Using Hull-Less Barley and Flax Seeds Flour to Produce Macaroni for Hyperglycemia Disease in Rats

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Abstract: This investigation was carried out to prepare macaroni from flax seeds and hull-less barley at different blends. Chemical composition in raw materials, fatty acids content in flax seeds, cooking taste parameters and sensory evaluation in all blends were determined. Biological experiments for four weeks were determined in hyperglycemic rats fed on different blends to give five groups and two controls negative and positive fed on basal diets. The results showed that the flax seeds are rich in protein, fat and total dietary fiber and had contained 21.23, 38.76, and 52.17%, respectively followed by hull-less barley was that contained 15.9, 2.12 and 14.6%, respectively. Linolenic acid (C18:3), a polyunsaturated fatty acid was the predominant fatty acid found in oil flaxseed mill (59.34%). The volume and weight cooking parameters and sensory evaluation of macaroni from equal weight flax seeds and hull-less barley (1:1) blend (5) were the highest parameters and total score followed by 50% flax seeds macaroni blend (3) and 50% hull-less barley macaroni blend (4). At the end of biological experiment the resultant data showed that the macaroni made from equal weight flax seeds and barley blend (5) was significantly decreased in lipids profile and blood sugar of hyperglycemic in rats. Whereas, the blend (3) had contained 50% flax seed lowering lipid profile and blood sugar followed by blend (4) prepared from 50% hull-less barley compared with blends (1 and 2) consists of 100 and 50% wheat flour 72% extraction. It could be concluded that the barley-flaxseed composites were unique because they provide the soluble fiber *β*-glucan that is beneficial for food texture and coronary heart disease prevention along with the health benefits of the omega-3 poly unsaturated fatty acids of flaxseed.

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1.Introduction

The newly developed barley-flaxseed composites were unique because barley provides the soluble fiber *β*-glucan that is beneficial for improving food texture and preventing coronary heart disease along with the health benefits of omega-3 polyunsaturated fatty acids (ώ-3 PUFAs) of flaxseed. The new composites of barley with flaxseeds were prepared using prowashonupana, a barley variety containing high *β*-glucan content, with 10, 20, and 50% flaxseed for enhancing health benefits of functional food. Besides the nutritional aspects of barley-flaxseed composites, they have improved water holding capacities, texture, and useful pasting and viscoelastic qualities measured using a Rapid Visco Analyzer (RVA) followed by an advanced rheometer. The pasting and rheological properties of the barley flour were not greatly influenced by 10% ground flaxseed replacements but showed differences at the 50% replacement level. Shear thinning properties were observed for all the composites. These functional composites could be valuable and applicable for developing new functional food products with health benefits of decreasing heart problems, diabetes, and obesity along with providing desirable texture **(Inglett*et al.*, 2013)**.

The carbohydrate distribution in prowashonupana barley is at least 30% dietary fiber and <30% starch which is 2 - 3 times the amount of fiber and half the amount of starch compared with other common cereal grains. Barley grains are generally rich in *β*-glucan that provides an excellent source of soluble dietary fiber for attenuating blood glucose, and reducing low-density lipoprotein cholesterols (LDL) **Cui and Wang (2009).** Barley grains also contain *β*-glucan which has beneficial health effects on coronary heart disease prevention by the reduction of serum cholesterol and postprandial serum glucose levels **(Klopfenstein, 1988).**

The benefits of dietary fiber on inflammatory bowel disease may be related to the fermentative production of butyrate in the colon which appears to decrease the inflammatory response **(Rose*et al.*, 2007).** Products containing *β*-glucan have numerous functional food applications to reduce fat content and calories in a variety of foods **(Lee*et al.*, 2004).** In addition, barley is gaining renewed interest as an ingredient for production of functional foods due to its high contents of bioactive compounds such as glucans, tocopherols and tocotrienols **(Gallegos-Infante*et al.*, 2010).** Moreover, there are many classes of phenolic compounds in barley, such as benzoic and cinnamicacid derivatives, proanthocyanidins, quinones, flavonols, chalcones, flavones, flavanones and amino phenolic compounds (**Verardo *et al.*,2008 and Inglett *et al.*,2011).**

Flaxseed (*Linumusitatissimum* L.) is a well known plant source for ώ -3 PUFAs-rich oils that have a positive effect on human health. The ώ-3 polyunsaturated fatty acids (ώ -3 PUFAs) have received increased attention because the consumption of ώ -3 PUFAs has been linked to reducing risk of coronary heart disease (CHD) **(Juturu, 2008) and Kris-Etherton *et al.*,2002)**. Flaxseed oil have been used to help reduce total blood cholesterol and low-density lipoprotein (LDL) cholesterol levels and it has being increasingly recognized for reducing the risk of cardiovascular diseases **(Zhao *et al.*,2007).** Also, flaxseed is rich in fiber, and contains natural antioxidants such as phenolic glycoside-Q and K, chlorogenic acid, caffeic acid, quercetin and kaempferol which may protect consumers against some cardiovascular diseases and types of cancer; as well as supplying vitamins and minerals **(Reyes-Caudillo *et al.*, 2008).** In addition, mucilaginous constituents of flaxseed have a considerable potential for use as a food gum **Mazza and Biliaderis (1989).** Previous studies have revealed that flaxseed mucilage consists of two types of polysaccharides: a neutral arabinoxylan and an acidic pectic-like material **(Muralikrishna *et al.*,1987).**

The barley flour was used to blend with flaxseed in this study to produce unique composites containing *β*-glucan in combination with flaxseed seeds containing its distinctive omega-3 oils. The barley flour component appears to be helpful in absorbing oil and improving physical properties such as water holding capacity. Furthermore, the rheological properties of flaxseed combined with barley provided new and useful information on the interesting composites. Therefore, the purpose of this study was conducted to explore the pasting and rheological characteristics of dry blended barley flour with ground flaxseed that could be valuable for processing and developing potential new functional food products having desirable texture and health benefits as lowering glucose.

2.Material and Methods

Material:

Flax seeds (*Linumusitatissimum* L.), hull-less barley (*Hordumvulgare* L.) and wheat flour 72% were obtained from local market west zone inSaudi Arabia.

Methods:

Flax seeds and hull-less barley were milled in a Laboratory Mill Junior to give a fine power to be used as a whole meal.

Chemical analysis of raw materials:

Protein content, ash, crude fiber, lipids content and total carbohydrates were determined in flax seeds, hull-less barley and wheat semolina according to **AOAC (2005).** Total dietary fibers, soluble and insoluble dietary fibers were determined in raw materials according to **Prosky *et al.* (1988).**

Identification of fatty acids content from flax seeds oil:

The oil extracted from flax seeds using n-hexane (40-60) at room temperature for 48 h. The extracts were filtrated and evaporated according to **AOAC (2005).** Oil from flax seeds was saponified and methylated with diazomethane as detailed by **Vogel (1975).** Fatty acids content were determined using the Sigma 3B Gas Chromatography equipped with dual flame ionization detectors. The separation conditions are reported by **Farag *et al.* (1981).**

Macaroni preparation processing:

The ingredients preparation processing macaroni are reported in Table (1). The ingredients were mixed in Hobert mixture at high speed until uniformly (10 min.) and the required amount of water was added. Macaroni was processed using a Demaco (De Francise Machine Corporation) Semi commercial scale Laboratory extruder, according to the method described by **Dexter *et al.* (1990).** The macaroni was dried at 60^{o}C for 24h and the relative humidity was 75 to 85% according to **Dexter *et al.* (1990).**

Table (1): The ingredients macaroni blends (on dry weight bases/100g).

Blends	Wheat flour 72%	Flax seeds	Hull-less barley
Blend 1	100	-	-
Blend 2	50	25	25
Blend 3	25	50	25
Blend 4	25	25	50
Blend 5	-	50	50

Physical characteristics of macaroni blends:

Cooking quality was determined namely weigh, volume and the amounts of absorption water during cooking macaroni blends according to **Dexter *et al.* (1990).** Moreover, total soluble solids of cooking liquor were determined according to the method of **Walsh and Gills (1971)**.

Sensory evaluation of macaroni blends:

The macaroni blends after cooking were organoleptically evaluated for their taste, odor, stickiness, color and appearance according to **Dexter *et al.* (1990)** by twenty experienced panelists from the staffs of King Abdul-Aziz Univ., Saudi Arabia.

Nutritional experiments:

Male adult rats (42rats) weight ranging 150-160g were purchased from National Organization for Drug and Control Research, Giza, Egypt. Animals were housed in individual cages with screen bottoms and fed on basal diet for eight days. The basal diet consisted of corn starch 70%, casein 10% corn oil 10%, salt mixture 4%, vitamin mixture 1% and cellulose 5% according **AOAC (2005).** After feeding on basal diet for eight days, rats were divided into tow groups. The first group (6 rats) was fed on the basal diet for another four weeks (30 days) and considered as negative control. The second main group (30 rats) was fasted overnight and injected with streptozootocin (was dissolved in 0.1M citric acid buffer and adjusted at pH 4.5) into the leg muscle (5mg /100g body weight) to induce diabetic rats according to **Madar (1983).** After 48 h of injection the second main group was divided into six subgroups (6 rats for each). The first one (6 rats) was continued to be fed on basal diet and considered as positive control. From the second to six subgroups (6 rats for each) were fed on 20% from macaroni after cooking prepared from five blends contained obviously ingredients. Each rat was weighted every two days and the gain body weight was calculated.

At the end of experimental period (four weeks), the blood samples were taken with drawn from the orbital plexus and centrifuged at 3000 rpm to obtain the sera. After that, the sera were kept on a deep freezer at -20^{o}C until their analyses. Serum glucose, total lipids, total cholesterol and triglycerides were determined according to **knight *et al.*(1972), Allain*et al.*(1974), Fossatiand Prencipe (1982) and Tietz (1986),** respectively. High and low densitylipoprotein-cholesterol in serum was determined according to **Burstein (1970) and Fruchart (1982**).

Statistical analysis:

Statistical analysis for each of the collected data was done of variance (ANOVA) test described the procedure outline by **Armitage and Berry (1987)**. The treatment means were compared using the least significant difference test (LSD) at 5% level of probability as outline by **Waller and Duncan (1969)**.

3. Results and Discussion

Chemical composition of raw materials:

The chemical composition of raw materials as protein, fat, ash, total fibers, total carbohydrates and total dietary fiber fractions were determined (wheat flour 72% extraction, flax seeds and hull- barley) and the results are reported in Table (2). From the data it could be noticed that the flax seeds are rich in protein, fat and total dietary fiber since they had contained 21.23, 38.76, and 52.17%, respectively followed by hull-less barley was 15.9, 2.12 and 14.6%, respectively. Moreover, wheat flour 72% extraction and barely had contained the highest total carbohydrates (86.55 and 71.49%) respectively.

Flax is rich in fat, protein and dietary fiber were averaged 41% fat, 20% protein, 28% total dietary fiber and 3.4% ash, which is the mineral-rich residue left after samples are burned**.** The composition of flaxseed can vary with genetics, growing environment, seed processing and method of analysis **(Daun *et al.*, 2003).** The protein content of the seed decreases as the oil content increases **(Daun and DeClercq, 1994).**

Whole barley grain consists of about 65–68% starch, 10–17% protein, 4–9% β-glucan, 2–3% free lipids and 1.5–2.5% minerals **(Quinde *et al.*, 2004).** Total dietary fiber ranges from 11 to 34% and soluble dietary fiber from 3 to 20% **(Fastnaught, 2001).** Hull-less or de-hulled barley grain contains 11–20% total dietary fiber, 11–14% insoluble dietary fiber and 3–10% soluble dietary fiber **(Virkki *et al.*,2004).**The total dietary fiber of flaxseed oilcake ranged from 53.13 % to 56.32 %.The generally high total dietary fiber content of flaxseed can be expected due tothe high mucilage content of flaxseed **(Bhatty and Cherdkiatgumchai, 1990).** Moreover, barley contains β-glucan as a source of soluble dietary fiber. The barley flour was prepared from Pakistani barley variety (Haider-93) and analyzed for its chemical composition. The barley flour possessed 11.48% total dietary fiber and 4.87% β-glucan content. B-glucan extracted from barley flour contained 75.05% soluble dietary fiber 10.25%, insoluble dietary fiber and 85.30% total dietary fiber. The beverage was prepared by incorporating β-glucan at 0, 0.2, 0.4, 0.6, 0.8 and 1.0% levels **(Din *et al.*,2009).**

The flaxseed contains both soluble and insoluble fibers. About one-third of the fiber in flaxseed is soluble and it may help to lower cholesterol and to regulate levels of blood sugar. The remaining two-thirds of the fiber in the flaxseed is insoluble which aids digestion by increasing bulk and preventing constipation **(Institute of Medicine, 2002).** Flaxseed proteins are relatively high in arginine, aspartic acid and glutamic acid whereas lysine, methionine and cystine are limiting amino acid. Flaxseed dietary fiber exhibits positive effect to reduce constipation, to keep better bowel movement and as hypocholestermic agent **(Ganorkar and Jain,2013).**

Fatty acids content in flax seeds oil:

The fatty acid profile of the lipid that was extracted from the flaxseed mill and the results are presented in Table (3). Linolenic acid (C18:3), a polyunsaturated fatty acid was the predominant fatty acid found in oil flaxseed mill (59.34%). The high linolenic acid content is an indication of the degree of unsaturation in flaxseed oil. The level of unsaturation is reported to vary with both environment and variety **(Daun et al., 2003).** Several workers have reported values in the ranges of 51.1 % to 59.6 % for linolenic acid in flaxseed oil **(Manthey *et al.*, 2002).** Also**, Daun *et al.* (2003)** reported linolenic acid in individual samples of Canadian flaxseed to range from 52 % to 63 %. Moreover, flaxseed contains good amount of α-Linolenic Acid (ALA), a omega-3 fatty acid, protein, dietary fiber, 357 ignin, specifically Secoisolariciresinoldiglucoside (SDG). ALA is beneficial for infant brain development, reducing blood lipids and cardiovascular diseases **(Ganorkar and Jain, 2013).**

Table (2): Chemical composition of raw materials.

Chemical analysis	Wheat flour 72%	Flax seeds	Hull-less barley
Protein	11.5	21.23	15.9
Fat	1.2	38.76	2.12
Ash	0.5	3.47	3.64
Total fiber	0.65	8.02	6.85
T.C.	86.55	28.52	71.49
T.D.F.	3.17	52.17	14.6
S.D.F.	1.03	17.39	4.8
I.D F.	2.14	34.78	9.8

TT.C. Total carbohydrates; S.D.F. Soluble dietary fiber
T.D.F.Total dietary fiber; I.D.F. Insoluble dietary fiber

Table (3): Percent of fatty acids content in flax seeds oil.

Fatty acids %	Flax seeds oil
Palmitic 16:0	6.74
Stearic 18:0	2.6
Oleic 18:1	15.15
Linoleic 18:2	16.40
Linolenic 18:3	59.34
Arachidonic 20:4	0.08
Eicosadiemoic 20:5	-

Physical properties of macaroni blends:

Data of the cooking test parameters (volume, weight and total soluble solids) of the macaroni blended, are shown in Table (4). The volume and weight cooking parameters of macaroni from equal weight flax seeds and hull-less barley (1:1) blend (5) (340.52 and 284.24%) and 50% flax seeds macaroni blend (3) (310.36 and 256.76%) was significant increased than50% barley macaroni blend (4) (261.56 and 229.51%). The cooking parameters for flax-barley composites were increased with increasing ground flaxseeds contents in the Blends. However, there was significant decreased between 100% extraction 72% wheat flour macaroni blend (1) (218.17 and 215.69%) and 50% wheat flour macaroni blend (2) (242.85 and 227.36%) than other blends. Barley-flaxseed composites in the macaroni blends by increasing cooking parameters could be widely used for their thickening and gelling properties and emulsion stabilization in food industries. Whereas, total soluble solids in macaroni blends were paralleled cooking test parameters.

Table (4): Percentage of cooking test parameters of macaroni blends.

Blends	Volume increase	Weight increase	Total soluble solids
Blend 1	218.17^{b}	215.69^{b}	7.62^{b}
Blend 2	242.85^{ab}	227.36^{ab}	10.85^{ab}
Blend 3	310.36^{a}	256.76^{a}	14.63^{a}
Blend 4	261.56^{ab}	229.51^{ab}	12.28^{ab}
Blend 5	340.52^{a}	284.24^{a}	16.54^{a}
LSD at 5%	10.351	9.294	2.357

Sensory evaluation for different blends of macaroni:

Flax seeds and hull-less barley were separately incorporated in macaroni blends with wheat flour 72% extraction. The macaroni products after cooking were evaluated for sensory characteristics (color, taste, appearance, odor and stickiness) after cooking and the results are shown in Table (5).

From the data in Table (5), it could be noticed thatthe overall quality values of tested blends were found. The blends 1, 2 and 4were high acceptability and score (48.7, 48.6 and 48.2, respectively) and was significantly different from the blends 3 and 5 (47.9 and 47.6, respectively).Moreover, it is possible to observe that the overall quality decreased with the increasing of the amount of flax seeds and barley. This result is due to the fact that the score of attributes such as color and stickiness decreased with the increase of the flax seed sand barley amount influencing positively the overall quality of the spaghetti blends. Moreover, the slightly decrease during overall acceptability in blends (5 and 3) followed by blend (4) than blends 1and 2 may be due to flax seeds and hull-less barley contained high amount of total dietary fiber 52.17 and 14.6%, respectively. Dietary fibers which is highly water-binding macromolecules is competing with starch for water absorption and hence limiting starch swelling and gelatinization resulting in a higher endothermic peak temperatures value **(Singh *et al.*, 2003).**

Table (5): Sensory evaluation for different blends of macaroni:

Blends	Color (10)	Taste (10)	Appearance (10)	Odor (10)	Stickiness (10)	Over all acceptability
Blend 1	9.8±0.87[a]	9.8±0.51[a]	9.7±0.19[a]	9.7±0.42[a]	9.7±0.37[a]	48.7±29[a]
Blend 2	9.8±0.68[a]	9.8±0.50[a]	9.7±0.17[a]	9.6±0.34[a]	9.7±0.13[a]	48.6±2.8[a]
Blend 3	9.5±0.74[a]	9.8±0.53[a]	9.8±0.14[a]	9.8±0.70[a]	9.0±0.44[a]	47.9±4.2[a]
Blend 4	9.6±1.19[a]	9.8±0.50[a]	9.6±0.21[a]	9.5±0.53[a]	9.7±0.56[a]	48.2±3.7[a]
Blend 5	9.3±0.41[ab]	9.7±0.47[a]	9.8±0.12[a]	9.8±0.41[a]	9.0±0.34[a]	47.6±3.6[a]
LSD at 5%	0.637	0.785	0.807	0.547	0.747	3.496

Effect macaroni blends after cooking on body weight in rats:

The results in Table (6) showed that effect of macaroni blends after cooking on body weight of hyperglycemic rats. The results concerning the initial, finial and gain body weight at the end of experiment are recorded in Table (6). The results showed that in case of rats fed on diet contained equal weight from flax seeds and hull-less barley (1:1) blend (5) and 50% flax seeds as blend (3) followed by 50% hull-less barley as blend (4) the gain body weight were decreased from 156.6, 126.0g in control negative and positive to70.5,77.6 and 91.8g respectively. This decrease in gain body weight in the blends containing flax seeds and hull-less barley may not be palatable to rats due to the presence of dietary fiber,β-glucanandώ-3 polyunsaturated fatty acids thereby leading to poor food intake.

Table (6): Effect of different diets on body weight in the rats.

Groups	**Body weight**			
	Initial (g)	**Finial (g)**	**Gain (g)**	**Daily gain(g)**
Control negative	155.0 ± 2.70[a]	312.0 ± 1.58[a]	156.6 ± 2.70[a]	5.22 ± 0.05[a]
Control positive	153.2 ± 2.58[a]	279.2 ± 4.43[a]	126.0 ± 2.44[b]	4.20 ± 0.04[b]
Blend 1	156.23±2.34[a]	276.53±3.51[a]	120.3±1.954[b]	4.01±0.04[b]
Blend 2	154.98±2.13[a]	260.48±2.05[ab]	105.5±1.213[ab]	3.52±0.08[ab]
Blend 3	155.4 ± 2.6[a]	233.0 ± 2.34[c]	77.6 ± 4.04[c]	2.59 ± 0.07[d]
Blend 4	153.8 ± 3.49[a]	245.8 ± 1.92[b]	91.8 ± 5.10[b]	3.06 ± 0.08[c]
Blend 5	157.36±3.95[a]	227.9±1.58[d]	70.5±4.54[c]	2.35±0.05[d]
LSD at 5%	3.851	3.756	4.998	0.0825

Effect of macaroni blends after cooking on hyperglycemic in rats:

Total lipid, triglycerides, total cholesterol, low dinesty lipoprotein, high dinesty lipoprotein and blood sugar were determined in hyperglycemic rats fed on all blends macaroni after cooking and the results are reported in Table (7). The results illustrated that the macaroni made from equal weight flax seeds and barley blend (5) was significant decreased in lipids profile and blood sugar on hyperglycemic in rats. Whereas, the blend (3) had contained 50% flax seed lowering lipid profile and blood sugar followed by blend (4) prepared from 50% hull-less barley compared with blends (1 and 2) consists of 100 and 50% wheat flour 72% extraction.

Previous studies have illustrated that the glycemic response of pasta can be lowered further by the addition of soluble fiber including *β*-glucan **(Yokoyama *et al.*, 1997).** The most widely known nutritional benefits of *β*-glucans (from both oat and barley grains) are the attenuation of blood glucose and insulin **(Wood *et al.*,1994).** Soluble dietary fibers are believed to slow the release of reducing sugars from food and hence lower postprandial blood glucose level by several mechanisms, including reduced amylolysis **(Colonna *et al.*,1990),** but more specifically at the gastrointestinal level, through delayed gastric emptying **(Cherburt, 1995)** and reduced nutrient motility **(Braaten *et al.*,1991)**. The effect of the addition of a *β*-glucan fiber fraction from barley to durum wheat pasta was evaluated by **Cleary and Brennan (2006)** in terms of cooking characteristics, structure, texture, and *in vitro* starch digestibility. Barley *β*-glucan (BBG) fiber fraction was incorporated into pasta at 2.5%, 5%, 7.5%, and 10% inclusion rates. Incorporation of the BBG fiber fraction to pasta attenuated reducing sugar release during in vitro digestion, the magnitude of reduction being related to the level of BBG fiber fraction inclusion.

Flaxseed (*Linumusitatissimum* L.) is a rich source of the lignansecoisolariciresinoldiglucoside (SDG), *α*-linolenic acid (ALA [18:3n-3]), and dietary fiber **(Thompson *et al.*, 1991)**. SDG is the predominant lignan found in flaxseed. The lignans of flaxseed are phytoestrogens and serve as precursors in the production of mammalian lignans. Flaxseed lignans are converted to the mammalian lignansenterolactone and enterodiol by intestinal flora **(Axelson *et al.*, 1982),** where they are believed to protect against hormone-sensitive cancers (such as breast, prostate, and colon) by reducing estrogen availability **(Thompson *et al.*, 1996).**

Thakur*et al.* (2009) reported in a recently published study, in which 5 g of flaxseed gum per day for three months reduced total and LDL cholesterol by 10 and 16%, respectively in type 2 diabetics although one could expect a more pronounced effect among diabetics with dyslipidemia. A recent meta-analysis on the effects of flaxseed on blood lipids showed that flaxseed consumption lower both total and LDL-cholesterol, whereas flaxseed oil does not, and the role of lignans is still controversial **Pan *et al.* (2009).**

Table (7): Effect macaroni Blends on lipid profile and blood sugar:

Groups	Total Lipid (g/dl)	Triglyceride (mg/dl)	Total cholesterol (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	Blood sugar (mg/dl)
Control negative	0.65 ±0.03[d]	112.3 ±6.1[b]	86.3 ±1.1[d]	83.7 ±10.0[a]	25.0 ±5.56[d]	115.3 ±5.7[d]
Control positive	1.42 ±0.17[a]	245.7 ±27.9[a]	196.3 ±6.5[b]	47.3 ±7.2[d]	131.7 ±20.2[a]	169.3 ±3.8[a]
Blend 1	1.12 ±0.59[a]	190.4 ±15.3[b]	150.2 ±3.4[a]	60.1 ±5.2[c]	85.4 ±12.3[b]	140.2 ±3.5[b]
Blend 2	0.97 ±1.02[b]	170.5 ±10.5[b]	140.6 ±4.1[a]	67.5 ±3.1[c]	77.3 ±9.8[b]	130.1 ±2.3[b]
Blend 3	0.73 ± 0.06[c]	118.7 ±9.07[c]	110.3 ± 3.5[d]	72.0 ±3.0[b]	50.3 ± 6.03[c]	120.6 ±1.2[c]
Blend 4	0.78 ±0.13[c]	141.0 ±30.0[b]	127.0 ±7.0[c]	74.0 ±5.3[b]	49.67 ±10.0[c]	125.3 ±1.2[c]
Blend 5	0.68 ±0.19[d]	110.1 ±7.5[c]	100.0 ±6.3[d]	80.0 ±4.2[a]	40.7 ±6.34[c]	110.7 2.8[d]±
LSD at 5%	0.2120	40.272	14.152	1.956	22.594	6.6123

From the obviously results it may be concluded that the macaroni properties of barley-flaxseed composites revealed some interesting properties and useful information on their potential nutritional food applications. Barley-flaxseed composites were unique because they provide the soluble fiber *β*-glucan that is beneficial for food texture and coronary heart disease prevention along with the health benefits of the omega-3 polyunsaturated fatty acids of flaxseed. Besides the nutritional aspects of the barley-flax-seed composites, these composites have improved cooking taste parameter and overall acceptability. These technologically developed products could be valuable for new functional foods having improved nutritional value and desirable texture qualities for health concerned consumers and hypoglycemic.

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