Original Research Article

Production of ready-to-bake whole grain barley cake mix with improved quality.

Abstract

Due to the busy and fast paced lifestyle in modern times, the demand for healthy and ready-to-cook foods has increased to a great extent. In the present study, ready-to-bake whole grain barley cake mix formulas were developed by the use of different additive (i.e. carboxymethyl cellulose CMC, maltodextrin and emulsifier), and were assessed with the aim of achieving nutritional benefits, shorter preparation times and improved cake quality. Results showed that incorporation of the aforementioned additives into the dry mix formulations led to the production of cakes with lower fat content and caloric value (up to 7.1%) less than the control cake, with improved physical characteristics such as higher volume and specific volume. Texture profile analysis showed an enhancement in cake textural properties such as lower hardness, springiness and chewiness. Sensory evaluation of test cakes demonstrated a general improvement in sensory attributes like cell structure, crumb grain and softer texture. Flavor of cakes in which 100% of fats was replaced by maltodextrin received significantly lower score. However, and in term of total sensory score, most of the developed cake mix formulas had significantly higher sensory scores than their control counterpart.

Keywords: barley; cake; maltodextrin; CMC; quality.

1. Introduction

Due to the continuously changing and busy lifestyle in the last decades, a growing demand has arisen for the manufacturing of convenience ready-to-eat (RTE) and ready-to-cook (RTC) foods. Such foods have some practical benefits as they require shorter time to prepare, fewer tools and less efforts/energy which represent them as a good alternative for the regularly prepared counterpart foods (Incoronato et al., 2016). Ready-to-cook foods can be defined as those foods containing all the required ingredients of a specific food item and need minimal preparations or cooking steps which are usually indicated on the food package (Tripathi et al, 2011 ; McGarry, 2017, Dhir et al., 2020) .

On the other hand, and as a result of the increasing consumer awareness of healthy foods in general, and bakery products in particular, whole grain (100% flour extraction) bakery items have become a priority for a wide range of consumers. The association between lower risk for disease (such as coronary heart diseases, type II diabetes, and obesity) and mortality, and the consumption of whole-grain foods has made it the first choice for those seeking a healthy lifestyle (Ross et al., 2017).

Barley (*Hordeum vulgare*) is the fourth cultivated cereal grain worldwide with a produced quantity of 156.08 million metric tons in the year 2019/2020 (USDA, 2020). Studies have shown that barley is rich in ß-glucan and many phytochemicals , and has the potential of enhancing the lipid profile, decreasing blood cholesterol and improving the glycemic responses of human (Baik, 2016; Izydorczyk and McMillan, 2019).

Cakes are of the most common bakery products that are consumed worldwide (Conforti, 2014). The process of cake making is relatively different than other bakery products as it includes the mixing of different ingredients (mainly flour, fat, sugar and egg) into a batter that has a liquid consistency and lower viscosity (Conforti, 2014). The different ingredients of cake formula have a key role in achieving a high quality product. A balanced formula, along with proper processing conditions is correspondent to the production acceptable cakes (Cauvian and Young, 2009).

Fats used in cake formulas can be successfully replaced with either carbohydrate- or protein-based fat replacers in low fat bakery applications (Psimouli and Oreopoulou, 2013). Maltodextrin is a white dry powder resulting from the partial hydrolysis of different types of starches either by acid or enzymes, and can be used to replace fats in different bakery products including cakes (Lakshminarayan et al., 2006).

Hydrocolloids have a wide number of functional properties in foods such as thickening, emulsifying and stabilization (Saha and Bhattacharya, 2010). They also have the ability to control the viscosity and texture of liquid and semi-liquid food systems through the stabilization of emulsions and foaming characteristics (Selomulyo and Zhou, 2007 ; Salehi, 2020). Carboxymethyl cellulose (CMC) is an anionic, water-soluble cellulose derivative hydrocolloid that forms a three-dimensional network with an ability to link water molecules inside the system and thus, is widely used as a thickener and texture enhancer in several food applications (Salehi, 2020). Cakes containing CMC in their formulations showed enhanced quality properties such as increased specific volume and improved texture (Jia et al., 2014; Mir et al., 2015; Shao et al., 2015).

The present work was carried out to develop and evaluate a ready-to-bake single-stage whole grain barley cake mix formula by using 100% extraction hull-less barley flour. In addition, other different dry ingredients were incorporated such as maltodextrin, which was used to partially or totally replace fat in the dry cake mix, and CMC as a textural improver. Chemical, physical, textural and sensory characteristics of cakes produced from barley cake mixes were studied.

2. Materials and Methods

2.1. Materials:

The materials used in this study and their sources were as follows:

Hull-less barley (*Hordeum vulgare* var. nudum, Giza 131) was obtained from Field Crop Research Institute (FCRI), Giza, Egypt), Corn starch maltodextrin (DE <20, Qinhuangdao Lihua Starch Co Ltd, Funing County Qinhuangdao China), Dried egg white and CMC (Jaffan Group for Food Solutions, Heliopolis, Cairo, Egypt), Fats (Fern, pure butter ghee, IFFCO, Suez, Egypt), Cake emulsifier mix (Polyglycerol esters of fatty acids E475 / Mono- and diglycerides E471 / Polyoxyethylene sorbitan monooleate E433 in a ratio of 1:1:1, Dreem Mashreq, Alexandria, Egypt) and salt (Tag El Melouk Food Industries, 6th of October City, Giza). Sugar (AlOsra, Savola Group, Nasr City, Egypt) and baking powder (Dreem Mashreq, Alexandria, Egypt) were purchased from a local market in Cairo, Egypt.

2.2. Methods:

2.2.1. Preparation of barley flour:

Hull-less barley grains were cleaned manually and then were milled twice in a Retsch rotor mill (type SK100, Retsch, Haan, Germany) to pass through 60 mesh (0.250 mm) sieve.

2.2.2. Preparation of cake mix:

After a series of preliminary trials was conducted, a tentative formula of the dry barley cake mix (control) was established and indicated in Table 1. Maltodextrin in a powder form was used to replace 50 and 100% of fat in the formulas from T1 to T4. Xanthan gum was added at levels of 0.5 and 1 g to the same formulas as indicated in the same table.

The procedure previously mentioned by Lee et al. (1982) for the preparation of the cake mix with some modifications was followed as illustrated in Figure 1.

2.2.3. Preparation of cake:

For the preparation of cakes, 230 g of the previously prepared barley dry cake mixes were mixed with 150 ml of water by using Moulinex mixer (Supermix150, Ecully, France) on the lower speed for 2 minutes followed by 3 minutes on the higher speed, the mixing bowl was scraped down and then the batter was mixed again for 1 min on the higher speed.

An amount of 50 g of batter was weighed and placed in paper baking cups in an aluminum muffin pan. The cupcakes were baked in a 191°C oven for 18 min. After baking, cakes were removed from pans, allowed to cool, then the baking papers were removed and cakes were kept in polyethylene bags for further examinations.

2.2.4. Analytical methods:

2.2.4.1. Proximate chemical composition:

Proximate chemical composition of cake samples produced in this study was determined according to the methods outlined in AACC (2010). The methods (along with their AACC numbers), that were used to determine moisture, protein, ether extract, dietary fiber and ash were as follows:

Moisture content (method no. 44-15.02) was determined by the gravimetric method by calculating the mass of water lost after drying at 130 ±1 °C for 1 hr in a forced air oven (GFL, model: 7105, Burgwedel, Germany).

Ash content was determined after incineration of cake samples in a muffle furnace (Thermolyne, model: F48010-26, Dubuque, Iowa, USA) at 550 ^{0}C until a light gray color ash is obtained as described in method no. 08-01.01.

Protein content (method no. 46-12.01) was determined according to Kjeldahl method which included digestion of samples with concentrated H_2SO_4, distillation in Behr distillation unit (Behr Lb-Technik, model: S2, Dusseldrof, Germany) and titration with standard 0.1N H_2SO_4. Protein content was calculated according to the following equation:

$$\% \text{ Protein} = \frac{(\text{ml standard H2SO4 x N of H2SO4) x 1.4007 x 5.7}}{\text{sample weight (g)}}$$

Ether extract (fat content) was measured after the extraction of cake samples with petroleum ether by using Soxhlet apparatus fixed with multiunit extraction heater (Lab-Line, model: 5000-1, Melrose park, Illinois, USA) as described in method no. 30-25.01.

Total dietary fiber content was determined after gelatinizing the cake samples with heat-stable α-amylase, digesting with protease and amyloglucosidase to remove protein and starch, and diluting the aqueous digest with four volumes ethanol to precipitate soluble dietary fiber as described in the method no. 32-05.01.

Digestible Carbohydrate content was calculated by difference according to the following equation:

% Digestible Carbohydrates = 100 – (% moisture + % ash + % protein + % fat + % dietary fiber)

<u>2.2.4.2. Physical characteristics:</u>

Average weight of 3 cakes was measured after cooling on a rack for 1 hr. Cake volume was determined by rapeseed displacement (AACC, 2010, method 10-05.01). Specific volume of cake was calculated by dividing the volume of cakes (in cm^3) by their weights (in g). Height of cakes (in cm) was measured at their center using a caliper.

2.2.4.3. Texture Profile Analysis (TPA):

Texture profile of the produced cakes was determined by using Brookfield CT3 instrument (Brookfield Engineering Laboratories, Inc., MA 02346-1031, USA) with a TA-AACC36 probe according to the method outlined in the AACC (2010). The following settings were made to the instrument:

Target = 40%, Pretest speed = 2 mm/s, trigger load = 5 N, test speed = 2.5 mm/s, return speed = 2.5 mm/s and a load cell of 10000 g.

The following texture profile characteristics were determined: hardness, cohesiveness, springiness and chewiness as described in the operating instruction manual.

2.2.4.4. Sensory characteristics:

Ten trained panelists in Food Technology Research Institute (FTRI) judged the cakes for cells, grain, texture, crumb color, and flavor (AACC, 2010). A 9-point hedonic scale was used to rate the sensory properties. The nine preference choices on the hedonic scale were : 9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much and 1-dislike extremely (Lim, 2011).

2.2.4.5. Statistical analysis:

Data obtained from different cake tests were analyzed by Analysis of Variance (ANOVA) using General Linear Model (GLM) procedure within a package program of

Statistical Analysis System (SAS, Cary, NC, USA. 1999). Means were separated using Least Significant Difference (L.S.D) test at a degree of significance (P≤ 0.05).

3. Results and Discussion

In the present study, dry ready-to-bake whole grain barley cake mixes were produced by using different ingredient. Maltodextrin , in a dry powder form which is more suitable for use in dry mixes applications, was used to partially (50%) or totally replace fats in cake dry mixes,. In addition, carboxymethyl cellulose (CMC) was used in 0.5 and 1% levels (flour weight basis) to benefit from its potential improving effect on both textural and sensory properties of produced cakes. Cakes were then subjected to chemical, physical, textural and sensory examinations .

3.1. Proximate chemical composition and physical characteristics of cakes produced from dry ready-to-bake barley cake mixes:

Chemical composition of the produced cakes is shown in Table 2. No significant ($p>0.05$) differences were practically observed between different tested cakes with regards to moisture, protein, ash and dietary fiber contents. Although being highly hygroscopic material, the effect of CMC on moisture content of cakes was not clearly identified. This can be attributed to the very low amount added of such a material. Dietary fiber contents that are provided by 100 g of cakes ranged from 4.1 to 4.6 g which is in a good agreement and represents 1/5 to 1/7 of the daily nutritional dietary goals of such nutrient (USDA, 2015). Fat content (ether extract) was significantly ($p < 0.05$) decreased by increasing fat replacement level with maltodextrin. The fat content of the produced cakes was lower by 45, 43% in case of T1, T2, and 87% in case of T3 and T4, respectively when compared to the original content in control cakes. On the other hand, carbohydrate content was increased in the tested cakes as a compensation for the decrease in fat content, which can be attributed to the replacement of the fatty material (butter) with a carbohydrate one (maltodextrin). As a result of the aforementioned changes in fat and carbohydrate contents, caloric value of cakes was reduced by 3.2, 3.2, 6.4 and 7.1% of that of control cakes. Theses reduction in caloric value reflects one of the main approaches in replacing fats (as the highest caloric dense food constituent, 9 kcal/g) with another carbohydrate one which is lower in caloric value (maltodextrin, 4 kcal/g) as previously described by Lakshminarayan et al. (2006).

Physical characteristics of barley cakes produced from dry ready-to-bake whole grain barley cake mixes are shown in the same Table 2. As can be seen, no big differences were observed in weight among the studied cakes with values ranged from 41.3 to 43 g. Cake sample with 50% fat replacement level and 0.5 g CMC was found to be the higher cake in height when compared to other cake samples including control one. Three of the cake treatments (T1, T2 and T3) were found to have significantly higher volumes than the control one (Fig. 2). However, the most determinant quality factor that distinguished the studied cakes (T1 – T4) was the higher specific volume when compared to the control one with the highest value observed in case of T3 treatment.

Several studies reported the effect of hydrocolloids on the specific volume of cakes. As in the present study, a significant increase in specific volume was associated with the use of different hydrocolloids including CMC and other gums. Shao et al. (2015) attributed this improving effect in cake specific volume to the contribution of hydrocolloids (including CMC) in increasing the cake batter viscosity which leads by its turn in more air bubbles trapping during cake batter mixing. In addition to the effect of higher batter viscosity in air bubble trapping, it also has a major role in slowing down the diffusion of such bubbles and allows them to be retained during the crucial early stage of cake baking (Gómez et al., 2007).

3.2. Texture Profile Analysis (TPA) of cakes produced from dry ready-to-bake barley cake mixes:

Texture Profile Analysis (TPA) results of produced barley cakes are shown in Table 3. Generally, cakes made of the formulas from T1 to T4 were significantly lower in hardness than their corresponding control one. This means that the force required compressing a cake piece between the molars, or in other words the force necessary to attain a given deformation of a cake piece, has become lower which is a desired quality characteristic in cakes. Moreover, cake samples with 50% fat replacement level with maltodextrin (i.e T1 and T2) showed a relatively higher hardness values than those of 100% fat replacement levels (i.e T3 and T4). For cohesiveness, which represents the strength of internal bonds making up the body of the cakes (or how well the structure of a product withstands compression), there were no observed big variations in values which ranged from 0.6 to 0.7 for the all tested cake samples. Another important TPA parameter is springiness which describes the height that the cake recovers during the time from the end of first bite and the start of the second bite. Most of tested cakes had a significantly lower springiness values than the control one which means that they require less mastication energy in the mouth. The same trend was also observed in case of the TPA parameter of chewiness which is the energy required to chew a cake piece to the point required for swallowing it.

A previous study (Lakshminarayan et al., 2006) reported that the replacement of fats in cake system with maltodextrin led to a decrease in batter viscosity and thus to a less incorporation of air during batter mixing, which resulted in production of cakes with lower volume and harder texture. They concluded that the addition of emulsifiers could improve the quality of such cakes. On contrast, the obtained TPA results by Shao et al.(2015) reported a decrease in hardness, springiness and chewiness of cakes including CMC. They attributed the improvements in such TPA parameters to the improvement gained during the foaming of cake batter. Another explanation for the lower hardness of cakes including CMC is the parallel negative correlation between cake specific volume (as shown in Table 3) and hardness. Higher specific volumes were correspondent to more air bubbles incorporated into cakes which by its turn requires less energy to compress the cakes as previously reported by Sahagún et al.(2018). Moreover, Pycarelle et al., (2020) suggested that high quality cakes, in terms of volume and texture, can be predicted from the higher incorporation of air bubbles as result of increased cake batter viscosity. They also added that cakes with softer crumbs tended to have less values of TPA springiness. However, and from the results of the present study, the incorporation of CMC and the emulsifier mix (as previously mentioned in Table 1) in cake formulations seems to counteract the deleterious effect of using maltodextrin in the cake system, and thus led to the production of cakes with higher textural quality characteristics.

3.3. Sensory characteristics of cakes produced from dry ready-to-bake barley cake mixes:

Table 4 summarizes the results of the sensory scores of cakes produced from the tested ready-to-bake barley cake mixes. Results showed that all treatments including maltodextrin and CMC in combination with emulsifier mix has significantly ($p<0.05$) higher cells scores. Cells of cake mixes from T1 to T3 were reported by the panelists to be more uniform and well distributed through the cake crumb when compared to the control cakes that had a compact crumb structure (Fig. 2). T4 cakes had a less-uniform cell structure with some big size irregular cells which led to lower sensory scores by the panelists. Grain of the evaluated cakes T1-T4 had received significantly higher scores than the control one, with higher scores for cakes containing 0.5 g of CMC. The higher grain scores for cake samples from T1 to T2 can be attributed to the good properties of cell walls that were well perceived by the panelists. Texture properties as assessed by the sensory test showed that all suggested cake formulas (treatments T1-T4) had significantly higher textural properties. Notes obtained from the panelists reported that those improved textural characteristics include better mouthfeel, soft and light crumb, better chewing and swallowing, and more tender cakes when compared to the control one. The results of sensory texture evaluation are in great agreement with those obtained from the mechanical measurement of textural properties by using TPA as previously indicated in Table 3. This assures the role of the modifications performed in the ingredients of dry cake formulas in this study on improving the textural quality of cake when compared to control one. The positive effect of emulsifier present in T1 to T4 cakes on textural quality can be explained by the interaction between the starch and the emulsifier, which affects the starch retrogradation as was confirmed by Gómez et al. (2004), Ronda et al. (2009), Jia et al. (2014) and Shao et al. (2015). Also, emulsifiers influence the amount and size of the bubbles and improve aeration in cake batters, resulting in higher volume and better crumb structure and tenderness (Orthoefer and Kim, 2019). In this regard, the effect of emulsifier on enhancing the textural quality of cakes cannot be discussed apart from the role of gums, Salehi (2020) reported also that gums (including CMC) can modify the starch pasting properties and have an important role in developing food flavor, mouthfeel and chewiness, texture, starch retrogradation retardation, enhanced moisture retention, and improving the total quality of the bakery products.

On the other hand, and with regard to color parameter, all tested cake samples, including control one, didn't attain any significantly ($p>0.05$) different scores for the color. Regarding the flavor, cake formulas with 50% of fat replaced didn't show any differences than the control one. However, replacing the whole fat in cake formulations (i.e. T3 and T4 formulas) led to a significant ($p<0.05$) decrease in the perception of flavor and scored lower accordingly. This can correspond to decreasing the flavor scoring on the 9-point hedonic scale from “like very much “in case of control, T1 and T2 cakes, to “like slightly“in case of T3 and T4 ones. As flavor (odor and taste) acceptability depends mainly on the flavor of the studied cake ingredients as previously described by Ronda et al. (2009), the lower flavor score for T3 and T4 cakes can be attributed to the total exclusion of added fat (butter) which is highly favorable by the consumers, with another one with bland flavor (maltodextrin). However, the final outcome of the aforementioned sensory characteristics (i.e. cells, grain, texture, crumb color and flavor) as calculated from the total score showed a significant increase in cake quality for T1, T2 and T3 samples when compared to the control one.

4. Conclusion

The produced ready-to-bake whole grain barley cake mixes in the present study showed a potential for the production barley cake with improved quality. In pace with the nutritional recommendations, the produced cakes had the advantage of containing relatively higher dietary fiber content as a result of using whole grain barley flour with a significant decrease in both fat content and caloric value. Using of maltodextrin and CMC has affected the physical quality characteristics of cakes (i.e. volume and specific volume) in different (and sometimes in opposite) ways. However, the final outcome of these effects was positive and towards cake quality improvement. Moreover, inclusion of those two additives along with emulsifier has a good effect on the physical, textural and sensory characteristics of cakes. Production of good quality whole grain barley cake has become feasible as shown in the present study. Although whole grain barley cakes is not a widely known bakery product , the recent awareness and demand for whole grain, high fiber and nutritious bakery items in general will increase the demand and consumer acceptability of such products. In addition, the recent trend for using alternative cereal grains (with improved crop adaptation to grow under moderate water deficit and wide range of climatic conditions) and also those having improved nutritional value to replace wheat, will make barley products as a priority. Further studies are needed to use whole grain barley flour in the production of other cereal products such as bread, cookies, muffins, pastry and noodles. More detailed nutritional considerations of such products can be taken into account (e.g. determination of ß-glucan, mineral contents, phytochemical and antinutritional factors). The effect of other food additives and improvers on the quality characteristics and consumer acceptability of other cereal products made of barley can also be a subject to study.

COMPETING INTERESTS DISCLAIMER:

Author has declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the author and producers of the products because I do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the author.

Ethical approval:

The study did not involve any human or animal testing.

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Table 1. Ready-to-bake whole grain barley cake mixes formula.

Ingredients (g)	Control	T1	T2	T3	T4
Barley flour	100	100	100	100	100
Sugar	100	100	100	100	100
Fat (butter)	20	10	10	-	-
Maltodextrin	-	10	10	20	20
Dry egg white	5	5	5	5	5
CMC	-	0.5	1	0.5	1
Emulsifier mix	-	5	5	5	5
Baking powder	4	4	4	4	4
Salt	1	1	1	1	1

Table 2. Proximate chemical composition and physical characteristics of cakes produced from whole grain ready-to-bake barley cake mixes.*

Sample	Chemical composition (g/100 g cake)							Physical characteristics			
	Moisture	Protein	Ether extract	Ash	Dietary fiber	Digestible Carbohydrates	Caloric value (Kcal/ 100g)	Weight (g)	Height (cm)	Volume (cm^3)	Specific volume (cm^3/g)
Control	30.0^{a} ± 0.3	5.2^{a} ± 0.1	4.7^{a} ± 0.4	0.8^{a} ± 0.0	4.4^{a} ± 0.4	54.9^{c} ± 0.3	282^{a} ± 4	43.0^{a} ± 0.4	4.1^{b} ± 0.1	96.7^{c} ± 1.2	2.3^{d} ± 0.0
T1	29.9^{a} ± 0.2	5.3^{a} ± 0.1	2.6^{b} ± 0.2	0.8^{a} ± 0.0	4.1^{a} ± 0.2	57.2^{b} ± 0.4	273^{b} ± 1	41.3^{b} ± 0.1	4.4^{a}± 0.1	108.0^{b} ± 2.0	2.6^{b} ± 0.1
T2	29.6^{a} ± 0.6	5.4^{a} ± 0.1	2.7^{b} ± 0.3	0.8^{a} ± 0.0	4.6^{a} ± 0.3	57.0^{b} ± 0.8	273^{b} ± 4	42.7^{a} ± 0.2	4.2^{b} ± 0.2	110.0^{ab} ± 1.2	2.6^{b} ± 0.0
T3	29.8^{a} ± 0.3	5.3^{a} ± 0.2	0.6^{c} ± 0.1	0.8^{a} ± 0.1	4.2^{a} ± 0.2	59. 5^{a} ± 0.2	264^{c} ± 1	41.7^{b} ± 0.3	4.2^{b} ± 0.1	113.3^{a} ± 1.2	2.7^{a} ± 0.0
T4	30.2^{a} ± 0.3	5.3^{a} ± 0.2	0.6^{c} ± 0.2	0.8^{a} ± 0.1	4.1^{a} ± 0.2	58.9^{a} ± 0.6	262^{c} ± 0	41.7 ^{b} ± 0.4	4.0^{b} ± 0.2	98.0^{c} ± 2.0	2.4^{c} ± 0.1

* Means (±SD) within the same column with the same letters are not significantly different (p>0.05), n=3.

Table 3. Texture Profile Analysis (TPA) of cakes produced from whole grain ready-to-bake barley cake mixes.*

Sample	Hardness (N)	Cohesiveness	Springiness (mm)	Chewiness (mJ)
Control	21.7^{a} ± 0.3	0.7^{b} ± 0.0	7.9^{b} ± 0.2	131.3^{a}±3.7
T1	18.7^{b} ± 1.0	0.8^{a} ± 0.0	8.1^{a} ± 0.1	124.8^{a}±9.1
T2	15.1^{c} ± 0.2	0.7^{b} ± 0.0	7.3^{c} ± 0.1	78.4^{b}±1.45
T3	12.8^{e}± 0.0	0.6^{c} ± 0.0	6.9^{d} ± 0.1	62.3^{c}± 3.9
T4	13.9^{d} ± 0.3	0.7^{b} ± 0.0	7.2^{c} ± 0.1	72.9^{b}±1.0

* Means (±SD) within the same column with the same letters are not significantly different (p>0.05), n=3.

Table 4. Mean sensory scores of cakes produced from whole grain ready-to-bake barley cake mixes.*

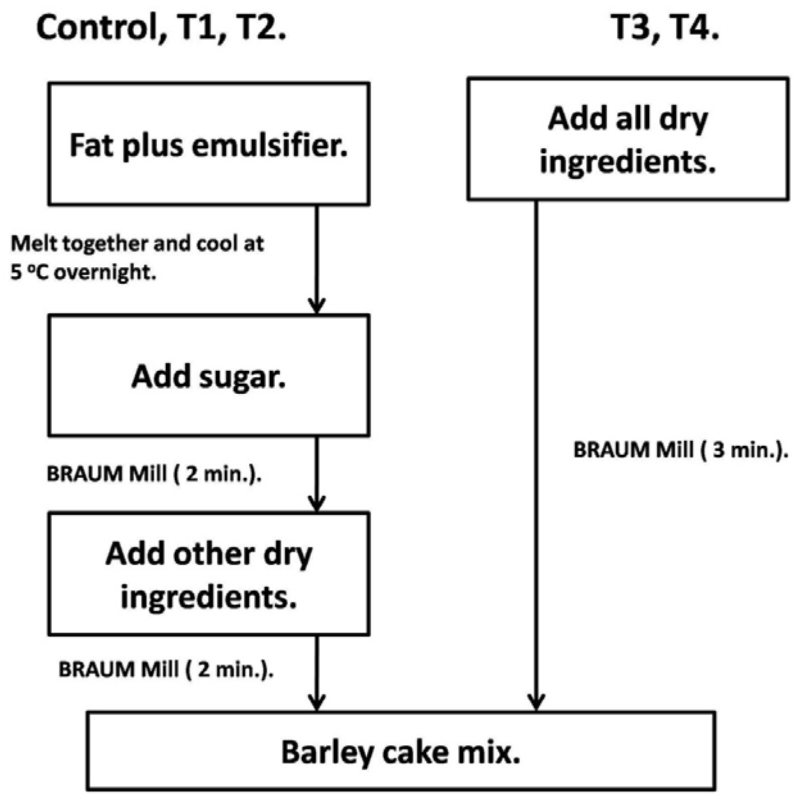
Sample	Cells (9)	Grain (9)	Texture (9)	Crumb color (9)	Flavor (9)	Total score
Control	$5.9^{c} \pm 0.6$	$5.5^{c} \pm 0.7$	$5.7^{c} \pm 0.7$	$7.2^{ab} \pm 0.4$	$7.8^{a} \pm 0.4$	$32.1^{c} \pm 1.5$
T1	$7.7^{a} \pm 0.5$	$7.8^{a} \pm 0.6$	$7.3^{a} \pm 0.8$	$7.8^{a} \pm 0.8$	$7.7^{a} \pm 0.8$	$38.3^{a} \pm 1.9$
T2	$8.0^{a} \pm 0.8$	$7.0^{b} \pm 0.9$	$6.9^{ab} \pm 0.7$	$7.6^{a} \pm 0.7$	$7.6^{a} \pm 1.0$	$37.1^{ab} \pm 2.1$
T3	$7.8^{a} \pm 0.4$	$7.7^{a} \pm 0.5$	$6.7^{ab} \pm 0.7$	$7.9^{a} \pm 0.7$	$5.8^{b} \pm 0.5$	$35.9^{b} \pm 1.3$
T4	$6.6^{b} \pm 0.5$	$6.5^{b} \pm 0.5$	$6.4^{b} \pm 0.7$	$6.7^{b} \pm 1.3$	$5.6^{b} \pm 0.5$	$31.8^{c} \pm 2.0$

* Means (±SD) within the same column with the same letters are not significantly different ($p>0.05$), $n=10$.

Figure captions:

Figure 1. Procedure for preparing whole grain ready-to-bake barley cake mixes.

Figure 2. Cross-sections of cakes prepared from whole grain ready-to-bake barley cake mixes.



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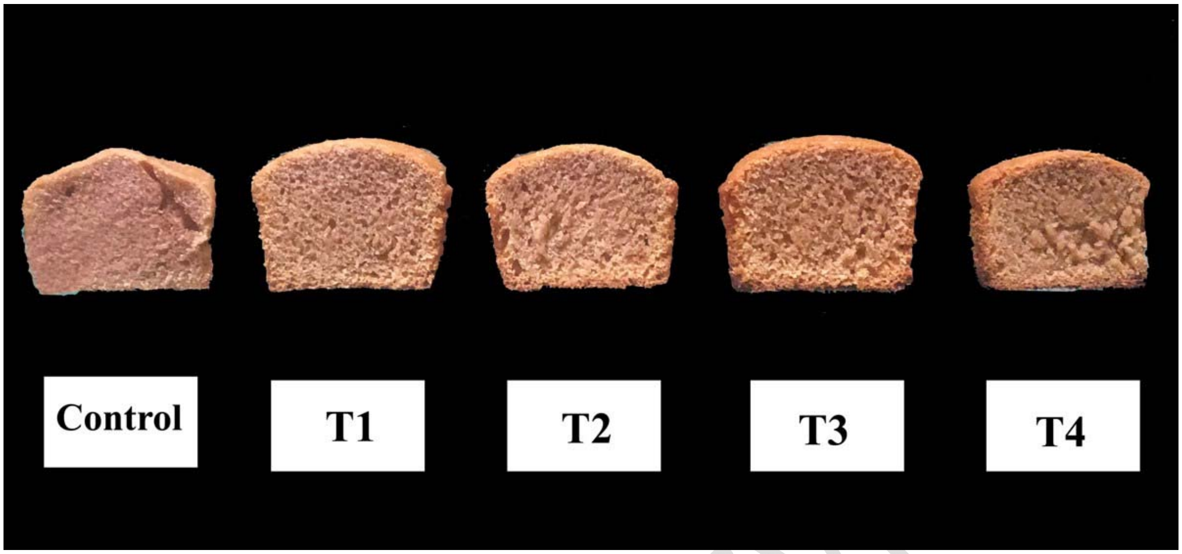

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