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Barley flour addition decreases the oil uptake of wheat chips during frying

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RESEARCH ARTICLE

Abstract

In the present study, wheat chips enriched with barley flour at different concentrations (5, 10, 15, 20, 25 and 30%) were produced and some physicochemical and textural properties, fatty acid composition and sensory quality of enriched chips were investigated. An increase in the values of some physicochemical parameters of wheat chips, namely hardness, dry matter, ash and some fatty acids levels, was observed with the increasing barley flour concentration in the formulation. Barley flour addition provided a significant oil uptake reduction as the oil content of the control sample was 27.23% while that of the enriched samples with 30% barley flour was 18.21%. Overall acceptability of wheat chips added with no barley flour samples was determined to be similar to compared to enriched ones. But addition of barley flour higher than 10% caused a decrease in sensory scores of the final products.

Keywords: wheat chips, barley flour, fatty acid composition, textural characteristic, oil uptake

1. Introduction

Snack foods, particularly potato and corn chips, are very popular snacks which are consumed by the people all over the world (Thakur and Saxena, 2000). Snack foods especially chips are accepted as fast foods and the consumers consider that the excess consumption of these types of foods is not healthy. For that reason, today's consumers demand foods having functional properties from industry because people become more conscious regarding what they eat (Melemma, 2003). Thus, food industries conduct research activities regarding to the new food formulation development to attract the consumers. As it is well known, functional foods have positive effects on human health and they can prevent or decrease the risk of some health problem like heart diseases, cardiovascular problems, constipation, and diabetes (Hasler, 2002; Koca and Anil, 2007). In the world, wheat and wheat based products are very popular and they are consumed in daily diet by the people nearly everywhere in the world. Wheat is also used for the production of chips because it is a good source for the carbohydrates and energy for the human nutrition. The utilisation of wheat for the production of wheat chips as a snack food can enable people to consume wheat in a different form compared to other conventional products produced using wheat like bread and pasta (Izydorczyk *et al.*, 2005; Kayacier *et al.*, 2014a; Mendonça *et al.*, 2000; Rababah *et al.*, 2011).

Barley (*Hordeum vulgare* L.) is one of the most important cereals used by the people. It has a quite large cropping area in the world and it has a large use in beer industry because it is a good choice for the malting and brewing due to the good source for the desired enzyme type and amount. It is also a rich source for the dietary fibre called as β-glucan which has functional effects for the human health (Bhatty, 1986; Hecker *et al.*, 1998; Kalra and Jood, 2000; Riaz, 1999). Barley consumption is very limited in the human diet in the world. Beside its functional properties, it has some advantages because barley flour is a good incorporation agent for the other cereal flours in the production of cereal based foods. Robbelen (1979) reported that the bakery products produced with composite flour have many advantages apart from the extending the wheat flour availability and they are looked upon as carriers on nutrition. In the literature, many studies reporting the rheological and baking properties of the flour mixtures concluded that the incorporation of some materials like hull-less barley (Bhatty, 1986), soybean (Rastogi and Singh, 1989), flaxseed (Yuksel *et al.*, 2014), sorghum (Rao and Rao, 1997) and cowpea (Sharma *et al.*, 1999) into the wheat flour at different concentrations could be made. According to our knowledge, there is no study focusing on the use possibilities of barley flour in the wheat chips formulation. The main purpose behind this study was to investigate the enrichment possibilities of wheat chips with the incorporation of barley flour at different concentrations for the production of a new snack for the consumers and determination of the ideal barley-wheat flour composition for the desired wheat chips products.

2. Material and methods

Materials

Wheat flour (13.7% moisture, 11.4% protein, 0.55% ash in dry matter, 35% wet gluten) was provided by Degirmencilik Flour Co. (Kayseri, Turkey). Barley flour (96% dry matter, 0.90% ash, 8.6% protein in dry matter) was provided by a local producer in Nigde (Hanımaga Flour Co., Turkey). Sunflower oil (Kristal, İzmir, Turkey) was purchased from a local market.

Methods

Preparation of chips

Wheat chips enriched with barley flour were produced according to the process flow chart illustrated in Figure 1. Wheat flour was blended with barley flour and water (50 ml) was added to the mixture to produce chips dough (Table 1). The mixture was mixed for 10 min with dough mixer (Kitchen Aid Professional 600; Kitchen Aid, St. Joseph, MI, USA). At the end of the kneading, the chips dough was covered with a stretch film and rested for 30 min at room conditions. After that, the thickness of dough was adjusted to 1 mm using a lab-scale sheeter (Doge, model SS0615; Rondo, Burgdorf, Switzerland) and their shapes were given by a special shaper. Afterwards, chips were deep fried at 170 °C for 50 s. After frying process, chips samples were cooled on paper towel at room conditions.

Proximate composition of wheat chip samples

Dry matter, protein, oil, and ash contents of the samples were determined according to procedures outlined by AOAC (2000). Dry matter content was measured after drying the

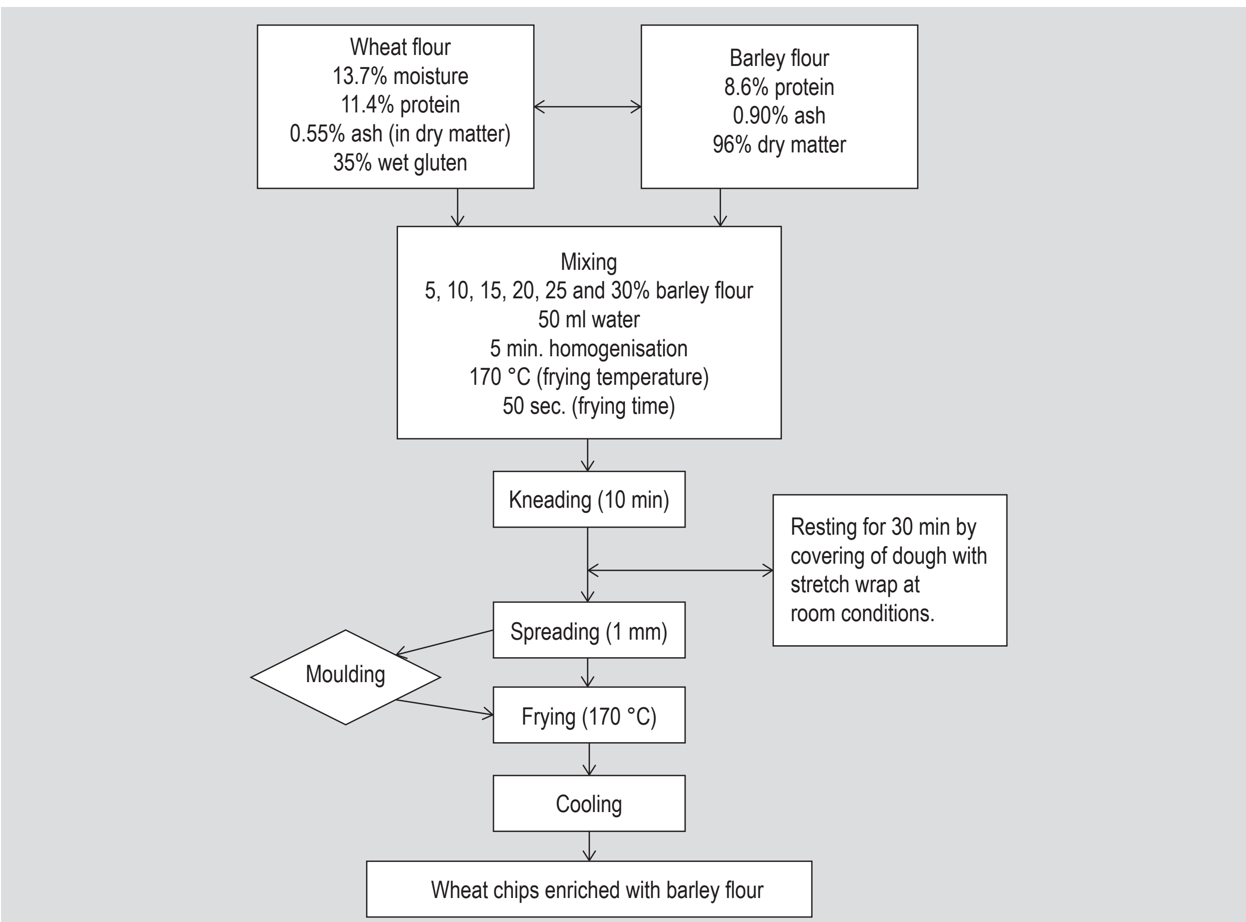

Figure 1. Process flow chart for the production of wheat chips enriched with barley flour.

Table 1. Experimental study design.

Sample no.	Wheat flour concentration (%)	Barley flour concentration (%)
1	100	0
2	95	5
3	90	10
4	85	15
5	80	20
6	75	25
7	70	30

samples at 105 °C for 4 h in a drying oven (Nüve FN 120; Nüve, Ankara, Turkey). Ash content was determined by incinerating of the samples at 550 °C for 5 h. Colour of samples were measured using a colorimeter (Lovibond RT Series Reflectance Tintometer; The Tintometer Limited, Amesbury, UK) and recorded as L, a and b. Oil content of chips was determined using a Soxhlet extraction system (B-811; Büchi Labortechnik AG, Flawil, Switzerland). Protein content of chips samples was determined using an automatic nitrogen analyser (FP 528; Leco Corp., St. Joseph, MI, USA) based on Dumas method.

Textural analysis

Textural properties of chips were determined using a texture analyser (TA.XT Plus; Stable Micro Systems Ltd., Godalming, UK) equipped with a Kramer shear cell attachment (HDP/KS-5; Stable Micro Systems Ltd.) using a 30 kg of load cell for the analysis. Two pieces of wheat chips (each approximately 3 g) were inserted in the Kramer shear cell and samples were located as vertical to Kramer shear blades. The blades on the samples travelled at 5 cm/min. The fracture force (kg) which is the maximum force required to break the sample was determined using the time-deformation curve.

Texture profile analysis (TPA) of dough enriched with barley flour was determined at 25±2 °C with three replicates with the texture analyser. 15 g dough sample was shaped and placed on heavy duty platform of the equipment. A double compression cycle test was applied up to 50% strain compression of the original portion height using an aluminium spherical probe (SMS P/1s, TA.XT Plus; Stable Micro Systems Ltd.). Test speed values were 5, 1 and 5 mm/s (post-test, test and pre-test speed), respectively. A time of 5 s was allowed to elapse between two compression cycles. Force-time deformation curves were obtained with a 30 kg load cell and 5 g trigger force. Force versus time plots were used for calculation of TPA parameter values. Dough hardness, chewiness, gumminess, springiness, adhesiveness and cohesiveness were determined, as described by Bourne (2002).

Sensory analysis

The panellist group (ten members) was selected from faculty and graduate students of Erciyes University of Food Engineering Department who are familiar with the sensory evaluation of snacks. Before the analysis, the panel members are trained related to the properties of the chips and sensorial parameters were explained. After training, wheat chips enriched with barley flour was served to trained panel groups. Panellists were requested to drink natural spring water to cleanse their palates before to proceeding to the next sample. Wheat chips enriched with barley flour were evaluated using a scaling method of descriptive attributes for taste (1 = undesired, 7 = desired), colour (1 = very brown, 7 = desired yellowness), crispness (1 = undesired texture, 7 = desired texture) and overall acceptability (1 = dislike, 7 = like).

Fatty acid composition

The oils (100 mg) extracted from the chips were dissolved with 3 ml of hexane and methylated in 100 µl of 2 N KOH prepared with methanol. The samples were strongly shaken with a vortex (Nüve NM 110, Turkey) for 1 min, and then centrifuged at 2,516×*g* for 5 min at 25 °C (MIKRO200; Hettich, Tuttlingen, Germany). 1 ml solution was put into vials and then 1 ml was injected to the gas chromatography (GC) system. For this analysis, a GC (Agilent 6890; Agilent Technologies, Santa Clara, CA, USA), equipped with a FID and a 100 m × 0.25 mm ID HP-88 column was used. The injection block temperature was set at 250 °C. The initial oven temperature was kept at 103 °C for 1 min, then programmed from 103 to 170 °C at 6.5 °C/min, from 170 to 215 °C for 12 min at 2.75 °C/min, finally, 230 °C for 5 min. Helium was used as the carrier gas with a flow rate of 2 ml/min and split rate was 1/50. The fatty acid analyses of the samples were duplicated.

Statistical analysis

All statistical analyses were performed using general linear model procedure with SAS software package (version 8.2, SAS 2002; SAS Institute Inc., Cary, NC, USA). ANOVA was applied and Duncan multiple comparison test was conducted to determine the differences between the parameters at the significance level of 0.05.

3. Results and discussion

Proximate composition

Table 2 shows the some physicochemical properties of wheat chips enriched with barley flour. As can be seen from the Table 2, dry matter contents of all chips samples were found to be higher than 95.30%. The lowest dry matter content was determined in control sample. The dry matter content of chips increased with the increment of barley flour concentration in the chips formulation significantly (P<0.05). The increase in the dry matter content of the chips sample is attributed to the dry matter content of the barley flour. Moisture content of the barley flour was determined to be very low (4%) compared to moisture of wheat flour (11.4%). A significant increase was observed in the ash content of the wheat based chips samples with the increase in barley flour concentration (P<0.05). While the ash content of the control wheat chips was 0.439%, the ash content of the wheat chips enriched with 30% barley flour was measured to be 0.761%. The main reason of increment in ash content with the increasing of barley flour amount is that the barley flour is a cereal rich in minerals. Lee *et al.* (1997) reported that β-glucan is a soluble dietary fibre component which has a cholesterol-lowering effect and it is major component of the dietary fibres of barley (*Hordeum vulgare* L.). It was found that there was a significant difference between the protein content of the samples. As can be seen from the Table 2, oil uptake level of the samples decreased significantly with the increase in barley flour amount in the formulation. Addition of barley flour provided a significant reduction in the oil content of the chips samples compared to control samples (P<0.05, Table 2). The oil content of the control samples were determined to be 27.23% while the oil content of the enriched samples with 30% barley flour was 18.21%. Lee and Inglett (2007) reported that the steam jet-cooked barley flour showed as an oil barrier in fried foods because its incorporation into frying batters increased batter pickup and viscosity while the moisture loss of fried batters was reduced and these combined effects significantly lowered the oil uptake of batters. As is known, frying, one of the food preparation techniques is an easy, fast and convenient method for food preparation at household and industry. Fried products have a special texture, colour and taste. But, oil level of fried foods is very high and it can increase up to 50% of the total weight (Funami *et al.*, 1999). Excessive consumption of oil or foods with high oil content can cause high caloric intake hence it could be attributed to some health disorders like obesity and heart diseases. Decrease in the oil content of the wheat chips with the addition of barley flour without negatively affecting the sensory acceptance is a very important result for the consumers.

Textural properties

It was concluded that the hardness values of samples significantly increased with the addition of barley flour (P<0.05). Hardness values of chips samples with no barley flour addition were recorded to be 13.481 kg while the hardness values of sample added with barley flour at the concentration of 30% was 27.277 kg. The increase in the hardness values of samples depending on the increase in the barley flour concentration is attributed to the water holding ability of the barley flour due to the dietary fibre content like β-glucan. Kayacier *et al.* (2014b) reported that the hardness of the chips enriched with legume flours increased similarly. Additionally, oil increase in a food formulation provides a softer texture for the food. As can be seen from the Table 2, oil level decreased with the increase in the barley flour concentration and hence, hardness values of samples increased significantly (P<0.05).

TPA parameters of wheat chips dough enriched with barley flour were illustrated in Figure 2. As can be seen from the figure, barley flour addition provided an increase in hardness, gumminess and chewiness, while cohesiveness values of the sample decreased compared to control sample (P<0.05). There was no trend for the adhesiveness of samples with respect to the amount of barley flour

Table 2. Mean values for the physicochemical properties of wheat chips enriched with barley flour.

Barley flour concentration (%)	Ash (%)	Hardness (kg)	Dry matter (%)	Protein (%)	Oil (%)
0	0.439^{d}	13.481^{d}	95.367^{e}	8.051^{d}	27.230^{a}
5	0.558^{c}	17.820^{c}	96.204^{d}	8.895^{a}	23.645^{b}
10	0.582^{c}	18.590^{c}	96.911^{c}	8.815^{a}	22.970^{b}
15	0.647^{b}	18.889^{c}	97.069^{c}	8.755^{ab}	23.120^{b}
20	0.719^{a}	19.717^{c}	97.608^{bc}	8.604^{b}	23.430^{b}
25	0.747^{a}	22.436^{b}	98.177^{b}	8.350^{c}	23.435^{b}
30	0.761^{a}	27.277^{a}	99.578^{a}	8.108^{d}	18.205^{c}

Differences in superscript letters indicate significant difference (P<0.05) in a column.

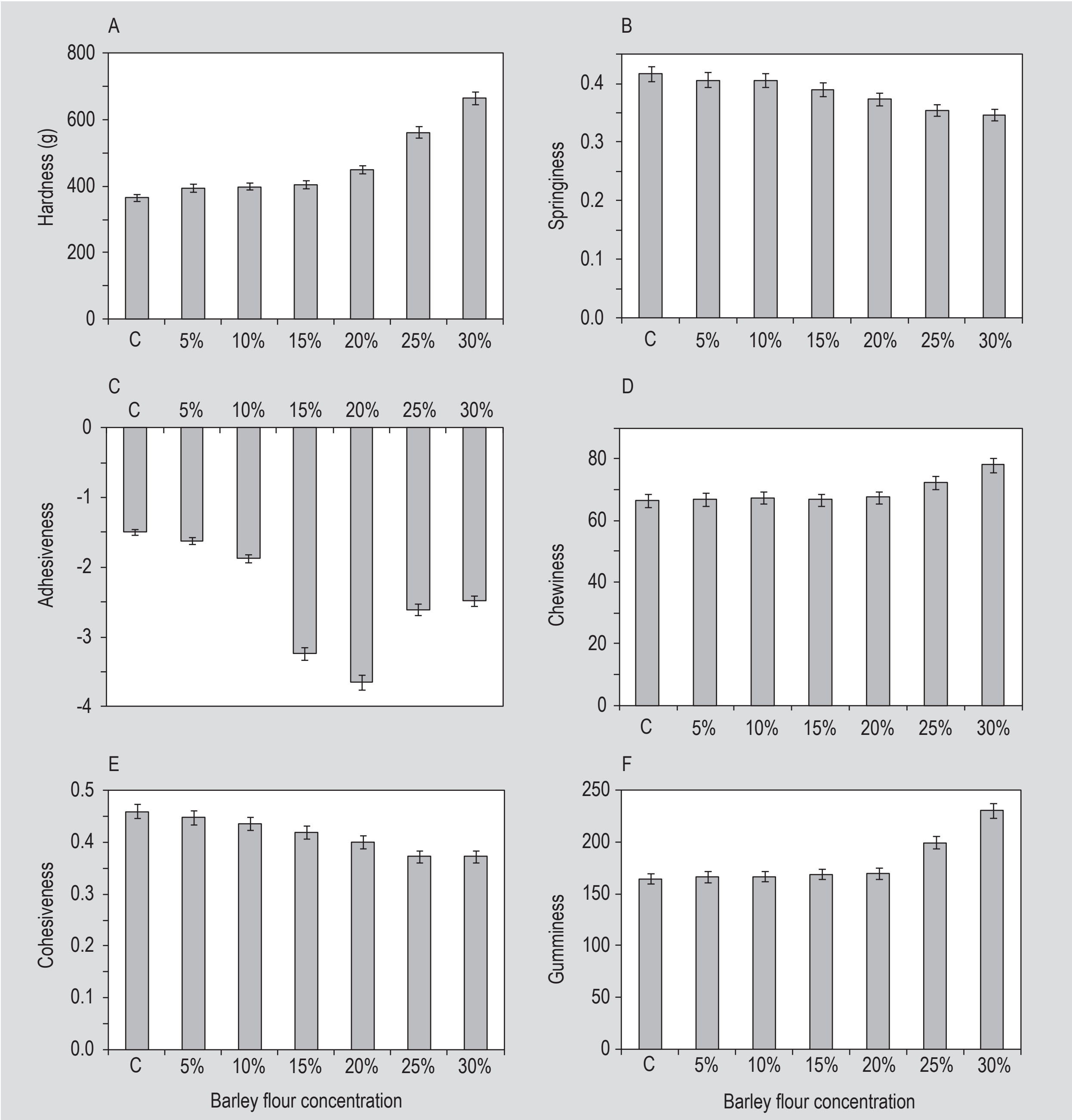

Figure 2. Mean values for the texture profile analysis parameters of wheat chips dough enriched with barley flour (C = control sample).

incorporated into the formulation of chips. Bojana *et al.* (2011) reported that the hardness of the honey biscuit dough enriched with buckwheat and rye increased but springiness values decreased similarly. Similar results were reported by Correa *et al.* (2011) for the dough enriched with pectin and they concluded that the increase in pectin level decreased the cohesiveness and springiness values of the dough significantly.

Colour values

Table 3 shows the colour properties of the samples. As can be seen from the table, barley flour addition provided an increase in the lightness values of the samples compared to control sample of which contains no barley flour. Lightness value of control samples was recorded as 52.57 while the lightness value for the wheat chips samples enriched with 30% barley flour was 58.24. There was no considerable change in redness values of the samples but it increased a little with the addition of barley flour into the chips

Table 3. Mean values for the colour properties of wheat chips enriched with barley flour.

Barley flour concentration (%)	L	a	b
0	52.57^{d}	5.69^{f}	19.90^{e}
5	62.57^{a}	6.32^{e}	20.81^{c}
10	58.42^{b}	6.97^{c}	21.16^{b}
15	58.71^{b}	6.39^{d}	20.12^{d}
20	54.60^{c}	7.55^{a}	20.90^{c}
25	54.34^{c}	6.97^{c}	20.96^{c}
30	58.24^{b}	7.45^{b}	21.63^{a}

Differences in superscript letters indicate significant difference (P<0.05) in a column.

formulation. Redness value of control chips sample was 5.69 while the redness value of sample containing 30% barley flour concentration was 7.45. Similar trend was also observed for the yellowness values of the samples. Yellowness increased with the increase in barley flour level in the formulation.

Fatty acid composition

Major fatty acids profile of wheat chips enriched with barley flour was shown in Table 4. As can be seen from the table, barley flour caused a significant change in the fatty acid compositions of the samples. Fatty acids levels changed with the addition of barley as depending on the flour concentration in the formulation. Palmitic acid (C16:0) level significantly decreased in the chips with the increase in barley flour amount (P<0.05). Its amount was determined to be 7.365% in control sample while it was 6.949% in the sample added with 30% barley flour. Stearic acid (C18:0) level decreased significantly (P<0.05) with the addition of the barley flour and it was determined to be 4.444% in control sample while 3.934% in the sample added with 30% barley flour. Significant decrease was observed in the oleic acid (C18:1) content of the sample and its concentration decreased with the increase of barley flour in the formulation significantly (P<0.05). Oleic acid level of the control sample was 32.411% while the oleic acid level of wheat chips added with barley flour at the concentration of 30% was 26.562%. In addition to that, linoleic acid (C18:2) level increased significantly (P<0.05). Linoleic acid was determined to be 55.777% in the control sample while it was 62.552% in the chips sample enriched with the addition of 30% barley flour (Table 4). Youssef *et al.* (2012) reported that the germinated barley had a high linoleic acid (C18:2) content and thus, the increment of linoleic acids level in the chips samples may be explained because of the barley flour fatty acids composition.

Sensory evaluation

Colour, crispness, taste and overall acceptability of the samples were determined and results were tabulated in Table 5. Regarding the colour parameter, in general, addition of barley flour decreased the colour scores of the samples. But, crispness scores given for the samples by the panel members were determined to be higher for the enriched chips compared to control. Taste scores did not change linearly depending on the increased level of barley flour, but no significant difference was recorded between the control sample and sample added with 30% barley flour. Similar findings were valid for the overall acceptability of the wheat based chips samples. Wheat chips enriched with barley flour gained a quite high sensory score similar to control samples. According to Table 5, the most preferred wheat chips enriched with barley flour was the sample added 10% barley flour. Gupta *et al.* (2011) investigated the effect of barley flour addition on organoleptic properties of rusk and reported that the increase of barley flour in the rusk formulation decreased the scores of sensory parameters like colour, texture, taste, flavour, appearance and overall preference.

Table 4. Mean values for the fatty acid compositions of wheat chips enriched with barley flour.

Barley flour concentration (%)	C16:0 (%)	C18:0 (%)	C18:1 (%)	C18:2 (%)
0	7.365^{a}	4.444^{a}	32.411^{a}	55.777^{g}
5	6.740^{e}	3.822^{d}	25.990^{g}	63.445^{a}
10	6.839^{d}	3.861^{c}	26.187^{f}	63.110^{b}
15	6.824^{d}	3.873^{c}	26.243^{e}	63.058^{c}
20	6.926^{cb}	3.864^{c}	26.335^{d}	62.873^{d}
25	6.908^{c}	3.918^{b}	26.425^{c}	62.745^{e}
30	6.949^{b}	3.934^{b}	26.562^{b}	62.552^{f}

Differences in superscript letters indicate significant difference (P<0.05) in a column.

Table 5. Mean values for the sensory properties of wheat chips enriched with barley flour.

Barley flour concentration (%)	Colour	Crispness	Taste	Overall acceptability
0	5.833[a]	5.833[ab]	5.333[ab]	5.500[a]
5	4.666[ab]	5.500[ab]	4.333[ab]	4.833[ab]
10	5.833[a]	5.500[ab]	5.833[a]	5.833[a]
15	3.666[b]	4.666[b]	3.833[b]	3.833[b]
20	4.166[b]	4.500[b]	4.166[ab]	4.333[ab]
25	4.500[ab]	5.500[ab]	4.666[ab]	4.500[ab]
30	4.500[ab]	6.500[a]	4.666[ab]	4.833[ab]

Differences in superscript letters indicate significant difference (P<0.05) in a column.

5. Conclusions

It was shown that the wheat chips could be enriched with the addition of barley flour. Barley flour addition to the wheat chips formulation altered the physicochemical and sensory properties and also major fatty acid profile of the chips samples. Addition of barley flour caused a significant change in textural characteristics of wheat chips dough. Increase in the barley flour concentration increased the ash values while protein content slightly changed in the samples. Compared to the control samples, oleic acid and linoleic acid levels of the chips samples decreased and increased with the increase of barley flour, respectively. The result showed that the wheat chips enriched with barley flour could be acceptable until the barley flour concentration reached to 10% in the formulation.

Conflict of interest

There is no conflict of interest.

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