Selcuk Journal of Agriculture and Food Sciences

http://sjafs.selcuk.edu.tr/sjafs/index

Research Article

SJAFS
(2019) 33 (1), 7-13
e-ISSN: 2458-8377
DOI: 10.15316/SJAFS.2019.149

Improvement of Physical and Sensory Properties of Bread Containing Cereal-Legume Composite Flour

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ARTICLE INFO

Article history:
Received date: 27.02.2019
Accepted date: 12.03.2019

Edited by:
Cemalettin SARIÇOBAN; *Selçuk University, Turkey*

Reviewed by:
Sultan ARSLAN TONTUL; *Selcuk Universiy, Turkey*
Ayşe Büşra MADENCİ; *Necmettin Erbakan University, Turkey*

Keywords:
Additives
Bread
Cereal
Flat bread
Legume

ABSTRACT

In this study, cereal-legume flour blend (CLFB) containing an equal amount of cereal (rye, barley and oat) and legume (chickpea, soy and lupin) were used in the formulations of commercial bread (CB) and traditional flat bread (TFB) at 25% level. The adverse effect of CLFB on technological quality of breads was tried to eliminate using different combinations of additives (vital gluten, fungal alpha amylase, sodium stearoyl-2-lactylate, ascorbic acid, transglutaminase, glucose oxidase, lipase, pentosanase and xylanase) in both breads. Combinations with vital gluten, sodium stearoyl-2-lactylate, fungal alpha amylase, ascorbic acid and xylanase or pentosanase provided the highest bread specific volume along with CB prepared with 100% wheat flour. The additive combination including xylanase also revealed the lowest hardness in CB, as well as resulted in a decrease in the spread ratio and hardness values of TFB. Crust colour values (L^*, a^* and b^*) were significantly ($P<0.05$) affected by all of the additive combinations in both CB and TFB. The combinations containing pentosanase or xylanase displayed a better improvement on the pore structure, appearance and overall acceptability scores of CB and TFB including 25% CLFB in comparison to other additives.

1. Introduction

Cereals such as rye, barley and oat are of great sources of carbohydrates, proteins, dietary fibres, phytochemicals, minerals and vitamins (B-complex and E) (Slavin, 2004). Legumes (chickpea, soy, lupin, etc.) have a remarkably high protein content, along with a good amount of lipid, dietary fibres, vitamins and minerals such as Ca, Fe, Zn, Mg, P and K (Garcia et al., 1997). Due to the rich nutritional composition of whole flours of cereals and legumes, they are used as functional ingredients in food formulations such as bread. Most common diseases such as obesity, diabetes, heart diseases and some type of cancer are associated with an unhealthy diet which lacks the beneficial nutrients for consumption. A number of studies have suggested that a high intake of whole flours of cereal and legume in diet might have a positive effect on human health and prevention of the diseases mentioned (Belski, 2012; Malkki and Virtanen, 2001). Although the nutritional and functional properties of breads improve in the presence of whole flours of cereal and legume, the technological properties of the end product are partially lost. Therefore, using some additives (vital gluten, oxidants, emulgators and enzymes) can help enhance the technological quality of the end-product.

Unique visco-elastic properties of vital wheat gluten improve bread volume and dough strength as well as mixing tolerance and handling properties of dough. It increases shelf life of the bread by increasing the water holding capacity of dough and gives softness to bread. Hence, vital gluten allows to enhance the nutritional value of refined wheat bread with various cereal and legume flours and renders it acceptable for consumers (Day et al., 2006).

Sodium stearoyl-2-lactylate (SSL) is an emulgator that is used as an anti-staling and dough improving agent (Stampfli and Nersten, 1995). Van Steertegem et al. (2013) reported that SSL interacts with gluten and strengthen dough structure. Ascorbic acid (AA) is another bread improving agent that also possess an anti-staling effect (Gujral et al., 2003).

Fungal alpha amylase (FAA), transglutaminase (TG), glucose oxidase (GO), lipase, pentosanase and xylanase are enzymes which can be used in bakery industry to enhance bread quality. FAA reduces staling

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rate, increases bread volume and improves handling properties, pore structure, crust and crumb colour (Maeda et al., 2003). TG enzyme changes chemical and functional properties of glutenin fraction and improves dough properties. Numerous studies have been reported that TG is used as a dough strengthener, loaf volume and crumb softness enhancer, handling properties improver (Gerrard et al., 1998; Seravalli et al., 2011). GO is an enzyme that catalyses D-glucose to D-gluconic acid and hydrogen peroxide. The hydrogen peroxide causes the formation of disulfide bonds and increases gelling properties of water-soluble pentosanes (Gujral and Rosell, 2004). Zeng et al. (2011) showed that alpha amylase and GO enzymes improved specific volume and pore structure of bread, with a delay in bread staling. Lipase enzyme provides in the formation of emulgators by hydrolyzing lipids. This enzyme has an anti-staling effect, and it improves rheological properties of dough, as well as increases bread volume (Castello et al., 1998; Olesen et al., 2000). Pentosanase hydrolyses high molecular weight arabinoxylans and affects dough and bread quality, provides a higher specific volume, softer dough structure and more sulphydryl groups (Rouau and Surget, 1998; Steffolani et al., 2010). Xylanase increases moisture content, volume, specific volume and overall acceptability while used in breadmaking (Shah et al., 2006). Hemalatha et al. (2014) reported that xylanase and amylase enzyme combination delays bread staling and alters rheological properties of bread.

The main objective of this study is therefore to evaluate the effects of different additive combinations on the physical and sensory properties of commercial bread (CB) and traditional flat bread (TFB) including 25% of cereal-legume flour blend (CLFB).

2. Materials and Methods

2.1. Materials

Wheat flour (commercial wheat flour contains 0.79% ash and 12.41% protein), baker's yeast, salt, chickpea and defatted whole soy flour were purchased from a local market in Konya, Turkey. Hull-less barley, hull-less oat and rye were obtained from Sağlık Tarım (Konya, Turkey). Traditionally debittered lupin seeds were provided by Doğanhisar, Konya, Turkey. Cereals and legumes (except soy) were milled (<500 µm) on a hammer mill (Perten 3100, Huddinge, Sweden) with 100% extraction ratio. Vital gluten, FAA, SSL, AA, TG, GO, lipase, pentosanase and xylanase were supplied from Vatan Gıda (İstanbul, Turkey).

2.2. Preparation of CLFB and bread samples

CLFB was prepared by mixing an equal amount of barley, oat, rye, soy, chickpea and lupin flours. CLFB was replaced with refined white wheat flour of 25% ratio (w/w) for preparation of bread formulations.

For the preparation of control-1 (C1) CB; 100 g wheat flour, 3 g baker's yeast, 1.5 g salt and water (determined by the farinograph absorption) kneaded in the mixer (Kenwood KMX750RD, Hampshire, UK) until obtaining a homogenous dough. The dough was left in bulk to fermentation (30+30 min, 30°C) and then rest at 30°C for 60 min. At the end of this period, dough samples were baked at 240°C for 15 min in an oven (Beko MF6, İstanbul, Turkey). In control-2 (C2) CB sample, wheat flour was replaced with CLFB of 25% ratio. To produce CB with 25% of CLFB and additives (from C3 to C9); vital gluten (2.5%), FAA (0.003%), SSL (0.5%), AA (0.01%), TG (0.5%), GO (0.001%), lipase (0.001%), pentosanase (0.004%) and xylanase (0.004%) were supplemented into bread formulations. Table 1 shows the enzyme combinations used in this study. The same procedure applied for C1 was also employed for C2-C9 CB.

Table 1
Combinations of additives used in CB[1] and TFB[2] formulations.

Formulations	Combinations of additives
C1 (Control-1)	0 % CLFB[3] (without additives)
C2 (Control-2)	25 % CLFB (without additives)
C3	25 % CLFB (Gluten+SSL[4]+FAA[5])
C4	25 % CLFB (Gluten+SSL+FAA+AA[6])
C5	25 % CLFB (Gluten+SSL+FAA+TG[7])
C6	25 % CLFB (Gluten+SSL+FAA+GO[8])
C7	25 % CLFB (Gluten+SSL+FAA+Lipase)
C8	25 % CLFB (Gluten+SSL+FAA+AA+Pentosanase)
C9	25 % CLFB (Gluten+SSL+FAA+AA+Xylanase)

[1]CB: Commercial bread. [2]TFB: Traditional flat bread. [3]CLFB: Cereal-legume flour blend. [4]SSL: Sodium stearoyl-2-lactylate. [5]FAA: Fungal alpha amylase. [6]AA: Ascorbic acid. [7]TG: Transglutaminase. [8]GO: Glucose oxidase

TFB was prepared according to the method given by Akbaş (2000). For the preparation of C1 TFB; 100 g wheat flour, 2.5 g baker's yeast, 1.5 g salt, 1 g sugar and water were kneaded until obtaining a homogeneous dough. After the dough was allowed to ferment at 30°C for 60 min, dough rounded into a ball shape and allowed to rest for 6 min at room conditions. The dough was flattened to the final thickness of 10 mm by a stainless steel circle of 17 cm diameter and then baked for 5 min on sac (metal plate heated by electrical resistances, 1500 W). To produce C2 TFB; wheat flour was replaced with 25% of CLFB. The enzyme combinations given in Table 1 were used from C3 to C9 TFB. The same method that was used in C1 TFB was also applied for the production of C2-C9 TFB.

2.3. Bread analyses

All bread samples were cooled at the room temperature (25±2°C) for 60 min, then the weight and volume of CB was measured (Elgün et al., 2001). The specific volume of CB was calculated by dividing the volume value by the weight. Diameter and thickness values of TFB samples were measured. The spread ratio was obtained by dividing the diameter values to the thickness values. Colour values (L^*, a^* and b^*) of breads were obtained by the colourimeter Minolta CR 400 (Konica Minolta Inc., Osaka, Japan). Saturation index (*SI*) was calculated by $(a^{*2}+b^{*2})^{1/2}$ formula and *hue* angle (if $a^*>0$ and $b^*>0$, arctan $[b^*/a^*]$; if $a^*<0$ and $b^*>0$, arctan $[b^*/a^*] + 180°$) was calculated using a^* and b^* values (Francis, 1998). Hardness values of both breads were measured using an aluminum 36 mm diameter cylindrical probe (P36/R) via a texture analyzer (Stable Micro Systems TA-XT.Plus, Surrey, UK) according to AACC 74-09 method at the end of 24 h and 72 h (Anon., 2002).

Sensory evaluation of the bread samples was performed by 25 panellists from the Food Engineering Department of Necmettin Erbakan University. Sensory properties (symmetry, pore structure, taste, odour, appearance and overall acceptability) of breads were evaluated using the hedonic scale 1-7 (1= dislike very much, 7 = like very much).

JMP (SAS Institute Inc., NC, USA) software was used to perform the statistical analyses. The averages of the data obtained were compared with each other and listed in the tables. All analyses were the average of triplicate measurements on the duplicate samples.

3. Results and Discussion

Physical properties of CB are presented in Table 2. Volume and specific volume of C2 CB reduced in comparison to C1 CB. The utilisation of 25% of CLFB in bread formulation decreased the bread volume due to the diluted gluten content as well as deterioration of the gluten network with CLFB. All the additive combinations had a positive effect on the volume and specific volume of breads compared to C2 CB. Combination of "vital gluten, SSL and FAA" (C3) markedly improved bread volume compared to C2 CB. SSL is considered as a dough strengthener and an emulsifier agent which provides a high volume and specific volume due to the formation of lamellar liquid films at the interfaces between starch and gluten (Gomes-Ruffi et al., 2012). FAA improves the gas holding capacity of dough during fermentation, thus it can increase the bread specific volume (Leon et al., 2002). At the same time, the combinations of "vital gluten, SSL, FAA, AA and pentosanase" (C8) and "vital gluten, SSL, FAA, AA and xylanase" (C9) provided the highest volume and specific volume results among additive combinations. Xylanase increases water absorption by dissolving water-insoluble arabinoxylan, thereby improves bread volume (Jeffries et al., 1998). The hardness values of at the end of 24 and 72 h have varied in the range of 2004 to 5321 g and 3059 to 5975 g, respectively. C8 and C9 showed a most positive effect on the hardness of CB. Similar results were also reported by Caballero et al. (2007) who studied the effects of enzyme combination (amylase and xylanase) on dough rheology, bread quality and shelf-life.

Table 2
Physical properties of CB samples.[1]

Formulations	Weight (g)	Volume (ml)	Specific volume (ml/g)	Hardness 24 h (F, g)	Hardness 72 h (F, g)
C1	139±0.85^{c}	372±2.83^{a}	2.67±0.03^{a}	2726±8.7^{e}	3555±9.3^{f}
C2	143±0.85^{a}	255±1.41^{f}	1.78±0.05^{d}	5321±8.3^{a}	5975±10.5^{a}
C3	142±0.42^{abc}	322±1.41^{e}	2.28±0.04^{c}	3181±8.7^{c}	4499±8.1^{b}
C4	141±0.57^{abc}	337±0.71^{c}	2.39±0.04^{bc}	3103±4.9^{d}	4335±9.2^{c}
C5	141±0.71^{abc}	325±1.41^{de}	2.30±0.06^{c}	3250±11.1^{b}	4521±10.9^{b}
C6	142±0.57^{abc}	327±2.83^{de}	2.31±0.06^{c}	3062±9.9^{d}	3871±16.2^{d}
C7	142±0.57^{ab}	330±0.71^{cd}	2.33±0.03^{c}	2695±15.3^{e}	3752±9.6^{e}
C8	141±0.42^{bc}	355±1.41^{b}	2.52±0.02^{ab}	2090±9.8^{f}	3132±12.5^{g}
C9	140±0.42^{bc}	362±2.83^{b}	2.58±0.05^{a}	2004±14.6^{g}	3059±12.5^{h}

[1]Means followed by the same letter within a column are not significantly different ($P < 0.05$). Values are the average of triplicate measurements on the duplicate samples. CB: Commercial bread.

Physical properties of TFB are given in Table 3. The diameter values of TFB have varied in the range of 15.22 to 16.58 cm. The combination of C3 demonstrated a very close diameter result to C1 TFB. However, C9 combination showed the lowest diameter value. Compared to C1 TFB, replacement of wheat flour with CLFB was significantly ($P<0.05$) reduced thickness value of C2 TFB. On the other hand, the combinations of C8 and C9 provided the highest thickness values. The spread ratio values of TFB changed between 10.71 and 15.46. The combinations of "vital gluten, SSL, FAA and AA" (C4), "vital gluten, SSL, FAA and lipase" (C7), C8 and C9 presented lower spread ratio values than C1 TFB. This result may also be related to dough strengthener effects of AA, lipase, pentosanase and xylanase. In literature, there are many studies on improvement of dough with supplemented of these enzymes in bread formulations (Gujral et al., 2003; Olesen et al., 2000; Shah et al., 2006; Steffolani et al., 2010). The combinations of additives using in CB and TFB presented similar effects on hardness values of bread at the end of 24 h and 72 h. Compared to C2, the additives displayed significant ($P<0.05$) decrease in hardness values of TFB, at the end of 24 and 72 h. Armero and Collar (1998) found that a combination of SSL and alpha amylase revealed lower hardness values in bread than control. Similar results were obtained in studies with pentosanase (Renzetti et al., 2010), GO, amylase and xylanase (Caballero et al., 2007), gluten and TG (Gerrard et al., 1998; Salmenkallio-Marttila et al., 2004).

Table 3
Physical properties of TFB samples.[1]

Formulations	Diameter (cm)	Thickness (cm)	Spread ratio	Hardness 24 h (F, g)	Hardness 72 h (F, g)
C1	16.56±0.04^{ab}	1.21±0.04^{c}	13.70±0.05^{d}	5194±13.7^{d}	9483±12.6^{e}
C2	15.77±0.07^{e}	1.02±0.06^{d}	15.46±0.03^{a}	7223±13.4^{a}	14091±14.4^{a}
C3	16.58±0.04^{a}	1.18±0.04^{cd}	14.05±0.04^{c}	5744±9.8^{b}	10342±17.2^{b}
C4	16.39±0.04^{bc}	1.23±0.05^{bc}	13.30±0.05^{e}	4234±15.7^{i}	8588±12.3^{g}
C5	16.36±0.04^{c}	1.11±0.04^{cd}	14.69±0.06^{b}	5429±14.6^{c}	9897±15.7^{c}
C6	16.07±0.04^{d}	1.11±0.04^{cd}	14.54±0.04^{b}	5034±13.8^{e}	9307±10.6^{f}
C7	16.05±0.04^{d}	1.21±0.04^{c}	13.26±0.02^{e}	4920±11.5^{f}	9555±10.0^{d}
C8	15.58±0.03^{f}	1.39±0.04^{ab}	11.22±0.05^{f}	4510±11.5^{g}	7850±13.2^{h}
C9	15.22±0.03^{g}	1.42±0.04^{a}	10.71±0.06^{g}	4426±13.1^{h}	7405±10.9^{i}

[1]Means followed by the same letter within a column are not significantly different (P < 0.05). Values are the average of triplicate measurements on the duplicate samples. TFB: Traditional flat bread.

Colour values of CB are demonstrated in Table 4. Crust *L** values of CB changed between 54.32 and 65.94. All the additive combinations in CB caused lower crust *L** values than C1 and C2. Usage of 25% ratio of CLFB in C2 significantly (P<0.05) reduced crust *a** values of CB. The highest *a** values were obtained using the combinations of C3 or "vital gluten, SSL, FAA and GO" (C6) in CB. Compared to other bread samples, the combination of C9 (xylanase) showed more decrease in terms of crust *b** value in CB. It was reported that TG increased crust *L** and *b** values, GO and TG decreased *a** value, and xylanase enzyme showed a decrease on all of the colour parameters in wheat-soy breads compared to control bread (Roccia et al., 2012). Usage of C9 combination in CB resulted in the lowest *SI* and *hue* values. Usage of 25% CLFB increased crumb *L**, *a** and *b** values of CB, and so, the lowest crumb *L**, *a**, *b** and *SI* values were found in C1 CB. However, C1 CB had the highest *hue* values. Among additive combinations, C4 and C9 provided higher crumb *L** values and the combinations of C6 and C9 revealed greater result in terms of crumb *b** and *SI* values after C2 CB.

Table 4
Colour values of CB samples.[1]

Formulations	*L**	*a**	*b**	*SI*	*Hue*
Crust					
C1	61.98±0.04^{b}	9.85±0.04^{f}	30.54±0.06^{a}	32.09±0.04^{b}	72.12±0.10^{b}
C2	65.94±0.05^{a}	7.79±0.04^{g}	29.26±0.04^{d}	30.28±0.05^{e}	75.09±0.06^{a}
C3	57.98±0.06^{e}	12.87±0.02^{a}	29.87±0.04^{b}	32.52±0.05^{a}	66.70±0.01^{ef}
C4	60.00±0.06^{c}	12.10±0.03^{d}	29.54±0.06^{c}	31.92±0.04^{b}	67.73±0.08^{d}
C5	59.32±0.04^{d}	11.30±0.04^{e}	28.70±0.04^{e}	30.85±0.05^{d}	68.50±0.04^{c}
C6	56.22±0.06^{f}	12.92±0.03^{a}	28.48±0.04^{f}	31.27±0.03^{c}	65.60±0.08^{g}
C7	57.88±0.03^{e}	12.47±0.04^{c}	28.71±0.04^{e}	31.30±0.06^{c}	66.52±0.04^{f}
C8	56.21±0.04^{f}	12.20±0.04^{d}	28.52±0.06^{ef}	31.02±0.07^{d}	66.84±0.03^{e}
C9	54.32±0.04^{g}	12.65±0.03^{b}	27.07±0.06^{g}	29.88±0.06^{f}	64.95±0.00^{h}
Crumb					
C1	66.12±0.06^{g}	0.68±0.01^{d}	18.75±0.06^{f}	18.76±0.06^{f}	87.92±0.05^{a}
C2	67.13±0.05^{f}	2.12±0.06^{a}	20.89±0.05^{a}	20.99±0.04^{a}	84.20±0.17^{cd}
C3	69.26±0.04^{c}	2.06±0.05^{ab}	19.68±0.05^{c}	19.79±0.04^{c}	84.01±0.15^{d}
C4	70.01±0.02^{ab}	2.03±0.06^{ab}	19.05±0.04^{e}	19.16±0.05^{e}	83.92±0.15^{d}
C5	69.09±0.05^{cd}	2.13±0.04^{a}	19.66±0.04^{c}	19.78±0.05^{c}	83.82±0.11^{d}
C6	68.48±0.06^{e}	1.91±0.06^{b}	19.96±0.06^{b}	20.06±0.06^{b}	84.54±0.19^{c}
C7	69.06±0.05^{d}	2.07±0.04^{ab}	19.37±0.04^{d}	19.48±0.05^{d}	83.90±0.11^{d}
C8	69.91±0.06^{b}	1.70±0.03^{c}	19.75±0.04^{c}	19.82±0.04^{c}	85.09±0.08^{b}
C9	70.21±0.05^{a}	1.63±0.03^{c}	20.05±0.04^{b}	20.12±0.04^{b}	85.36±0.08^{b}

[1]Means followed by the same letter within a column are not significantly different (P < 0.05). Values are the average of triplicate measurements on the duplicate samples. CB: Commercial bread.

Crust colour values of TFB are reported in Table 5. Crust *L** values of TFB ranged between 55.19 to 68.72. The combinations of "vital gluten, SSL, FAA and TG" (C5) or C7 in TFB resulted in higher crust *L** values among all the additive combinations after C1 and C2 CB. The highest crust *a** values were observed in C6 and C9 TFB. Moreover, the combinations of C6, C7 and C9 resulted in higher crust *b** values in TFB than other additive combinations. Su et al. (2005) reported that *L**, *a** and *b** values of control bread were 90.49, 0.68 and 20.64, respectively, and the same values of bread containing xylanase were 88.26, 0.75 and 20.39, respectively. Crust *SI* and *hue* values of TFB changed between 26.31 and 30.04 and 64.14 and 81.40, respectively. C2 TFB had the lowest *SI* value, and also the highest *hue* result was obtained in C2. Compared to C2, the additive combinations increased *SI* values while decreased *hue* values in TFB.

Table 5
Crust colour values of TFB samples.[1]

Formulations	*L**	*a**	*b**	*SI*	*Hue*
C1	63.47±0.04[b]	10.55±0.05[f]	26.87±0.04[bc]	28.87±0.02[d]	68.57±0.11[b]
C2	68.72±0.04[a]	3.93±0.04[g]	26.01±0.04[e]	26.31±0.05[g]	81.40±0.07[a]
C3	57.23±0.11[e]	12.76±0.04[bc]	26.74±0.07[c]	29.63±0.08[b]	64.49±0.01[e]
C4	56.13±0.07[f]	12.07±0.04[d]	25.57±0.06[f]	28.27±0.04[e]	64.73±0.13[e]
C5	59.10±0.11[c]	11.19±0.04[e]	25.24±0.06[g]	27.61±0.03[f]	66.09±0.13[d]
C6	55.52±0.06[g]	13.10±0.06[a]	27.03±0.07[ab]	30.04±0.09[a]	64.14±0.04[f]
C7	59.12±0.07[c]	11.04±0.06[e]	26.94±0.04[abc]	29.11±0.06[cd]	67.72±0.07[c]
C8	57.67±0.07[d]	12.59±0.04[c]	26.43±0.05[d]	29.28±0.07[c]	64.53±0.02[e]
C9	55.19±0.05[h]	12.94±0.04[ab]	27.12±0.10[a]	30.05±0.11[a]	64.49±0.01[e]

[1]Means followed by the same letter within a column are not significantly different ($P < 0.05$). Values are the average of triplicate measurements on the duplicate samples. TFB: Traditional flat bread.

Sensory properties of CB are given in Figure 1. Generally, additive combinations positively influenced the pore structure, appearance and overall acceptability parameters in CB when compared to C2. Especially, the combinations of C8 with pentosanase and C9 with xylanase in CB provided a greater increase in terms of overall acceptability score in comparison to C2. Similar positive effects of xylanase on the sensory properties (symmetry, texture, flavour, taste and total score) were reported on whole wheat bread (Shah et al., 2006).

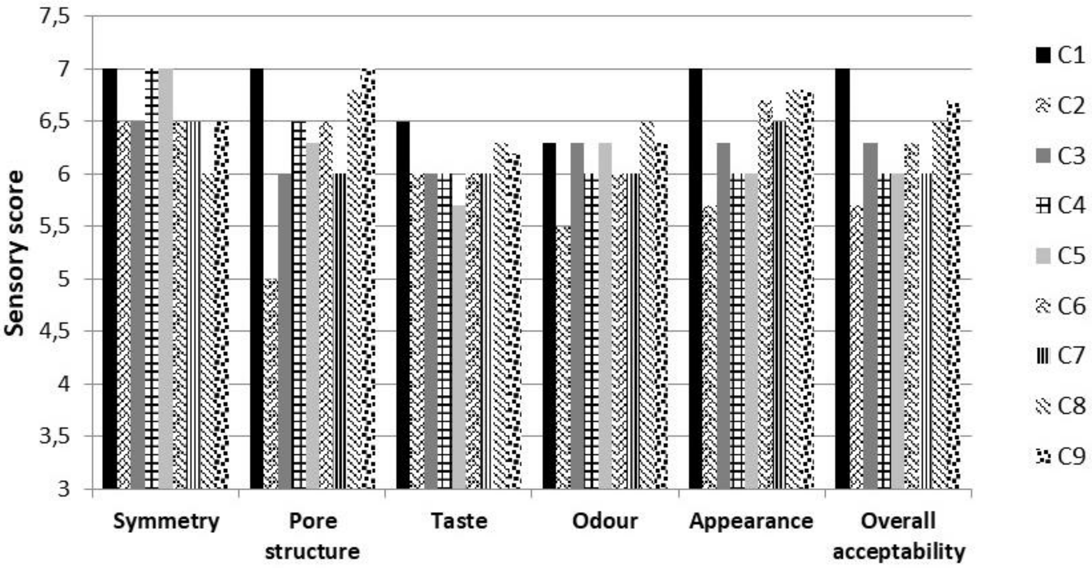

Figure 1
Sensory scores of CB samples.

Sensory properties of TFB are presented in Figure 2. The combination of C8 showed similar symmetry to C1 TFB. In terms of pore structure, appearance and overall acceptability, the additives displayed remarkably increase in TFB compared to C2. The highest overall acceptability scores were obtained with the combinations of C8 and C9 in TFB.

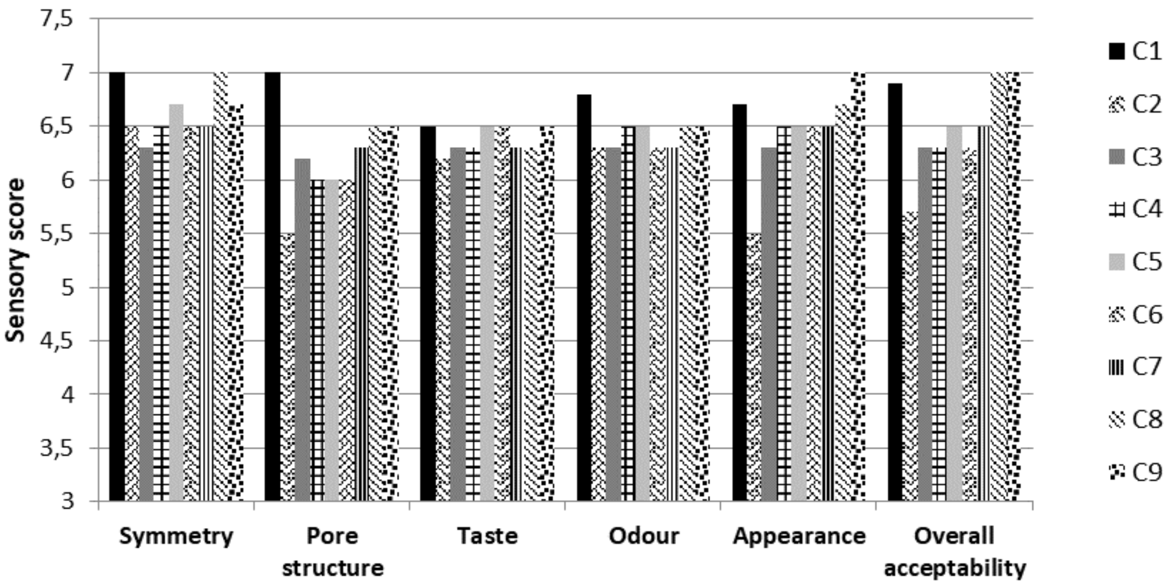

Figure 2
Sensory scores of TFB samples.

4. Conclusions

The utilisation of CLFB in bread formulation resulted in undesirable effects on some technological properties such as dough structure, volume and texture. Different additives were combined to overcome these effects and make the end products more acceptable by consumers. Among all the additive combinations, C8 and C9 had the greatest action on volume and specific volume parameters of CB. In addition, the combination of C9 showed the lowest hardness values at the end of 24 h and 72 h in both CB and TFB. The additive combinations altered crust L*, a* and b* values of CB and TFB including composite flour. In terms of overall acceptability, C9 was the best additive combination that was followed by C8 (gluten, SSL, FAA, AA and pentosanase) > C6 (gluten, SSL, FAA and GO) > C3 (gluten, SSL and FAA) > C4 (gluten, SSL, FAA and AA), C5 (gluten, SSL, FAA and TG) and C7 (gluten, SSL, FAA and lipase) in CB. In TFB, C8 had the similar overall acceptability score to that of C9 which was followed by the combinations of C5 and C7 > C3, C4 and C6. As a result, xylanase or pentosanase enzymes combined with gluten, SSL, FAA and AA could be used to improve the technological quality of bread formulations containing cereal-legume composite flour. Production of breads with superior nutritional, technological and sensory qualities could be provided using those combinations of additives.

5. Acknowledgements

This study was financially supported by Necmettin Erbakan University, Scientific Research Projects (BAP – 131319002).

6. References

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