, yeast, were purchased local market in Konya, Turkey.

Stabilization processes

Wheat bran was stabilized with three different applications after milling with hammer mill with 0.5 mm sieve (Perten, LM 3100, Perten Instruments AB, Huddinge, Sweden). First application is applied in the hot air oven (HAO) at 150˚C for 20 min, and the second application is applied with domestic microwave oven (MW) at 800W for 3 min and third application (AC) is applied with autoclave bags in autoclave at 121˚C for 90 min to wheat bran. Then, SWB samples were cooled down in the tray about 30 min to reach room temperature. The samples were placed into the polyethylene bags and kept in a cooler. Each stabilization processes were applied in duplicate. And the mixture of these two batches was used for analysis.

Bazlama production

The bazlama and yufka were prepared according to the formulas in Table 1. Flat breads were prepared in triplicate and some modifications on dough were done according to the bazlama production method described by Akbaş (2000). Bazlama containing no bran and whole wheat flour were used as the control samples. In our *pre-trials*, wheat bran can be used at 15% level successfully for bazlama and yufka was determined. The ingredients of bazlama were mixed in a Hobart mixer (Hobart N50, Canada Instruments, and North York, Ontario, Canada) to obtain optimum dough development. Water absorption was determined using the Farinograph-E (Brabender GmbH and Co KG, Duisburg, Germany) equipped with a 300 g mixing bowl (AACCI 54-21, 2000). Water absorption of flat bread flour mix (with SWB) varied between 62.6 and 64.1% (HAO: 64.1%, MW: 63.2% and AUT: 62.6%). The highest water absorption was observed with flat bread flour mix fortified with hot air oven SWB. Fiber-rich fractions have ability to absorb considerable amounts of water (Kasprzak and Rzedzicki, 2010; Rosell et al., 2010).

Mixed dough was fermented at 30˚C and 85% relative humidity in Nüve KD 200 for 1 hour. After 1-hour fermenting, the dough was divided by hand into 2 equal parts. Each part rested at room temperature for 6 min. After 6 min resting, dough was flattened in trays into sheets of 17cm diameter and 10 mm thickness. The samples were baked with the preheated electric sac (1500W) for 8 min (for one surface 4 min, 4 min for the other surface). The loaves were measured after the bazlama was cooled down to room temperature. Bazlama samples were placed in polyethylene bags and stored at room temperature until tested.

Yufka production

Yufka doughs were prepared with some modifications in the method given by Başman and Köksel (2001). Yufka containing no bran and whole wheat flour were used as the control yufka samples. All yufka ingredients were mixed in a Hobart mixer (Hobart N50, Canada Instruments, and North York, Ontario, Canada) to obtain optimum dough development. Yufka dough divided into four equal pieces, shaped like a ball and rested at 30ºC for 30 min in order to gain enough water absorption for starch and proteins in dough after mixing, and then sheeted with the help of a hand rolling pin to 1 mm thickness. Sheeted dough pieces baked on preheated electric sac (Otm, San Ltd. Şti, Konya, Turkey) at 280±5ºC for 1 min. After baking, yufka samples were cooled at room temperature, and then placed in polyethylene bags.

Physical attributes

120 min after the baking, physical properties (color, diameter, thickness, spread ratio) of bazlama and yufka samples were evaluated. The bazlama and yufka surface color was measured instrumentally using a Minolta CR-400 (Konica Minolta Sensing, Inc., Osaka, Japan) colorimeter. The results were expressed in terms of L* (lightness), a* (redness to greenness) and b* (yellowness to blueness), according to the CIELab system. Hue angle ($\tan^{-1} b^* a^{*-1}$) and Saturation index (SI) ($(a^{*2} + b^{*2})^{1/2}$) of the samples were calculated from a* and b* values.

To measure the thickness of bazlama and yufka samples, a digital micrometer (0.001 mm, Mitutoyo, Minoto-Ku, Tokyo, Japan) was used. Diameter values were measured with an ordinary ruler. An average of six readings was recorded as bazlama and yufka diameter and thickness. Spread factor was then calculated as *diameter* divided by thickness of the bazlama and yufka samples.

Table 1. Formulation of bazlama and yufka samples (%)

Ingredients	Bazlama	Yufka
Wheat flour	100	100
Salt	1.5	1.5
Vital gluten	1.4	1.4
SSL	0.5	0.5
Powder sugar	1	-
Yeast	2.5	-
Stabilized wheat bran	15	15
Water	Variable	Variable

Chemical and nutritional properties

The bazlama and yufka samples were analyzed for their moisture, crude ash and crude protein using standard methods (AACC, 1990). An inductive coupled plasma atomic emission spectrometry (ICP-AES) (Vista series, Varian International AG, Zug, Switzerland) was used to determine the mineral (Ca, K, Mg, Mn, P, Na, Fe and Zn) contents of the bazlama and yufka samples (Bubert and Hagenah, 1987). Phytic acid and phytate phosphorus content of bazlama and yufka samples were determined by the method of Haugh and Lantzsch (1983). The sample was extracted by adding 10 mL 0.2 N Hydrochloric acid to 0.3 g sample and then shaking in shaker at room temperature for 3 hours. 0.5 mL of extracted sample was boiled with 1 mL ferric ammonium sulphate solution for half an hour, and then cooled. Phytate phosphorous in the supernatant was measured as the decrease in absorbance of iron content using 2 mL 2,2-bipyridine solution at 519 nm with a spectrophotometer (UV-Vis mini spectrophotometer 1240, Shimadzu, Kyoto, Japan).

Sensory properties

To determine sensory properties of bazlama and yufka samples, thirty-five panelists ranging in age from 25 to 40 with nonsmokers from Food Engineering Department at Necmettin Erbakan University in Turkey were asked to score the bazlama in terms of color/appearance, shape symmetry, taste/flavor, porosity and chewiness, the yufka in terms of color, shape symmetry, taste/flavor, tenderness and chewiness using 9-point hedonic scale with 1-2 dislike, 5 acceptable, 8-9 like extremely. The samples were assigned three digit random codes and served to the panelists. Each replicate was presented over 2 days to each panelist.

Statistical analysis

JMP statistical package software (Version 5.0.1.a, SAS Institute. Inc. Cary, NC, USA) was used to perform statistical analyses. Data were assessed by analysis of variance. Tukey HSD test was used to separate means. Significance was accepted at $p<0.05$ throughout the analysis.

Results and Discussion

Dimensions of SWB supplemented bazlama and yufka samples

Dimensions of SWB supplemented bazlama and yufka samples were shown in Table 2. Diameter values ranged between 15.3 - 15.6 cm cm for control bazlama and MW-SWB added bazlama samples respectively. There was not significant ($p>0.05$) difference between the bazlama samples in terms of diameter factor. But in yufka samples AC-SWB added yufka samples gave the highest diameter values. Thickness values of bazlama and yufka samples varied from 1.14 cm to 1.48 cm and 0.71 cm to 0.97 cm respectively. While SWB added bazlama samples gave statistically ($p<0.05$) lower thickness values compared to the control bazlama samples, spread factor of SWB added bazlama samples were higher than control and WWF control bazlama samples.

Loaf volume is the most effective parameters in the estimation of wheat and flour quality. In the study of Elgün et al. (2011), the positive effects of the MW and AC methods on loaf volume were determined and the highest spesific volume value was obtained with MW stabilized branny fraction flour mixes.

Bazlama samples made whole wheat flour gave lower spread factor than bazlama made with SWB. Levent and Bilgiçli (2012) stated that substitution of wheat flour with resistant starch increased the diameter and decreased the thickness when compared to the control bazlama, lavaş and yufka sample. While microwave SWB added yufka samples showed significantly similar thickness values with control yufka, hot air oven and AC-SWB added yufka samples showed the lowest thickness values among all yufka samples. In literature, the substitution of wheat bran and wheat germ fractions resulted in smaller volume or lesser thickness of biscuits and bread has been reported by Rao et al., (1980); Sidhu et al., (2001); Gomez et al., (2012) and Curti et al., (2013). It may be due to the weakened structure of bread dough diluted with non-gluten components such as wheat bran. ANOVA results showed a difference in the spread factor between control bazlama and SWB added bazlama samples, and also control yufka and SWB added yufka samples ($p<0.05$). The control bazlama and yufka samples showed lower spread factor values than SWB added bazlama samples. The highest spread factor values were observed with SWB by all stabilization methods added bazlama samples and autoclaved SWB added yufka samples.

Table 2. Dimensions of SWB supplemented bazlama and yufka samples

Bazlama samples		**Diameter (cm)**	**Thickness (cm)**	**Spread Factor**
Control bazlama		15.3 ± 0.37 a	1.48 ± 0.03 a	10.3 ± 0.05 c
Control WWF bazlama		15.4 ± 0.21 a	1.30 ± 0.03 b	11.9 ± 0.21 b
Stabilization process	**Hot air oven**	15.4 ± 0.44 a	1.20 ± 0.04 bc	12.8 ± 0.09 a
	Microwave	15.6 ± 0.41 a	1.14 ± 0.03 c	13.6 ± 0.02 a
	Autoclave	15.4 ± 0.51 a	1.16 ± 0.03 c	13.2 ± 0.12 a
Yufka samples		**Diameter (cm)**	**Thickness (cm)**	**Spread Factor**
Control yufka		39.6 ± 0.48 b	0.83 ± 0.04 b	47.7 ± 1.86 c
Control WWF yufka		39.7 ± 0.57 b	0.97 ± 0.01 a	40.9 ± 0.01 d
Stabilization process	**Hot air oven**	39.3 ± 0.52 c	0.75 ± 0.03 c	52.4 ± 1.28 b
	Microwave	37.3 ± 0.47 d	0.82 ± 0.01 b	45.5 ± 0.22 c
	Autoclave	43.1 ± 0.54 a	0.71 ± 0.03 c	60.7 ± 1.66 a

The means with the same letter in column are not significantly different ($p<0.05$). WWF: Whole wheat flour, SWB; Stabilized wheat bran

Color attributes of SWB supplemented bazlama and yufka samples

The bazlama color significantly decreased for lightness (L*) and hue angle values. Significant ($p<0.05$) increase in redness was observed with SWB addition compared to the control bazlama sample. Color values (L*, a* and b*) were measured as 66.14; 6.68 and 19.45 for HAO-SWB; 68.14; 6.28 and 18.35 for MW-SWB and 56.04; 7.84 and 20.39 for AC-SWB. The addition of SWB resulted in darker bazlama product that is attributed to the color changes brought about by the SWB substitution for wheat flour (Table 3). As expected, SWB colour intensity affected the colour of the end product, bazlama and yufka. It was also verified by Almeida et al., (2013) that wheat bran is the fibre source that has a greatest effect such as reducing lightness and hue angle, increasing chroma, making darker crumb color, due to its inherent color. Pınarlı et al., (2004) reported that microwave application on wheat germ, decreased the lightness, increased the redness values compared to the control samples. Demir and Elgün (2013) reported that stabilization applications such as autoclave and microwave on whole wheat flour increased the redness (a*) values of bread crumb and crust colour compared to the control samples. Autoclaved SWB addition gave the lowest lightness values to bazlama and yufka samples. Stabilization of wheat bran showed a decrease in yellowness and saturation index according to control whole wheat flour bazlama sample, but an increase according to control bazlama sample, and also control whole wheat flour bazlama gave the highest b* and saturation index values in all bazlama samples. In yufka samples, using whole wheat flour resulted in lower lightness and yellowness values.

Microwave treatment showed lower redness, yellowness and saturation index values of SWB added yufka samples than the other stabilization processes, while higher yellowness and saturation index values observed in AC-SWB added yufka samples than the other stabilization methods.

Chemical and nutritional properties of SWB supplemented bazlama and yufka samples

Crude ash, crude protein, phytate phosphorus and phytic acid analysis results of bazlama and yufka samples are presented in Table 4. It has been reported that wheat bran contains higher protein (13.65%), ash (4.32%), Ca (543 mg/100g), Cu (0.91 mg/100g), Fe (10.0 mg/100g), K (1388.6 mg/100g), Mg (334.9 mg/100g), Mn (7.39 mg/100g),P (640.9 mg/100g), Zn (5.10 mg/100g) and phytic acid (3116 mg/100g) content than wheat flour (Bilgiçli et al., 2006). According to results presented in Table 4, SWB added bazlama and yufka samples had higher crude ash, phytate phosphorus and phytic acid content in comparison to control bazlama and yufka samples. And also more ash content means more mineral content (Delahaye et al., 2005). This means that with SWB addition, the nutritional quality of bazlama and yufka improved. Similar crude ash amounts obtained with using whole wheat flour and SWB in flat breads. Other studies carried out wheat germ and wheat bran, several authors reported (Srivastava et al., 2007; Porres et al., 2003; Nandeesh et al.,

2011) that the ash content increase with microwave and autoclave treatments. Crude protein did not show statistically significant ($p<0.05$) differences, the sample shows 12.36%, 12.87% 12.45%, 12.81% and 12.64% for control, whole wheat flour control, hot air oven, microwave and autoclave SWB added bazlama respectively. Similar results had been reported by Demir and Elgün (2014). It may be due to a closer crude protein content of wheat flour and the SWB. Yadav et al., (2010) stated that stabilization treatments on whole wheat flour increase the dry matter, and also Moran et al., (1968) and Zhao et al., (2007) stated that microwave application increased the dry matter and also increased the ash content of applied to the product. But there were significant ($p<0.05$) differences among phytate phosphorus and phytic acid contents of bazlama and yufka samples according to stabilization process. Bazlama samples gave lower phytic acid and phytate phosphorus content than yufka samples, this is due to phytase activity of bakers' yeast containing of bazlama. In general, yeast addition results in an intensive degradation of phytic acid (Lasztity and Lasztity, 1990). It is believed that foods is higher nutritional value due to the containing a minimum amount of phytic acid as an anti-nutritional compound. Microwave and autoclave stabilization processes showed higher loss of phytate phosphorus and phytic acid content of bazlama samples than hot air oven stabilization process. Therefore, autoclave treatment in SWB added yufka samples as shown in the present study seems to be an effective treatment to decrease phytate among all stabilization processes. A research studied by Özkaya (2004), coarse and fine wheat bran samples were dephytinised with three different methods (by adding yeast, by adding malt flour, by applying autoclaving process) and investigated the changes of phytic acid and phytate phosphorus ratios. Among three methods, the highest phytic acid degradation was achieved through autoclaving method (Özkaya, 2004). Demir and Elgün (2014) stated that the best reduction of the phytic acid content were obtained by autoclave and microwave stabilization methods among all stabilization methods due to the thermal process (autoclave, microwave, IR and UV-C). Also Sharma and Sehgal, (1992) reported that phytic acid is relatively heat stable, for its destruction; prolonged autoclaving process can be apply effectively.

Table 3. Color attributes of SWB supplemented bazlama and yufka samples

Bazlama samples		L*	a*	b*	Saturation index	Hue angle
Control bazlama		75.21 ± 0.31 a	1.44 ± 0.16 c	8.03 ± 0.13 d	8.72 ± 0.20 d	79.83 ± 0.92 a
Control WWF bazlama		70.39 ± 0.24 b	3.81 ± 0.05 b	22.82 ± 0.10 a	24.65 ± 0.13 a	80.54 ± 0.08 a
Stabilization process	**Hot air oven**	68.59 ± 0.37 c	5.26 ± 0.21 a	21.15 ± 0.16 b	23.63 ± 0.25 b	76.03 ± 0.44 b
	Microwave	69.27 ± 0.71 bc	4.78 ± 0.28 a	20.43 ± 0.18 c	22.69 ± 0.31 c	76.83 ± 0.64 b
	Autoclave	63.35 ± 0.58 d	5.34 ± 0.23 a	20.02 ± 0.11 c	22.53 ± 0.21 c	75.07 ± 0.52 b
Yufka samples		**L***	**a***	**b***	**Saturation index**	**Hue angle**
Control yufka		83.72 ± 0.23 a	1.95 ± 0.33 b	18.74 ± 0.20 a	19.69 ± 0.35 a	84.06 ± 0.92 a
Control WWF yufka		81.56 ± 0.61 c	2.58 ± 0.31 a	14.25 ± 0.21 d	15.49 ± 0.36 d	79.74 ± 1.06 d
Stabilization process	**Hot air oven**	82.25 ± 0.41 b	2.43 ± 0.25 a	14.91 ± 0.18 c	16.08 ± 0.30 c	80.74 ± 0.84 c
	Microwave	82.73 ± 0.51 b	2.12 ± 0.20 b	14.34 ± 0.18 d	15.36 ± 0.28 d	81.59 ± 0.67 b
	Autoclave	78.55 ± 0.47 d	2.40 ± 0.34 a	15.27 ± 0.16 b	16.43 ± 0.31 b	81.07 ± 1.15 bc

The means with the same letter in column are not significantly different ($p<0.05$). WWF: Whole wheat flour, SWB; Stabilized wheat bran

Table 4. Crude ash, crude protein, phytate phosphorus and phytic acid content of SWB supplemented bazlama and yufka samples

Bazlama samples		Crude ash (%)	Crude protein (%)	Phytate phosphorus (mg/100g)	Phytic acid (mg/100g)
Control bazlama		1.68 ± 0.03 b	12.36 ± 0.14 a	16.58 ± 7.00 c	58.80 ± 24.82 c
Control WWF bazlama		2.62 ± 0.04 a	12.87 ± 0.16 a	218.00 ± 4.75b	773.03 ± 16.85b
Stabilization process	Hot air oven	2.35 ± 0.04 a	12.45 ± 0.14 a	257.02 ± 3.22 a	911.40 ± 11.41 a
	Microwave	2.39 ± 0.06 a	12.81 ± 0.11 a	221.49 ± 9.00 b	785.40 ± 31.90 b
	Autoclave	2.37 ± 0.04 a	12.64 ± 0.08 a	212.01 ± 4.67 b	751.80 ± 16.57 b
Yufka samples		**Crude ash (%)**	**Crude protein (%)**	**Phytate phosphorus (mg/100g)**	**Phytic acid (mg/100g)**
Control yufka		1.62 ± 0.03 c	11.85 ± 0.17 b	66.33 ± 6.23 e	235.20 ± 22.10 e
Control WWF yufka		2.48 ± 0.01 a	12.58 ± 0.11 a	231.58 ± 4.24 c	821.18 ± 15.02 c
Stabilization process	Hot air oven	2.22 ± 0.06 b	12.33 ± 0.13 a	281.89 ± 7.47 a	1003.79 ± 26.49 a
	Microwave	2.30 ± 0.04 b	12.53 ± 0.10 a	267.68 ± 8.42 b	949.20 ± 29.87 b
	Autoclave	2.27 ± 0.03 b	12.49 ± 0.16 a	214.38 ± 9.81 d	760.20 ± 34.80 d

The means with the same letter in column are not significantly different ($p<0.05$). Values are based on dry matter. WWF: Whole wheat flour, SWB; Stabilized wheat bran

Table. 5 Mineral content of SWB supplemented bazlama and yufka samples(mg/100g)

Bazlama samples		Calcium	Potassium	Magnesium	Manganese
Control bazlama		24.52 ± 1.19 c	231.30 ± 1.22 d	32.92 ± 1.15 d	0.78 ± 0.04 c
Control WWF bazlama		39.76 ± 1.53 ab	477.90 ± 2.13 ab	56.26 ± 1.18 c	1.41 ± 0.08 b
Stabilization process	Hot air oven	37.92 ± 1.40 a	461.97 ± 1.27 b	120.10 ± 1.20 a	2.49 ± 0.04 a
	Microwave	43.45 ± 1.12 b	482.24 ± 1.16 c	129.34 ± 1.07 b	2.67 ± 0.03 a
	Autoclave	41.58 ± 1.20 ab	474.21 ± 1.15 a	128.22 ± 1.22 a	2.62 ± 0.05 a
Yufka samples		**Calcium**	**Potassium**	**Magnesium**	**Manganese**
Control yufka		25.55 ± 1.50 e	224.68 ± 1.13 e	35.36 ± 1.33 e	0.83 ± 0.04 d
Control WWF yufka		40.28 ± 1.46 c	411.36 ± 1.32 c	53.12 ± 1.27 d	1.56 ± 0.04 c
Stabilization process	Hot air oven	32.63 ± 1.15 d	389.34 ± 1.24 d	104.54 ± 1.22 c	2.16 ± 0.04 b
	Microwave	44.65 ± 1.41 a	418.62 ± 1.12 a	114.47 ± 1.19 a	2.35 ± 0.04 a
	Autoclave	41.54 ± 1.32 b	414.74 ± 1.27 b	111.55 ± 1.29 b	2.33 ± 0.03 a
Bazlama samples		**Sodium**	**Phosphorus**	**Iron**	**Zinc**
Control bazlama		686.03 ± 2.15 b	200.45 ± 1.81 d	2.32 ± 0.10 c	0.79 ± 0.03 c
Control WWF bazlama		656.54 ± 4.65 c	207.03 ± 2.39 d	2.86 ± 0.03 a	2.24 ± 0.04 a
Stabilization process	Hot air oven	749.74 ± 2.36 a	409.83 ± 1.92 a	3.48 ± 0.11 a	1.55 ± 0.02 b
	Microwave	756.69 ± 3.51 a	438.73 ± 1.87 c	3.82 ± 0.11 a	1.63 ± 0.03 b
	Autoclave	754.83 ± 3.34 a	418.90 ± 1.75 b	3.51 ± 0.13 a	1.62 ± 0.02 b
Yufka samples		**Sodium**	**Phosphorus**	**Iron**	**Zinc**
Control yufka		611.98 ± 4.58 b	224.44 ± 1.97 e	2.36 ± 0.11 e	0.86 ± 0.02 e
Control WWF yufka		471.01 ± 1.91 d	226.34 ± 1.57 d	3.64 ± 0.10 b	2.11 ± 0.03 a
Stabilization process	Hot air oven	578.52 ± 4.44 c	345.97 ± 1.88 c	2.91 ± 0.11 d	1.35 ± 0.03 d
	Microwave	631.78 ± 3.35 a	394.88 ± 1.68 a	4.80 ± 0.13 a	1.45 ± 0.04 b
	Autoclave	629.96 ± 3.45 a	370.33 ± 1.77 b	3.27 ± 0.13 c	1.42 ± 0.03 c

The means with the same letter in column are not significantly different ($p<0.05$). Values are based on dry matter. WWF: Whole wheat flour, SWB; Stabilized wheat bran

Substitution of wheat bran for wheat flour, the mineral elements particularly calcium, potassium, magnessium, manganese, sodium, phosphorus, iron and zinc content was increased and improved the nutritional quality characteristics of bazlama and yufka samples.

It is normally expected that the mineral content of wheat bran was relatively high, Ca, K, Mg, Mn, Na, P, Fe and Zn values of bazlama and yufka enriched with SWB samples were found to be high as well. Hot air oven, microwave and autoclave stabilization of wheat bran showed significantly ($p<0.05$) similar manganese, sodium, iron and zinc contents of bazlama samples. Microwave stabilization process showed the lower calcium, potassium, magnesium and phosphorus content of bazlama samples among all stabilization processes, also in yufka samples the highest calcium, potassium, magnesium, phosphorus and iron content obtained with microwave SWB added yufka samples. In literature ultraviolet, autoclave, infrared and microwave applications increase or protect the mineral content of food products (Mccurdy, 1992; Yue et al., 1998; Porres et al., 2003; Nandeesh et al., 2011; Demir and Elgün 2014). Also Porres et al., (2003) reported that autoclave stabilization application (at 120°C, 101325,01 Pa, 30 min) on lentil increased the ash content from 3.4 to 3.5%, and, consequently the calcium content increased from 691 to 736 mg/kg.

Sensorial attributes of SWB supplemented bazlama and yufka samples

Faridi and Rubenthaler (1984) made quality classification for pita breads. Homogeneity of upper and under surfaces; soft, moist, shiny and white crumb; glossy gold brown colored crust; high specific volume and low reological value comes from the criteria used in quality classification for pita. But there is no scientific classification and for bazlama and yufka breads. Pita, leavened and double layered flat bread, is different from bazlama (single layered) and yufka (unleavened) among the flat breads.

Figure 1A presented the hedonic sensory evaluation scores for the parameters of color/appearance, shape/symmetry, taste/flavour, porosity and chewiness for bazlama samples. Substitution of SWB by different stabilization processes with wheat flour significantly ($p<0.05$) affected the sensory properties of bazlama and yufka samples. The best color/appearance was achieved by control bazlama, however SWB addition in bazlama formulation lowered the surface color/appearance scores of bazlama. This may be due to the natural color of wheat bran directly affected the color of flat breads. Control and hot air oven SWB added bazlama samples gave similar and higher shape/symmetry scores than the other bazlama samples. Control bazlama possessed the highest scores for color appearance. All stabilization methods gave significantly ($p<0.01$) similar and lower color/appearance scores than control bazlama and whole wheat flour control sample. Supplemantation of hot air oven SWB gave the best shape/symmetry properties among all bazlama samples include the control samples.

Porosity scores significantly ($p<0.05$) decreased by substitution of SWB with different stabilization processes, moreover, the lowest porosity and taste/flavour scores obtained with microwave SWB bazlama. The panellists gave the highest chewiness score for bazlama substituted with autoclave SWB. Also Yildiz and Bilgiçli (2012) reported that addition of whole wheat flour positively affected the chewiness and elasticity of the lavaş and higher elasticity and chewiness scores obtained with 40% whole buckwheat flour addition level than control sample. Caprez et al., (1986) stated that the largest effects of the thermal treatments of wheat bran were rheological changes observed in the Farinograph. Figure 1B presented color, shape/symmetry, taste/flavour, tenderness and chewiness for yufka samples. Figure 1B showed that surface color of hot air oven SWB added yufka sample did not differ from control sample and they were evaluated as better than other yufka samples. Except the microwave SWB added yufka samples, all the yufka samples gave similar shape/symmetry scores. It was observed that microwave SWB addition in yufka showed the adverse effect on color, shape/symmetry, taste, tenderness and chewiness characteristics and also hot air oven and autoclave stabilization processes demonstrated similar and better sensory characteristics than microwave stabilization process. But according to taste, tenderness, and chewiness, control yufka sample showed the highest scores in all yufka samples.

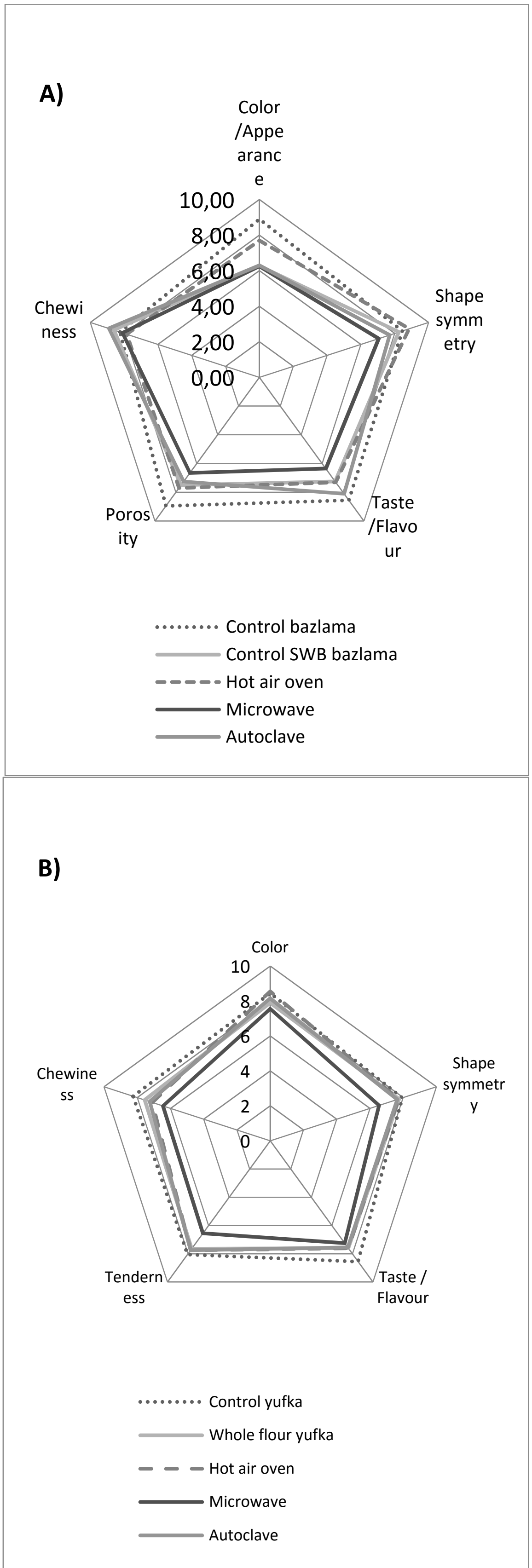

Figure 1. A) Sensory attributes of SWB supplemented bazlama and B) yufka samples

Conclusion

Dimensions (diameter, thickness and spread factor) and color attributes (L*, a*, b*, SI and Hue angle) of the yufka samples were significantly influenced by the substitution of SWB. Stabilization processes statistically ($p<0.05$) affected color properties of bazlama samples, but whole wheat flour control bazlama sample gave the highest b* values of bazlama in all bazlama samples. Higher crude ash, phytate phosphorus content in comparison to control bazlama and yufka samples were observed with SWB added bazlama and yufka samples. The higher loss of phytate phosphorus and phytic acid contents of bazlama samples were achieved by microwave and autoclave stabilization processes than hot air oven stabilization process. The autoclave treatment had a greater effect on the phytic acid loss of yufka samples than those of stabilization processes. This study demonstrated that hot air oven SWB added bazlama samples gave higher shape/symmetry scores than the other bazlama samples substituted SWB by other stabilization treatments for wheat flour. Autoclave SWB substitution can be good alternative to improve the nutritional properties of flat breads.

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