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Gluten-free cookies from sorghum and Turkish beans; effect of some non-conventional and commercial hydrocolloids on their technological and sensory attributes

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Abstract

Consumption of gluten-free products is the best possible option for patients with celiac disease. The development of gluten-free cookies may provide a suitable alternative for individuals who are gluten-intolerant. The purpose of this research was to assess the use of hydrocolloids as gluten substitutes in cookies. Commercially available (gum Arabic and xanthan gum) and freshly extracted (cress seed, fenugreek, flaxseed, okra) hydrocolloids were added at a substitution level of 5% in gluten-free flour prepared from sorghum and Turkish beans. Pasting temperature of flour blends decreased significantly as a function of the type of hydrocolloid, except for gum Arabic, whereas the inclusion of gum resulted in an increase in water activity, moisture, ash, and fiber content of cookies. The hardness of cookies was higher in the presence of gum, while lightness and diameter were reduced with gum addition. Okra- and gum Arabic-substituted cookies had similar sensory acceptability as the control, and the presence of cress seed gum resulted in higher antioxidant activity. The cookies produced were acceptable from the technological and sensory standpoint and this may help the baking industry to provide gluten-free options for consumers who cannot tolerate gluten.

Keywords: gluten-free cookies; gum; sorghum; Turkish beans; antioxidants.

Practical Application: Celiac disease is a worldwide concern since it is an immune disease in which patients cannot tolerate gluten-containing diets. It is also widespread in the Saudi population including children and women. The consumption of a gluten-free diet is the only possible dietary solution for such patients. The current research was aimed at developing gluten-free cookies from sorghum and Turkish bean flours. The product was acceptable from the technological and sensory standpoint and this may help the baking industry to provide gluten-free options for consumers who cannot tolerate gluten.

1 Introduction

Food industries have been recently engaged in the development of functional foods that are safe for ingestion and have health benefits. One of such developments is the production of gluten-free products. A chronic enteropathy disorder defined as celiac disease or gluten intolerance, triggered by the prolamine fraction of gluten proteins from wheat, barley, oat, spelt, and rye, causes atrophy of intestinal villi, malabsorption, and clinical symptoms that occur both in childhood and adulthood (Benkadri et al., 2018; Pestorić et al., 2017). Furthermore, it causes inadequate absorption of nutrients such as macro or micro minerals and vitamins. It is estimated that up to 1% of the world population is suffering from celiac disease and the only treatment is to avoid the ingestion of gluten-containing products (Walker & Talley, 2011). Recently, the use of sorghum in the production of gluten-free foods has begun to emerge in some developed countries. Sorghum (*Sorghum bicolor L.*) is the fifth most important and gluten-free cereal that belongs to family *Poaceae*, and is widely cultivated in Africa, South Asia, and Central America (Adeyeye, 2016). It has been characterized as staple food for about 500 million people in at least 30 countries. Furthermore, it is a rich source of antioxidants and phenolic compounds as compared to other cereals such as rice. However, the development of superior-quality products from gluten-free flours such as sorghum results in poor nutritive quality and technological challenges. Thus, efforts have been made to adopt procedures such as the inclusion of hydrocolloids, or the use of flours from different legumes or pseudo-cereals, to obtain gluten-free products with superior quality and to overcome the difficulties during processing (Pellegrini & Agostoni, 2015). Turkish white beans (*Phaseolus vulgaris L.*) belong to the family *Fabaceae*, widely cultivated in Europe, Turkey, and America. Beans are a rich source of phytochemicals such as phenolics, tannins, and flavonoids. In recent years, more emphasis has been put on the utilization of beans as a functional or nutraceutical component (Camara et al., 2013). Fortification of corn flour with bean flour has been reported and the fortified extruded snacks produced have a better ability to substitute regular extruded snacks as a healthier option. Cookies are the most popular bakery items in many parts of the world and are consumed quite frequently due to their good nutritional quality, prolonged shelf life, ready-to-

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eat nature, convenience, cost effectiveness, and availability in various flavors (Sudha et al., 2007). In gluten-free cookies, the lack of gluten usually results in weak binding, poor stretching, improper color, and quality defects which could be improved by the use of additives (1%) such as non-starch hydrocolloids (Devisetti et al., 2015).

Hydrocolloids or gums are a diverse group of high-molecular weight biopolymers which are extensively utilized as additives in the food industry. Hydrocolloids perform several functions in food production such as water holding, dietary fiber addition, thickening, stabilizing, dispersing, foaming, gelling, and texture modification. In addition, they improve the mouthfeel, thermal stability, starch retrogradation, gas retention in dough systems, and also increase sensorial quality (Ferrero, 2017). Their main applications are in the manufacturing of cookies, bread, cakes, jellies mayonnaise, dressings, dessert, and ice-cream (Funami, 2011). Several researchers have already reported that cookie quality can be improved by using commercial gums such as xanthan, guar, and gum Arabic in different concentrations (Gul et al., 2018; Kaur et al., 2015; Thejasri et al., 2017). The main objective of the current research was to study the role of six different types of hydrocolloids in sorghum- and Turkish bean-based gluten-free cookie formulations.

2 Materials and methods

2.1 Materials

Commercial gums (gum Arabic and xanthan) were provided by Qualikems Fine Chem Pvt. Ltd. Seed grains (Cress seed, fenugreek, and flaxseed), okra pods, sorghum and Turkish bean flour were procured from local supermarket. Sucrose (common sugar), shortening, baking powder, fennel seed powder, table salt, and eggs were also purchased from local supermarkets in Riyadh, Saudi Arabia.

2.2 Methods

Extraction of non-commercial gums

Cress seed, fenugreek, and flaxseed grains were cleaned to remove extraneous material whereas okra pods were washed, cut into halves, and seeds were removed before gum extraction. Gum extraction was conducted as follows.

Cress seed gum

Gum was extracted according to Karazhiyan et al. (2011) with slight modifications. Briefly, 50 g of seeds were soaked in 1 L of water for 3 hours. Cheesecloth was used to squeeze and separate the swollen seeds from the filtrate. The filtrate was freeze-dried, ground to fine powder (60 mesh), and stored at 4 °C in airtight glass bottles.

Fenugreek gum

Gum was extracted according to Qian et al. (2012) with slight modifications. Fenugreek seeds (75 g) were soaked overnight in 1 L of water with continuous stirring. Ruptured seeds were separated by filtration through a sieve. The filtrate was then mixed with ethanol to precipitate the gum and the precipitate was filtered using muslin cloth. The gum was freeze-dried, milled to fine powder (60 mesh), and stored at 4 °C in airtight glass bottles.

Flaxseed gum

Flaxseed gum was extracted according to Qian et al. (2012). Flaxseeds (500 g) were soaked overnight in 4 L of water with continuous stirring. Cheesecloth was used to separate the seeds from the filtrate. Collected filtrate was centrifuged and supernatant was mixed with one part of 100% ethanol. Precipitated polysaccharide was freeze-dried, milled to fine powder (60 mesh), and stored at 4 °C in airtight glass bottles.

Okra gum

Okra mucilage was extracted according to Alamri (2014a). Clean okra pods (100 g) were blended with 500 mL 0.05 M NaOH in a heavy duty blender for 5 minutes and then centrifuged at 2000 g for 15 minutes. The supernatant was separated and the pH adjusted to the neutrality. Further, the resulting mucilage was freeze-dried, milled to fine powder (60 mesh), and stored at 4 °C in airtight glass bottles.

Pasting properties of gluten-free flour/gum blends

Flour blends were prepared substituting 5% of the flour with each gum while plain flour was used as a control. Pasting properties were analyzed using the Rapid Visco Analyzer (RVA) (Newport Scientific, Sydney, Australia) according to Kaiser Mahmood et al. (2018) with slight modifications. Distilled water was added to a 3.5 g sample at 14% moisture basis for both control and blends to attain a total weight of 28 g in an RVA aluminum canister. The resultant slurry was retained initially for 60 seconds at 50 °C. The speed of the paddle was maintained at 960 rpm for the first 10 seconds and then reduced to 160 rpm during the whole test. Samples were heated for 3.42 minutes at 13.15 °C/m from 50 °C to 95 °C and then retained for 2.5 minutes at 95°C. Afterwards, temperature was reduced from 95°C to 50°C in 3.42 minutes at the rate of 13.15 °C/m and then retained for 2 minutes at 50 °C. Data were processed using Thermocline software (Newport Scientific, Sydney, Australia).

Cookie preparation

Cookies (molded) were prepared according to the Approved Methods of the AACC (American Association of Cereal Chemists, 2000), method nº 10-50 with some modifications. The formulation used for cookie production is listed in Table 1. The flour mixture consisted of 1:1 (w/w) sorghum and Turkish bean flour. Replacement of mixed flour with 5% of each gum (gum Arabic, xanthan, cress seed, fenugreek, flaxseed, and okra gum) was conducted to get different flour blends. For cookie dough preparation, all the ingredients were added in the mixing bowl in a specific order. Sugar and shortening were mixed for 2 minutes at low speed. Eggs were added and further mixed for 1 minute. Thoroughly mixed flour, salt, fennel seed powder, and baking powder were added and mixed for 1 minute at low

Table 1. Gluten-free cookie formulation.

Ingredients	Control	Gum arabic	Xanthan	Cress seed	Fenugreek	Flaxseed	Okra
Flour† (g)	200	190	190	190	190	190	190
Gum (g)	-	10	10	10	10	10	10
Shortening (g)	55	55	55	55	55	55	55
Sugar (g)	110	110	110	110	110	110	110
Salt (g)	2	2	2	2	2	2	2
Fennel powder (g)	8	8	8	8	8	8	8
Baking powder (g)	2	2	2	2	2	2	2
Dextrose 6% (mL)	30	30	30	30	30	30	30
Distilled water (mL)	14	14	14	14	14	14	14
Egg (No)	1	1	1	1	1	1	1

† Flour = Sorghum + Turkish bean (50% + 50% w/w).

speed. Finally, dextrose and distilled water were added and mixed for another minute or until homogenized. The dough was further sheeted to 5-mm thickness with the help of rolling pins. Cookies were cut with a cutter, placed on baking trays, and baked at 225 °C for 11 minutes. Baked cookies were cooled at room temperature, sealed in plastic bags, and stored at room temperature for further analysis.

Cookie chemical analysis

Moisture, ash, protein, fat, and fiber were determined according to AACC (American Association of Cereal Chemists, 2000) method nº 44-15A, 08-01, 46-10, 30-10, and 32-10, respectively. Total carbohydrates were determined by the difference method.

Cookie physical analysis

Cookie thickness, diameter, and spread factor were measured according to Kaur et al. (2015). Six cookies were stacked to get an average thickness in mm with the help of a digital Vernier caliper. Similarly, for the average diameter, six cookies were lined edge to edge and the average width in mm was calculated by rotating the cookies at 90 degrees angle. Spread factor was calculated with the ration between the diameter and the thickness of the cookies.

Cookie texture analysis

Cookie texture was determined according to Gul et al. (2018) using a texture analyzer (TA-XT plus Stable Micro Systems, Haslemere, UK) fitted with a 50 kg load cell, a 3-point bending rig, and a heavy-duty platform. The pre-test speed was adjusted to 1 mm/s, the test speed was 3 mm/s while the post-test speed was 10 mm/s; the distance to the bend was adjusted to 5 mm. Data were recorded as fracturability (distance to break) and hardness (force required to break).

Determination of water activity

Water activity (a_w) was determined using an Aqua Lab Series 3 Water activity meter (Decagon devices, Pullman, USA) according to Inglett et al. (2015). Cookie pieces of 2 mm were placed in the measuring cell at 25 °C.

Cookie color analysis

The color was determined using a Hunter lab calorimeter (LabScan XE, USA) according to Inglett et al. (2015). The color values of cookies were recorded as L* which indicates lightness and ranges between 0 (black) and 100 (white), a* which indicates redness to greenness, and b* which indicates yellowness to blueness of cookies.

Sensory evaluation of cookies

Coded cookie samples were presented to 30 semi-trained panelists in a random order. The cookies were coded with a three-digit number and were evaluated for their sensory attributes such as appearance, color, texture, aroma, taste, aftertaste, and overall acceptability according to Gat & Ananthanarayan (2016). Scaling of the above-mentioned parameters was done using a 9-point hedonic scale, with 1 for "dislike extremely", 5 for "neither dislike nor like", and 9 for "like extremely".

Determination of total phenols, antioxidants, and radical scavenging activity

Cookie samples (1 g) were mixed in a shaker with 25 mL of ethanol for 24 hours. The mixture was centrifuged at 10000 rpm for 15 minutes. The supernatant was collected and filtered through Whatman Nº 41 filter paper. Final volume of the filtrate was adjusted to 25 mL and stored at 4 °C for further analysis. Total polyphenols were determined according to Wu et al. (2007) with slight modifications. The results were compared with a standard curve obtained with gallic acid and expressed as gallic acid equivalents per gram of dry weight of sample. Determination of the ferric-reducing antioxidant power (FRAP) was performed according to Gouveia & Castilho (2011). FRAP was expressed as mmol $FeSO_4 \cdot 7H_2O$ per mg of cookie dried sample (mmol Fe (II)/mg). Determination of DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity was done according to Akillioglu & Karakaya (2010), while determination of ABTS 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) radical scavenging activity was performed according to Gouveia & Castilho (2011). Results were expressed as g Trolox equivalent per g of dried sample and compared with standard calibration curve for Trolox.

Statistical analysis

All readings were collected at least in three replicates. Data were analyzed using analysis of variance (ANOVA). This analysis allowed us to detect significant effect of gums on different cookies´ attributes. Duncan's Multiple Range (DMR) test at sig ≤0.05 was used to compare means using SPSS (IBM Statistical Analysis Version 21).

3 Results and discussion

3.1 Pasting properties of gluten-free flour/gum blends

The pasting properties of gluten-free flour/hydrocolloid blends are shown in Table 2 and RVA profiles are depicted in Figure 1. Increase in peak viscosity (PV) as a function the hydrocolloid used was observed except for gum Arabic (441cP) whose PV was statistically the same as for the control (464cp).

The highest PV (3378cP) was recorded in the blend containing xanthan gum which might be due to the thickening effect of the hydrocolloid (Li et al., 2015). Another plausible explanation for this result might be the development of an interaction between the hydrocolloid and starch granules resulting in a decrease in the movement of the starch molecules (Shi & BeMiller, 2002).

The final viscosity represents the ability of starch to form a viscous paste. A significant increase in final viscosity was also observed as a function of the added gum except with gum Arabic and okra gum. The decrease in the final viscosity with both gums could be ascribed to the starch dilution effect of gluten-free flour due to the replacement with the gum. However, the increase in the final viscosity was attributed to the re-association of leached amylose which was promoted by the presence of the gum (Ahmed & Thomas, 2018). A similar trend was observed by Ahmed & Thomas (2018) and Yoon et al. (2016) when xanthan was incorporated to β-glucan-substituted wheat flour or barley flour. A remarkable increase in the PV (7.3%) and the final viscosity (3.2%) as compared to the control were noticed with the addition of xanthan, which was attributed to the unique molecular structure and the flexibility of the gum molecular chains (Achayuthakan & Suphantharika, 2008). Setback viscosity, which is used as an indicator of starch retrogradation that involves the re-association of amylose, significantly decreased with gum Arabic, cress seed, and okra gum compared to the control. According to Alamri et al. (2012), the development of the network and lining up could be attributed to the incorporation of the gum which behaved as a barrier between amylose molecules. In contrast, setback viscosity increased with xanthan, flaxseed, and fenugreek. The possible explanation could be that the gums were colonized in the liquid phase which allowed amylose to retrograde (Alamri, 2014b). Pasting temperature revealed the least temperature needed to cook the flour. Significant reduction was caused by the hydrocolloids except for gum Arabic which

Table 2. Pasting properties of flour/gums.

Treatment	Peak Viscosity (cP†)	Final Viscosity (cP)	Setback (cP)	Pasting temp. (°C)
Control	464 ± 07[f]	1291 ± 22[e]	878 ± 16[d]	86.55 ± 0.1[b]
Gum arabic	441 ± 12[f]	911 ± 17[g]	509 ± 12[g]	88.15 ± 0.1[a]
Xanthan	3378 ± 12[a]	4176 ± 48[a]	1090 ± 07[c]	76.70 ± 0.1[g]
Cress seed	747 ± 26[d]	1389 ± 07[d]	693 ± 18[e]	79.90 ± 0.2[f]
Fenugreek	1770 ± 28[b]	2972 ± 27[b]	1300 ± 28[a]	81.55 ± 0.1[e]
Flaxseed	855 ± 14[c]	1963 ± 06[c]	1182 ± 16[b]	84.85 ± 0.3[c]
Okra	699 ± 13[e]	1216 ± 06[f]	579 ± 12[f]	82.35 ± 0.2[d]

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different; † cP= Centipoise.

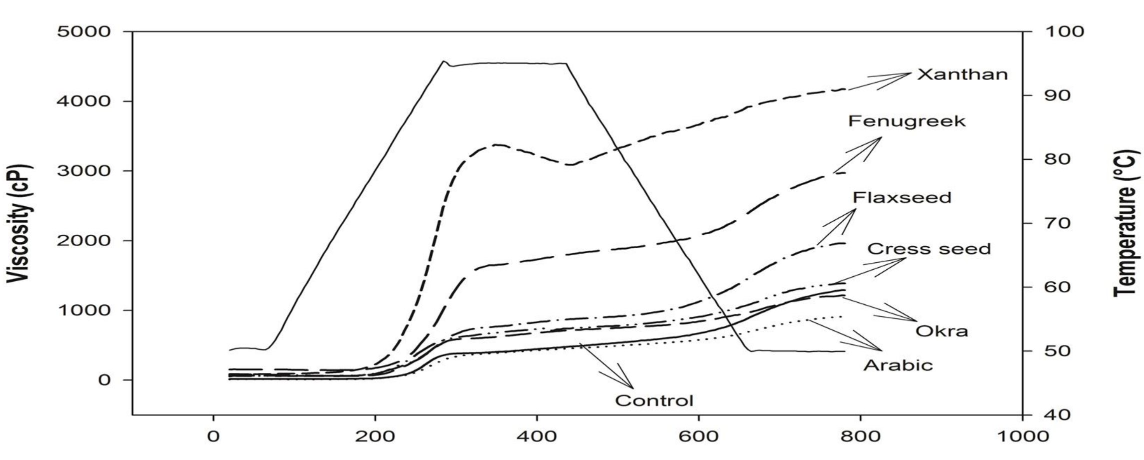

Figure 1. RVA profile of composite flours with or without gum.

in contrast, increased the pasting temperature significantly as compared to the control. The pasting temperature for the control was 86.55 °C which reduced to 76.70 °C with xanthan inclusion. Phimolsiripol et al. (2011) reported that the pasting temperature of 5% malva nut gum-substituted wheat flour decreased from 85.5 °C to 59.3 °C. Yoon et al. (2016) also observed a similar effect while using various hydrocolloids and barley flour. The decrease in pasting temperature was explained by the increasing concentration of starch granules in the continuous phase and the boosted association among the granules (Gałkowska et al., 2014). However, the increase in pasting temperature with gum Arabic might be due to the gum surrounding the starch granules in the composite system, which delayed the gelatinization of the starch present in gluten-free flour.

3.2 Cookie chemical analysis

The chemical composition of gluten-free cookies and the control are listed in Table 3. Moisture content increased significantly with the incorporation of gum irrespective of the gum type. Inclusion of cress seed gum or okra gum in the second place resulted in cookies with a maximum water retention. Increased in moisture content was attributed to the ability of hydrocolloids to bind water molecules (Rosell et al., 2001). Similar findings were reported by other authors who investigated the effect of adding different hydrocolloids (Arabic, xanthan, guar gum) to buckwheat flour on cookies or xanthan rice-chickpea flour blend on the development of gluten-free biscuits (Benkadri et al., 2018; Kaur et al., 2015).

Significant increase in ash content was observed with the addition of gum except for xanthan gum which yielded statistically the same results as the control. This result was attributed to the presence of mineral content in the gums as they are not pure (with the exception of commercial gums. Similar results were reported by Thejasri et al. (2017) and Benkadri et al. (2018) who incorporated xanthan in quinoa and gluten-free flour, respectively. Similarly, an increase in fiber content was noticed. Increase in the crude fiber content was attributed to the addition of soluble fiber content, i.e. hydrocolloids, in the cookies. No significant difference was observed in crude protein, fat, and total carbohydrates content. The results of crude protein and fat were in agreement with Andrade et al. (2018) who studied the effect of xanthan and galactomannan addition in gluten-free cakes made from fava beans.

3.3 Cookie texture analysis and water activity

The analysis of the texture profile (hardness and fracturability) of gluten-free cookies with or without gum addition is presented in Table 4. Hardness is defined as the maximum force required to break the cookies, and it increased significantly as compared to the control irrespective of the gum used. Xanthan exhibited the highest hardness (78.90 N) followed by okra (67.68 N) while the control showed the lowest (29.62 N). The increase in hardness with the incorporation of gums was attributed to the ability of hydrocolloids (long-chain biopolymers) to bind considerable amount of free water. Furthermore, according to Gul et al. (2018) too much increase in hardness with xanthan could be ascribed to the extremely branched structure of the xanthan which easily interacts to form associations with other constituents. These results were in agreement with those of previous studies by Devisetti et al. (2015) and Gul et al. (2018) who evaluated the effect of the addition of hydrocolloids (guar and xanthan) on millet flour and xanthan gum on gluten-free flour, and reported an increase in hardness. Fracturability, which measures the resistance of a sample to bend before it breaks, was

Table 3. Chemical composition of cookies.

Treatment	Moisture %	Ash %	Crude Protein %	Crude Fat %	Crude Fiber %	Total Carbohydrates %
Control	5.12 ± 0.06^{d}	2.13 ± 0.04^{e}	10.67 ± 0.44^{a}	13.87 ± 0.06^{a}	1.60 ± 0.05^{d}	66.60 ± 0.36^{a}
Gum arabic	5.62 ± 0.33^{c}	2.25 ± 0.05^{cd}	10.54 ± 0.18^{a}	13.47 ± 0.23^{a}	2.04 ± 0.04^{a}	66.07 ± 0.32^{a}
Xanthan	5.82 ± 0.19^{bc}	2.20 ± 0.04^{de}	10.44 ± 0.30^{a}	13.42 ± 0.15^{a}	1.75 ± 0.03^{bc}	66.35 ± 0.05^{a}
Cress seed	6.30 ± 0.07^{a}	2.42 ± 0.03^{a}	10.14 ± 0.06^{a}	13.35 ± 0.15^{a}	2.06 ± 0.03^{a}	65.72 ± 0.11^{a}
Fenugreek	5.68 ± 0.18^{c}	2.30 ± 0.01^{bc}	10.23 ± 0.16^{a}	13.50 ± 0.43^{a}	1.86 ± 0.03^{bc}	66.40 ± 0.53^{a}
Flaxseed	5.72 ± 0.27^{c}	2.34 ± 0.07^{ab}	10.51 ± 0.08^{a}	13.78 ± 0.28^{a}	1.88 ± 0.17^{b}	65.74 ± 0.67^{a}
Okra	6.09 ± 0.02^{ab}	2.40 ± 0.02^{a}	10.30 ± 0.48^{a}	13.55 ± 0.34^{a}	1.74 ± 0.04^{c}	65.90 ± 0.55^{a}

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different.

Table 4. Textural properties and water activity of cookies.

Treatment	Hardness (N)	Fracturability (mm)	Water activity
Control	29.62 ± 0.49^{g}	4.18 ± 0.17^{b}	0.341 ± 0.00^{e}
Gum arabic	47.12 ± 0.47^{f}	4.42 ± 0.49^{b}	0.356 ± 0.00^{de}
Xanthan	78.90 ± 0.40^{a}	4.32 ± 0.17^{b}	0.405 ± 0.00^{c}
Cress seed	63.57 ± 0.85^{c}	3.54 ± 0.23^{c}	0.475 ± 0.01^{a}
Fenugreek	52.67 ± 0.09^{d}	4.36 ± 0.07^{b}	0.376 ± 0.02^{d}
Flaxseed	48.54 ± 1.24^{e}	4.23 ± 0.29^{b}	0.377 ± 0.01^{d}
Okra	67.68 ± 0.41^{b}	5.50 ± 0.12^{a}	0.439 ± 0.02^{b}

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different. N: Newton.

significantly increased with okra gum while it was significantly decreased with cress seed gum which might be due to the high water activity in the cress seed sample. Water activity was also increased as a function of gum except for gum Arabic which was statistically the same as the control. The sample containing cress seed gum exhibited the highest water activity (0.475) compared to the control (0.341). Increases in water activity values were attributed to the hydrophilic nature of the gums. Variation in water activity values with various gums might be due to differences in their chemical structure and their association with added food components (Gomez et al., 2007).

3.4 Cookie physical analysis

The physical properties such as diameter, thickness, and spread ratio of gluten-free cookies with or without hydrocolloid addition are summarized in Table 5. The cookie diameter varied significantly with the incorporation of different hydrocolloids as shown in Figure 2.

Table 5. Physical properties of cookies.

Treatment	Diameter (mm)	Thickness (mm)	Spread Ratio
Control	61.97 ± 0.05^{a}	8.95 ± 0.07^{b}	6.92 ± 0.05^{a}
Gum arabic	59.74 ± 0.29^{b}	8.71 ± 0.03^{c}	6.86 ± 0.02^{ab}
Xanthan	56.35 ± 0.48^{d}	8.36 ± 0.06^{f}	6.74 ± 0.03^{c}
Cress seed	58.61 ± 0.25^{c}	8.57 ± 0.06^{d}	6.84 ± 0.04^{ab}
Fenugreek	56.28 ± 0.34^{d}	8.31 ± 0.05^{f}	6.78 ± 0.05^{bc}
Flaxseed	56.25 ± 0.58^{d}	8.46 ± 0.02^{e}	6.65 ± 0.08^{d}
Okra	59.80 ± 0.20^{b}	9.75 ± 0.05^{a}	6.13 ± 0.04^{e}

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different.

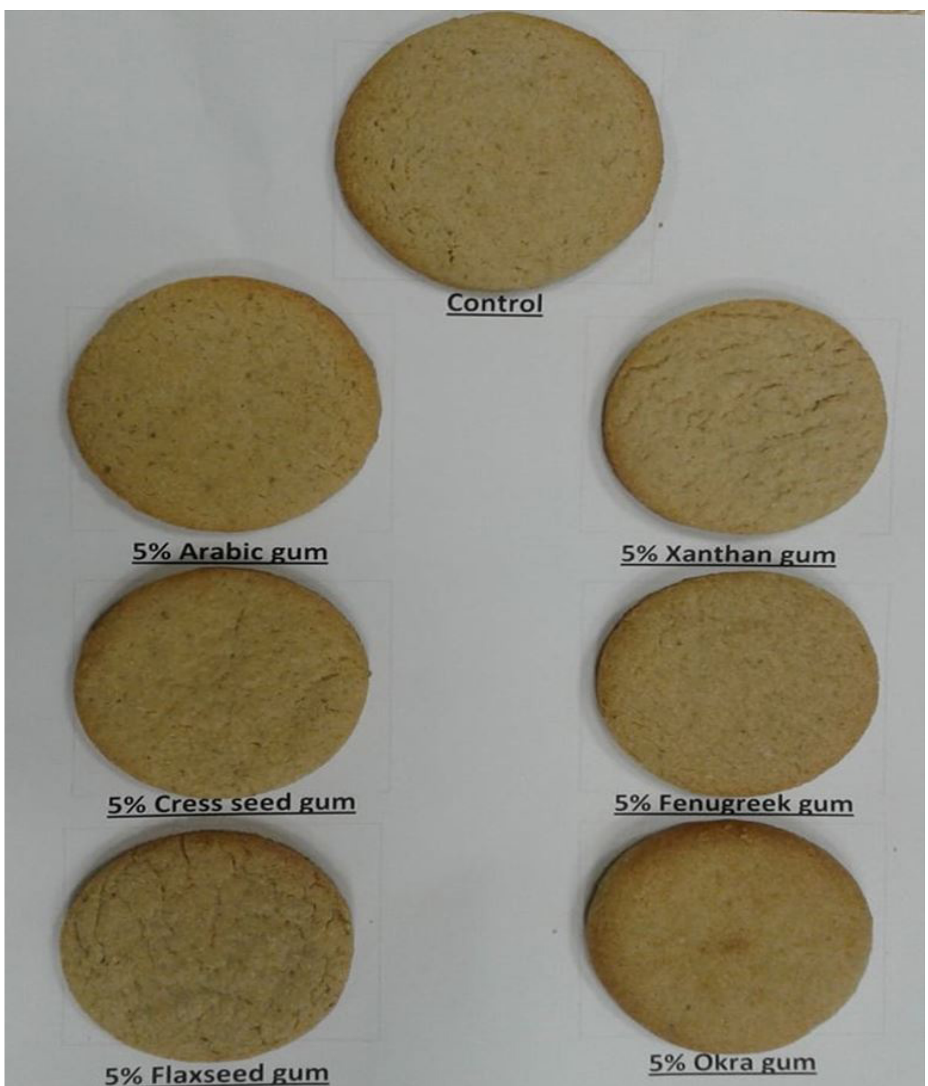

Figure 2. Photographs of the cookies prepared with various hydrocolloids.

The diameter decreased as a function of the gum added. The control sample exhibited the largest diameter (61.97 mm) followed by the okra cookie (59.80) while the flaxseed gum-containing sample presented the smallest diameter (56.25 mm). Devisetti et al. (2015) studied the effect of different hydrocolloid addition in millet flour and reported also a diameter reduction. The plausible explanation for the largest diameter of control cookies (no gum added) could be ascribed to the absence of gluten in their formulation which resulted in an inferior binding and stretching attributes (Gul et al., 2018). The thickness of the cookies dramatically increased with the addition of okra gum, exhibiting the highest thickness (9.75 mm) as compared to the control (8.95 mm). Similar results were reported by Kaur et al. (2015) and Thejasri et al. (2017) who studied the effect of various gums on buckwheat flour, quinoa, or millet flour. In contrast, thickness decreased compared to the control for all the other gums tested. Spread ratio, calculated as a ratio of diameter to thickness, decreased with the inclusion of gum in the gluten-free flour except for gum Arabic and cress seed gum which showed a spread ratio statistically the same as for the control. The least spread ratio was found with okra (6.13) followed by flaxseed (6.78) gum. Similar trends were also observed by Kaur et al. (2015) and Gul et al. (2018) when adding xanthan or tragacanth gum to buckwheat flour and xanthan gum to gluten-free flour. According to Devisetti et al. (2015) the reduction in the spread ratio might be due to the large number of hydroxyl groups in the gum structure which bind to available water via hydrogen bonding. This ultimately leads to an increase in the water holding capacity of gums which results in insufficient water for hydration. Furthermore, usually gum addition increased the viscosity of the solution; therefore, the flow of the dough particularly depended on the viscosity: the greater the viscosity, the lesser the spread ratio (Giuberti et al., 2018).

3.5 Cookie color analysis

Hydrocolloid inclusion significantly affected the color properties of gluten-free cookies as shown in Table 6. The L* value, which indicates lightness, was the highest for cookies without gum (control), and significantly decreased for the rest of the gums tested. The lowest L* value exhibited by the okra gum-substituted cookies meant that their color was darker compared to the control. Significant drop in the L* value for okra was attributed to the dark color (green) of the gum.

Furthermore, the darker color of cookies with hydrocolloid added compared to control ones was expected because during the Maillard reaction between proteins and reducing sugars, a dark color is produced due to melanoidin formation (Zucco et al., 2011). Similar results were reported by Alamri (2014a) and K Mahmood et al. (2014) who studied the effect of okra and cordia gums on wheat bread. However, an opposite trend was noticed with the redness (a*) value, as okra presented the highest a* value which means more redness. In contrast, control cookies exhibited the least a* value which means greenness. For b* (yellowness) the control showed the highest value. Yellowness decreased with the incorporation of gums which indicated more blueness except with gum arabic which showed statistically the same results as the control. Thejasri et al. (2017) and Gul et al. (2018) also reported a similar observation when studying the influence of the mixture of guar and xanthan gum on millet cookies, xanthan, on gluten-free cookies.

3.6 Cookie sensory evaluation

Cookies formulated from gluten-free flour, with or without gum addition, were subjected to consumer acceptability tests and were evaluated for appearance, color, texture, aroma, taste, after taste, and overall acceptability using a 9-point hedonic scale. In general, results revealed that panelists assessed the control cookies as better in terms of overall acceptability followed by the gum Arabic- and okra-gum substituted cookies. In contrast, cookies with the addition of fenugreek and cress seed exhibited the lowest scores. Hydrocolloid addition significantly affects the sensory attributes as shown in the Table 7. The incorporation of okra resulted in a relatively better appearance and color of the cookies while xanthan and flaxseed affected negatively the product as compared to the control. The lowest scores from panelists might be due to the development of a highly cracked surface compared to the smooth surface of the okra-substituted cookies as shown in Figure 2. Several researchers reported an improvement in the appearance and color of the cookies with the inclusion of hydrocolloids (Kaur et al., 2015; Thejasri et al., 2017). Supplementation of gum Arabic resulted in a slightly better texture while it was negatively affected by xanthan, fenugreek, and cress seed gums, maybe due to the strong water holding capacity of gums which resulted in higher hardness values as depicted in Table 3. The decrease in textural scores were noticed by the addition of xanthan gum beyond 3% concentration (Gul et al., 2018). Aroma, taste, and after taste were negatively affected by the cress seed and fenugreek inclusion. This result might be ascribed to the presence in high amounts of various phenolic compounds (Table 8) which caused the poor flavor

Table 6. Color properties of cookies.

Treatment	Lightness (L*)	Redness (a*)	Yellowness (b*)
Control	34.23 ± 0.08^{a}	0.65 ± 0.04^{d}	6.56 ± 0.10^{a}
Gum Arabic	33.82 ± 0.13^{b}	0.86 ± 0.09^{bc}	6.50 ± 0.15^{a}
Xanthan	33.33 ± 0.28^{c}	0.68 ± 0.05^{cd}	5.72 ± 0.20^{c}
Cress seed	33.47 ± 0.08^{c}	0.73 ± 0.05^{cd}	6.16 ± 0.04^{b}
Fenugreek	32.81 ± 0.04^{d}	0.96 ± 0.09^{b}	6.23 ± 0.09^{b}
Flaxseed	32.93 ± 0.06^{d}	0.75 ± 0.05^{cd}	5.56 ± 0.07^{c}
Okra	31.49 ± 0.14^{e}	1.52 ± 0.19^{a}	6.11 ± 0.11^{b}

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different.

Table 7. Sensorial properties of cookies.

Treatment	Appearance	Color	Texture	Aroma	Taste	After Taste	Overall acceptability
Control	7.5 ± 0.7[ab]	7.6 ± 1.0[ab]	7.4 ± 1.0[ab]	7.5 ± 0.8[a]	7.8 ± 0.4[ab]	7.7 ± 0.8[a]	8.0 ± 0.5[a]
Gum Arabic	7.7 ± 0.5[ab]	7.8 ± 0.4[ab]	7.5 ± 0.7[a]	7.1 ± 0.9[abc]	8.0 ± 0.5[a]	7.3 ± 0.9[ab]	7.7 ± 0.5[a]
Xanthan	6.1 ± 0.7[c]	6.6 ± 1.0[c]	5.9 ± 0.7[d]	6.3 ± 0.8[c]	6.8 ± 0.6[c]	6.6 ± 1.0[b]	6.6 ± 1.0[b]
Cress seed	6.9 ± 1.0[b]	7.2 ± 0.9[bc]	6.4 ± 0.8[cd]	5.5 ± 0.8[d]	5.8 ± 0.9[d]	5.0 ± 0.9[c]	5.8 ± 0.8[c]
Fenugreek	7.2 ± 0.9[ab]	7.2 ± 0.8[bc]	5.9 ± 0.9[d]	5.2 ± 0.9[d]	4.6 ± 0.8[e]	3.7 ± 0.8[d]	5.5 ± 1.0[c]
Flaxseed	5.9 ± 0.9[c]	6.4 ± 0.8[c]	6.6 ± 1.0[bcd]	6.6 ± 1.0[bc]	7.1 ± 0.6[c]	6.8 ± 0.8[b]	6.7 ± 0.9[b]
Okra	7.9 ± 1.0[a]	8.1 ± 1.0[a]	7.0 ± 0.9[abc]	7.2 ± 0.9[ab]	7.3 ± 0.9[bc]	7.2 ± 0.8[ab]	7.6 ± 0.8[a]

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different.

Table 8. Total phenols and antioxidants of cookies samples.

Treatment	T. Phenols (mg GAE/g)	DPPH[†] (%)	ABTS[‡] (g Trolox/g)	FRAP[§] (g Trolox/g)
Control	5.61 ± 0.17[c]	10.60 ± 0.76[c]	0.042 ± 0.001[b]	0.069 ± 0.001[c]
Gum Arabic	6.75 ± 0.20[b]	12.82 ± 0.10[b]	0.040 ± 0.002[b]	0.095 ± 0.003[a]
Xanthan	4.60 ± 0.24[d]	10.71 ± 0.25[c]	0.001 ± 0.001[d]	0.062 ± 0.003[d]
Cress seed	5.42 ± 0.37[c]	14.53 ± 0.42[a]	0.047 ± 0.002[a]	0.081 ± 0.003[b]
Fenugreek	8.00 ± 0.30[a]	12.22 ± 0.35[b]	0.004 ± 0.001[d]	0.065 ± 0.003[c]
Flaxseed	4.12 ± 0.20[e]	12.38 ± 0.44[b]	0.023 ± 0.002[c]	0.068 ± 0.001[c]
Okra	5.37 ± 0.36[c]	12.71 ± 0.10[b]	0.043 ± 0.004[b]	0.065 ± 0.002[c]

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different; † 2,2-diphenyl-1-picrylhydrazyl; ‡ 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid); § Ferric reducing antioxidant power.

development and bitterness in fenugreek-substituted cookies. Similar results were reported for buckwheat flour cookies by Kaur et al. (2015) who stated that low scores for taste were attributed to the presence of a noticeable amount of phenolic compounds in the flour. It was suggested that the variation in the attributes might be due to the dissimilarity in chemical structure and association among the food constituents and the gums. From the overall acceptability, it was concluded that gum Arabic- and okra-substituted cookies were of the same quality as compared to the control as they were acceptable for the consumer, while cress seed and fenugreek gum-containing cookies were not acceptable because of the bad flavor and bitterness.

3.7 Cookie total phenolics and antioxidants content

The total phenolic content of cookies with various incorporated gums is presented in Table 8. Fenugreek gum-substituted cookies showed the highest total phenol content (8 mg GAE/g) followed by the gum Arabic (6.75 mg GAE/g) containing cookies. Herald et al. (2012) reported that the total phenolic content for sorghum flour was up to 18.10 mg GAE/g while Orak et al. (2016) stated that total phenolic content in different varieties of Turkish bean was up to 0.63 mg GAE/g. Increase in phenolic content in flour with added fenugreek was attributed to the higher phenolic content of the seeds. Fezea et al. (2015) stated that a water extract of fenugreek seeds contain 19.31 mg GAE/g. In contrast, a significant decrease in the phenolic content with xanthan and flaxseed gum was noticed, and it might be ascribed to the development of strong interactions between xanthan and phenolics which did not release the phenols during baking.

Antioxidant activity of cookies with or with gums assessed by DPPH, ABTS, and FRAP methods is listed in Table 8. Antioxidants increased with the inclusion of cress seed and gum Arabic while the addition of xanthan decreased them significantly. However, with fenugreek, flaxseed, and okra the amount of phenols and antioxidants were statistically the same as for the control. The higher content of antioxidants might be attributed to the higher content of crude fiber. Alvarez-Jubete et al. (2010) reported that flours with higher content dietary fiber exhibited higher levels of antioxidant than those with low dietary fiber content.

4 Conclusion

The utilization of various hydrocolloids in the preparation of gluten-free cookies had significant effects on the textural, physical, chemical, and sensory attributes of cookies. Pasting properties of flour blends were improved with the presence of gums. Hardness of cookies increased due to gum addition while lightness decreased. Cookies with different gums added were high in protein, dietary fiber, and antioxidant properties compared to the control. Panelists rated cookies prepared with the incorporation of gum Arabic and okra gum as having better appearance, color, and texture than those prepared without gum. These gluten-free cookies are a good dietary option because they are rich in minerals, soluble fiber, total phenolics, and antioxidants.

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References

Achayuthakan, P., & Suphantharika, M. (2008). Pasting and rheological properties of waxy corn starch as affected by guar gum and xanthan gum. *Carbohydrate Polymers*, 71(1), 9-17. http://dx.doi.org/10.1016/j.carbpol.2007.05.006.

Adeyeye, S. A. O. (2016). Assessment of quality and sensory properties of sorghum–wheat flour cookies. *Cogent Food & Agriculture*, 2(1), 1245059. http://dx.doi.org/10.1080/23311932.2016.1245059.

Ahmed, J., & Thomas, L. (2018). Effect of xanthan and guar gum on the pasting, stickiness and extensional properties of brown wheat flour/β-glucan composite doughs. *Lebensmittel-Wissenschaft + Technologie*, 87, 443-449. http://dx.doi.org/10.1016/j.lwt.2017.09.017.

Akillioglu, H. G., & Karakaya, S. (2010). Changes in total phenols, total flavonoids, and antioxidant activities of common beans and pinto beans after soaking, cooking, and in vitro digestion process. *Food Science and Biotechnology*, 19(3), 633-639. http://dx.doi.org/10.1007/s10068-010-0089-8.

Alamri, M. S. (2014a). Okra-gum fortified bread: formulation and quality. *Journal of Food Science and Technology*, 51(10), 2370-2381. http://dx.doi.org/10.1007/s13197-012-0803-z. PMid:25328176.

Alamri, M. S. (2014b). Sweet potato/potato starch and Abelmoschus esculentus-gum blends: Thermal and textural properties. *Stärke*, 66(1-2), 132-141. http://dx.doi.org/10.1002/star.201300012.

Alamri, M. S., Mohamed, A., Hussain, S., & Xu, J. (2012). Effect of Okra extract on properties of wheat, corn and rice starches. *Journal of Food Agriculture and Environment*, 10(1), 217-222.

Alvarez-Jubete, L., Wijngaard, H., Arendt, E., & Gallagher, E. (2010). Polyphenol composition and in vitro antioxidant activity of amaranth, quinoa buckwheat and wheat as affected by sprouting and baking. *Food Chemistry*, 119(2), 770-778. http://dx.doi.org/10.1016/j.foodchem.2009.07.032.

American Association of Cereal Chemists – AACC. (2000). *Approved methods of the AACC* (10th ed.). St. Paul: AACC.

Andrade, F. J. E. T., Albuquerque, P. B. S., Moraes, G. M. D., Farias, M. D. P., Teixeira-Sá, D. M. A., Vicente, A. A., & Carneiro-da-Cunha, M. G. (2018). Influence of hydrocolloids (galactomannan and xanthan gum) on the physicochemical and sensory characteristics of gluten-free cakes based on fava beans (Phaseolus lunatus). *Food & Function*, 9(12), 6369-6379. http://dx.doi.org/10.1039/C8FO01448E. PMid:30456405.

Benkadri, S., Salvador, A., Zidoune, M. N., & Sanz, T. (2018). Gluten-free biscuits based on composite rice–chickpea flour and xanthan gum. *Food Science & Technology International*, 24(7), 607-616. http://dx.doi.org/10.1177/1082013218779323. PMid:29808729.

Camara, C. R., Urrea, C. A., & Schlegel, V. (2013). Pinto beans (Phaseolus vulgaris L.) as a functional food: Implications on human health. *Agriculture*, 3(1), 90-111. http://dx.doi.org/10.3390/agriculture3010090.

Devisetti, R., Ravi, R., & Bhattacharya, S. (2015). Effect of hydrocolloids on quality of proso millet cookie. *Food and Bioprocess Technology*, 8(11), 2298-2308. http://dx.doi.org/10.1007/s11947-015-1579-8.

Ferrero, C. (2017). Hydrocolloids in wheat breadmaking: a concise review. *Food Hydrocolloids*, 68, 15-22. http://dx.doi.org/10.1016/j.foodhyd.2016.11.044.

Fezea, F., Norziah, M., Bhat, R., & Ahmad, M. (2015). Effect of extraction solvents on antioxidant and antimicrobial properties of fenugreek seeds (Trigonella foenum-graecum L.). *International Food Research Journal*, 22(3), 1261-1271.

Funami, T. (2011). Next target for food hydrocolloid studies: Texture design of foods using hydrocolloid technology. *Food Hydrocolloids*, 25(8), 1904-1914. http://dx.doi.org/10.1016/j.foodhyd.2011.03.010.

Gałkowska, D., Pycia, K., Juszczak, L., & Pająk, P. (2014). Influence of cassia gum on rheological and textural properties of native potato and corn starch. *Stärke*, 66(11-12), 1060-1070. http://dx.doi.org/10.1002/star.201400078.

Gat, Y., & Ananthanarayan, L. (2016). Use of paprika oily extract as pre-extrusion colouring of rice extrudates: impact of processing and storage on colour stability. *Journal of Food Science and Technology*, 53(6), 2887-2894. http://dx.doi.org/10.1007/s13197-016-2271-3. PMid:27478245.

Giuberti, G., Rocchetti, G., Sigolo, S., Fortunati, P., Lucini, L., & Gallo, A. (2018). Exploitation of alfalfa seed (Medicago sativa L.) flour into gluten-free rice cookies: Nutritional, antioxidant and quality characteristics. *Food Chemistry*, 239, 679-687. http://dx.doi.org/10.1016/j.foodchem.2017.07.004. PMid:28873621.

Gomez, M., Ronda, F., Caballero, P. A., Blanco, C. A., & Rosell, C. M. (2007). Functionality of different hydrocolloids on the quality and shelf-life of yellow layer cakes. *Food Hydrocolloids*, 21(2), 167-173. http://dx.doi.org/10.1016/j.foodhyd.2006.03.012.

Gouveia, S., & Castilho, P. C. (2011). Antioxidant potential of Artemisia argentea L´Hér alcoholic extract and its relation with the phenolic composition. *Food Research International*, 44(6), 1620-1631. http://dx.doi.org/10.1016/j.foodres.2011.04.040.

Gul, H., Hayit, F., Acun, S., & Tekeli, S. G. (2018). Improvement of quality characteristics of gluten-free cookies with the addition of Xanthan Gum, *Sciendo*, 1(1), 529-535. http://dx.doi.org/10.2478/alife-2018-0083.

Herald, T. J., Gadgil, P., & Tilley, M. (2012). High-throughput micro plate assays for screening flavonoid content and DPPH-scavenging activity in sorghum bran and flour. *Journal of the Science of Food and Agriculture*, 92(11), 2326-2331. http://dx.doi.org/10.1002/jsfa.5633. PMid:22419130.

Inglett, G. E., Chen, D., & Liu, S. X. (2015). Physical properties of gluten-free sugar cookies made from amaranth–oat composites. *Lebensmittel-Wissenschaft + Technologie*, 63(1), 214-220. http://dx.doi.org/10.1016/j.lwt.2015.03.056.

Karazhiyan, H., Razavi, S. M., & Phillips, G. O. (2011). Extraction optimization of a hydrocolloid extract from cress seed (Lepidium sativum) using response surface methodology. *Food Hydrocolloids*, 25(5), 915-920. http://dx.doi.org/10.1016/j.foodhyd.2010.08.022.

Kaur, M., Sandhu, K. S., Arora, A., & Sharma, A. (2015). Gluten free biscuits prepared from buckwheat flour by incorporation of various gums: physicochemical and sensory properties. *Lebensmittel-Wissenschaft + Technologie*, 62(1), 628-632. http://dx.doi.org/10.1016/j.lwt.2014.02.039.

Li, X., Xing, Y., Sun, Q., Chu, L., & Xiong, L. (2015). Effect of food gums on properties of pea starch and vermicelli prepared from pea starch. *Stärke*, 67(5-6), 399-406. http://dx.doi.org/10.1002/star.201400100.

Mahmood, K., Alamri, M. S., Abdellatif, M. A., Hussain, S., & Qasem, A. A. A. (2018). Wheat flour and gum cordia composite system: pasting, rheology and texture studies. *Food Science and Technology (Campinas)*, 38(4), 691-697. http://dx.doi.org/10.1590/fst.10717.

Mahmood, K., Alamri, M., Mohamed, A., Hussain, S., & Abdu Qasem, A. (2014). Gum cordia: physico-functional properties and effect on dough rheology and pan bread quality. *Quality Assurance and Safety of Crops & Foods*, 7(4), 569-579. http://dx.doi.org/10.3920/QAS2014.0474.

Orak, H. H., Karamać, M., Orak, A., & Amarowicz, R. (2016). Antioxidant potential and phenolic compounds of some widely consumed Turkish white bean (Phaseolus vulgaris L.) varieties. *Polish Journal of Food and Nutrition Sciences*, 66(4), 253-260. http://dx.doi.org/10.1515/pjfns-2016-0022.

Pellegrini, N., & Agostoni, C. (2015). Nutritional aspects of gluten-free products. *Journal of the Science of Food and Agriculture*, 95(12), 2380-2385. http://dx.doi.org/10.1002/jsfa.7101. PMid:25615408.

Pestorić, M., Sakač, M., Pezo, L., Škrobot, D., Nedeljković, N., Jovanov, P., Šimurina, O., & Mandić, A. (2017). Physicochemical characteristics as the markers in predicting the self-life of gluten-free cookies. *Journal of Cereal Science*, 77, 172-179. http://dx.doi.org/10.1016/j.jcs.2017.08.013.

Phimolsiripol, Y., Siripatrawan, U., & Henry, C. J. K. (2011). Pasting behaviour, textural properties and freeze–thaw stability of wheat flour–crude malva nut (Scaphium scaphigerum) gum system. *Journal of Food Engineering*, 105(3), 557-562. http://dx.doi.org/10.1016/j.jfoodeng.2011.03.022.

Qian, K., Cui, S., Wu, Y., & Goff, H. (2012). Flaxseed gum from flaxseed hulls: extraction, fractionation, and characterization. *Food Hydrocolloids*, 28(2), 275-283. http://dx.doi.org/10.1016/j.foodhyd.2011.12.019.

Rosell, C. M., Haros, M., Escrivá, C., & Benedito de Barber, C. (2001). Experimental approach to optimize the use of α-amylases in breadmaking. *Journal of Agricultural and Food Chemistry*, 49(6), 2973-2977. http://dx.doi.org/10.1021/jf010012j. PMid:11409995.

Shi, X., & BeMiller, J. N. (2002). Effects of food gums on viscosities of starch suspensions during pasting. *Carbohydrate Polymers*, 50(1), 7-18. http://dx.doi.org/10.1016/S0144-8617(01)00369-1.

Sudha, M., Vetrimani, R., & Leelavathi, K. (2007). Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. *Food Chemistry*, 100(4), 1365-1370. http://dx.doi.org/10.1016/j.foodchem.2005.12.013.

Thejasri, V., Hymavathi, T., Roberts, T. P., Anusha, B., & Devi, S. S. (2017). Sensory, physico-chemical and nutritional properties of gluten free biscuits formulated with Quinoa (Chenopodium quinoa Willd.), Foxtail Millet (Setaria italica) and hydrocolloids. *International Journal of Current Microbiology and Applied Sciences*, 6(8), 1710-1721. http://dx.doi.org/10.20546/ijcmas.2017.608.205.

Walker, M. M., & Talley, N. J. (2011). Clinical value of duodenal biopsies–beyond the diagnosis of coeliac disease. *Pathology, Research and Practice*, 207(9), 538-544. http://dx.doi.org/10.1016/j.prp.2011.08.001. PMid:21940106.

Wu, C.-H., Murthy, H. N., Hahn, E.-J., & Paek, K.-Y. (2007). Improved production of caffeic acid derivatives in suspension cultures of Echinacea purpurea by medium replenishment strategy. *Archives of Pharmacal Research*, 30(8), 945-949. http://dx.doi.org/10.1007/BF02993961. PMid:17879746.

Yoon, S.-J., Lee, Y., & Yoo, B. (2016). Rheological and pasting properties of naked barley flour as modified by Guar, Xanthan, and locust bean gums. *Preventive Nutrition and Food Science*, 21(4), 367-372. http://dx.doi.org/10.3746/pnf.2016.21.4.367. PMid:28078260.

Zucco, F., Borsuk, Y., & Arntfield, S. D. (2011). Physical and nutritional evaluation of wheat cookies supplemented with pulse flours of different particle sizes. *Lebensmittel-Wissenschaft + Technologie*, 44(10), 2070-2076. http://dx.doi.org/10.1016/j.lwt.2011.06.007.