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Review article

Modification of physicochemical and nutritional properties of gluten free cakes by natural additives application

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A B S T R A C T

The demand for gluten-free products has increased in recent years, owing to the market trends and an increase in the number of celiac and other gluten sensitivities and wheat allergies. Products that contain gluten are also a major diet for a large portion of the world's population. For this reason, the development of gluten-free products is not only an urgent need for celiac patients but also a difficult task for food scientists. The preparation of gluten-free bakery products requires the use of different flours to replace the wheat flour, so the created taste often is not similar to the classic gluten contain products. The role of food technologists is to design such guidelines for gluten-free products that can improve their expansion, structure and taste, and it would help the people with celiac disease, to achieve their nutritional goals that make daily use of dietary fiber, minerals and other foods. Flours such as rice (*Orysa sativa*), potato, corn (*Zea mays*) and gums, such as xanthan, guar, carrageenan, tara and locust beans and pseudocereal powders as quinoa, chia, amaranth are used in high quality gluten-free cakes. This review focuses on the finding suitable alternatives for gluten-free cakes to improve their baking and sensory quality and nutritional properties.

Keywords: Modification, Gluten-free cakes, Celiac disease, Pseudocereals

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1. Introduction

An Celiac disease (CD) happens in one percent of the world population, caused by an environmental possible, in genetically gluten sensitive persons (Grace-Farfaglia, 2015). It causes inflammation and destruction of the small intestine lining and reduces absorption of nutrients such as calcium, iron, vitamins A, D, E, K and folate (Jnawali et al., 2016).

At present, the only common treatment for CD is a rigid Gluten-free diet (GFD) during the patient's lifetime. Since any bread, cereal or other food products are made of wheat, rye, barley, triticale, dinkel, kamut and oat flour or components, and their byproducts, processed foods which contain wheat and gluten-derivatives as thickeners and fillers and medications that use gluten as a pill or tablet binders are not permitted in a GFD. The dietary revisions required for the CD may have an adverse effects on daily life (Bozdogan et al., 2019).

Therefore eliminating of immunological trigger forms, is the basis for the treatment of all symptoms (Rizzello et al., 2014). International Food Authority requires a complete absence of gluten for the eligibility of a GF diet, while the Codex Alimentarius allows about 200 PPM of gluten per meal. However, considering the need to produce a completely GFD poses many challenges. Gluten is the prevalent structural protein found in wheat, which shows the functional characteristics that cause the individual status of wheat flour (WF) and its products (Sapone et al., 2012).

Cereal products have been the basic food material for thousands of years and are therefore one of the main sources of protein in the human diet. Gluten causes them to expand throughout baking and help maintain moisture for a longer time (Rasmussen & Hansen, 2001).

The preparation of GF bakery products requires the application of different flours to replace the wheat flour, so the created taste often is not similar to the classic gluten- containing products. The role of food technologists is to design such guidelines for GF products that can improve their expansion, structure and taste (Gallagher et al., 2004), and it would help people with celiac disease, to achieve their daily nutritional requirements of dietary fiber, minerals and other foods (Thompson et al., 2005).

This review aims to evaluate the effects of alternative grains, starches, natural additives and techniques on GF cakes to improve their physicochemical, nutritional properties and increase their general acceptability as a healthy snack for gluten sensitive people.

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2. Importance of developing GF products

A strict GFD reduces the risk of serious long-term complications associated with untreated CD. However, following a GFD may seem simple but it is not easy, because it requires permanent attention, and is also a sense of social isolation and pressure that makes the process more difficult (Bauman, 2008). Avoiding all gluten containing products needs a complete change in lifestyle that may not be possible for everyone. For all these reasons, the demand for GF products is increasing now (Gallagher, 2008). Despite many efforts made by researchers and engineers in industry development, the production of high-quality GF products is still a major technological challenge (Simurina et al., 2017). The absence of gluten can alter the shape, texture, smell and taste of bakery products, and speed up the crumb drying (Gambus et al., 2009). The subject mentioned is also about confectionery products, which are often suited to the taste of children than ordinary bread. GF products usually do not have protein enough. Extract of proteins exclude vitamins and minerals, from raw materials leading to a nutritional value reduction. That is why GF products should be supplemented with natural GF raw materials and rich in nutrients (Kiskini et al., 2007). GF bakery supplemented products can be made by adding artificial or natural nutrients. The first group contains nutrients such as calcium and iron, thiamine, riboflavin and sometimes pyridoxine (Thompson et al., 2005). In the second group, the most commonly used ingredients are milk powder, whey, dried yeast, soy derivatives and various types of oilseeds, legumes and pseudocereals. Improvement by natural products is more reasonable because it contains many important components (Gallagher et al., 2004). Nowadays most of the GF bakery products that are available in the market contain rice, maize, soya, guar and pseudo cereals such as amaranth, quinoa and buckwheat flour in their formulation (Alvarez-Jubete et al., 2010).

3. GF cakes

The definitions of the cake are different, but basically this term refers to **the** products that are characterized by formulas based on wheat flour, sugar, whole eggs and other liquids, which can be added to fat or oil (Gallagher, 2008). In cake, wheat flour has a low protein content, low alpha-amylase levels and good particle size. The flour function is mainly for creating the cake structure, giving it a crystalline texture without the "sponge" properties that commonly associated with bread texture. When water is added to the formula, flour proteins form a weak network of gluten, due to sugar and fat interference (Gallagher, 2008). The high amount of water in the cake formulation reduces the batter viscosity that is necessary for gluten network formation. Additionally, the size of sugar granules affects the viscosity of batter (Gallagher, 2008). As mentioned previously, the presence of wheat flour plays many roles in cake formulation, from the change of cake batter viscosity to build-up crumb structure and palatability of the final baked product. To date, relatively little work has been done on the use of alternative sources of flour to produce GF cake products (Gallagher, 2008). For soft wheat products such as cakes and cookies, the gluten network-forming property is not as crucial, but gluten is believed to nevertheless contribute to final product structure and texture (El Khoury et al., 2018).

4. Properties of cake batters

In general, raw cake batter can be considered as an emulsion of oil in water with a continuous phase containing soluble sugars and suspended flour particles. The ingredients interactions and its effects on the batter structure occur during both mixing and baking. At first, after the mixing step of cake preparing, the role of fat is very important for batter aeration. The obstruction of air cells during the mixing process creates foam. To give the maximum volume of cake, the air distribution in the system should be in a large number of small cells. During the baking process, the aqueous mixture of cake batter turns into a semi-solid, porous and soft structure. This is mainly due to gelatinization of starch, protein coagulation and gas bubbles produced from dissolved chemical materials in the battery, obstructed air and the interaction between the ingredients (Gallagher, 2008).

5. Challenges in GF cakes production

Wheat flour is often used in bakery products and its widespread use is due to the expanding power and viscoelasticity of gluten proteins. GF flour base batter is therefore important to have alternative ingredients with similar technological characteristics of gluten for bakery products (Sivaramakrishnan et al., 2004). Unlike bread dough, in cake batter, a strong gluten network is not formed due to the disruptions caused by high levels of sugar and fat. However, gluten still plays a major role in producing a product with an optimum volume, soft and palatable texture, and hence lack of gluten reduces quality (Wilderjans et al., 2008). Defects of GF cakes are mostly related to their low volume, firm texture, poor elasticity and inferior sensory attributes (Majzoobi et al., 2016).

6. Improving the Formulation of GF Cakes

GF muffin, cake or cupcake recipes contain rice flour as the main ingredient (Gularte et al., 2012), or other starch sources, such as corn, potato or wheat, pseudocereals, … (Ronda et al., 2011). To compensate for GF application deficiencies, some additives have been used, for instance; hydrocolloids such as xanthan gum (Preichardt et al., 2011), Guar gum (Gularte et al., 2012) and an emulsifier (Turabi et al., 2008).

Quinoa[1] unlike wheat, is a GF pseudocereal that contains a lot of fiber, high biological proteins, essential fatty acids (ω-3 and ω-6), vitamins and minerals (Stikic et al., 2012). Consumed as natural or processed as flake and flour, quinoa can also be used in the bakery industry because the seeds starch has similar properties of wheat grains (Gomez-Caravaca et al., 2011). Besides, to increase nutritional value, quinoa flour application has a positive effect on the rheological and sensory characteristics of bakery products (Stikic et al., 2012).

Amaranth seeds contain up to19% protein, which has a higher value than milk proteins and is very rich in essential amino acids. This flour also contains more minerals than ordinary cereals, especially iron, potassium, calcium and magnesium. It is also rich in dietary fiber, which is soluble in most cases. Fat in amaranth seeds is higher than in cereals. In addition, it contains more scalene than common vegetable oils (Pisarikova et al., 2005). This should be informed that linseed protein is readily available and digestible at 85-90%, making it one of the most nutritious proteins and

[1]*Chenopodium quinoa* Willd

affecting the immune response of organs. On the other hand, soluble and insoluble fibers are used to replace rice flour in GF layer cakes formulas. Their application has led to improvements in the specific volume, brighter crust and crumb (Naqash et al., 2017). The GF cakes characteristics can be changed and improved by using the mentioned natural additives. Their effects are informed in this paper.

7. Viscosity

Gluten in cake/muffin batter acts as a bonding agent and viscosity enhancer. Gularte (2012) research showed that the use of inulin in GF layer cakes reduced the viscosity of the batter, but the combination of oat and inulin (insoluble and soluble fiber), increased that, which is probably due to water retention capacity of insoluble fiber (Herranz et al., 2016; Shevkani & Singh, 2014). However, both corn and rice flour make a batter with lower viscosity and stability compared to wheat flour. The quality of the cake depends on the batter's viscosity and stability to obtain a sponged structure that does not fall off (Preichardt et al., 2011). In the Majzoobi study, carrot pomace powder (CPP) with different particle sizes was added to the GF sponge cake recipe. Flour (rice and corn flour, 1: 1, w/w) was replaced with 0, 10, 20 and 30% CPP. By increasing the content and size of the CPP particles, the density, viscosity, consistency and strength of the batter are increased. Properties such as density, tissue hardness, shape regularity and sensory scores have been improved by adding CPP (Majzoobi et al., 2016).

The rice flour with a particle size less than 100 µm could increase the viscosity of the batter (compared to the coarser rice flour) and produce small and same bubbles in the cake (Kang et al., 2015; Gao et al., 2018). The finest flours increased the viscosity and reached the maximum viscosity later than the coarsest flours(de la Hera, Martinez et al., 2013). The findings of Shevkani and Singh (2014) study showed that kidney beans (KB), field pea (FP) and amaranth (AM) protein isolates can be successfully applied to make GF muffins with properties comparable to those made from wheat gluten.

The rheological properties of batters and cakes made with rice flour, gums (xanthan, guar, carrageenan, locust bean) and a combination of emulsifiers were studied by Turabi et al. (2008). In general, the gums combining with emulsifiers lead to the batter with the ability of more air absorption during the blending step and increase the emulsion stability. In this study using 1%, xanthan gum increased the viscosity of the cake batter and prevented the cake collapse in the oven. Herranz research has shown that the increased viscoelasticity of the batter is due to an increase in xanthan gum but is not associated with an increase in the number of air bubbles (Herranz et al., 2016)

8. Physical properties

By regulating starch gelatinization, sugar affects the physical structure of baked products. The delay in starch gelatinization during cooking causes air bubbles to grow properly due to increased steam pressure build-up by carbon dioxide and water vapor before the cake sets (Gallagher, 2008). The addition of xanthan gum improves the physical characteristics of the GF cakes and also, making the cakes softer and retarding their staling (Preichardt et al., 2011). The authors pointed out the effect of total or partial replacement of wheat flour (WF) with Chickpea Flour (CF) on the quality characteristics of the two types of cakes and found that the color of the cakes decreases when CF is increased. By contrast, some studies have shown that GF muffins, comparable to those of WF, can be prepared from corn starch using kidney bean and field pea protein isolates, as legume protein isolates increase the viscoelasticity of GF muffin batters (Shevkani & Singh, 2014). Replacement of rice flour with inulin also significantly reduced springiness in GF layer cakes (Herranz et al., 2016).

9. Firmness

Use of different protein isolates results in muffins with higher springiness and cohesiveness. The firmness of muffins varies with the source of the protein isolates. Protein isolates of KB result in stronger muffins than those made from FP, AM and wheat gluten (WG) (Shevkani & Singh, 2014). Cakes formulated with xanthan gum display improved quality properties such as enhanced texture in terms of reduced firmness (Preichardt et al., 2011). In the Gularte study, they included inulin 20% in cake formulation. Compare to other soluble / non-soluble fibers, such as oat and oat-guar gum in cakes, the cakes collapse with higher levels of inulin during the baking process. Interestingly, though the specific volume of the cake was similar to the control, its texture was strong and uncompressed (Non springy) (Gularte et al., 2012). The finest flours produced batters with lower firmness in sponge cakes (Marston et al., 2016).

10. Rheological properties

O'Shea and Marcet (2015) added egg protein to improve the structure of GF cakes, and Matos et al. (2014) studied rheological properties, particularly the viscoelastic behavior of rice-based GF muffins batter. However, Tambunan et al. (2015) used soy isolate protein along with corn starch and guar gum to improve the texture and appearance of egg-free, GF cakes. Shevkani and Singh (2014) used protein isolates from kidney bean, field pea and amaranth to improve gas cell formation and the springiness of GF muffins. Bozdogan et al. (2019) performed a rheological analysis on gluten-free cakes containing quinoa flour and showed that the physical, chemical and quality parameters of cakes improved significantly with replacement of quinoa flour. In general, the volume of cakes increased, but the hardness of cake crumbs decreased by increasing the replacement of quinoa flour. The results of the Bozdogan study showed that the replacement of quinoa flour significantly improved the rheological properties of cakes. Anthropological analysis showed that the stability, homogeneity and mechanical resistance of the batter were improved by adding quinoa flour. Rice does not contain gluten but contains low amounts of sodium, protein, fat and fiber, and contains a lot of digestible carbohydrates while it is used as a wheat substitute in GF food products (Sivaramakrishnan et al., 2004). Corn, like rice, does not contain gluten, and therefore corn flour- based batter cannot show rheological properties similar to those of wheat flour batter (Xue & Ngadi, 2006). The rice flour and corn starch mixture were used in the GF cake formulation was replaced with chia flour (CF) and quinoa flour (QF) up to 25% CF and 25% QF level. The effects of CF and QF on the physical, chemical and sensory properties of GF cakes were investigated.CF and QF replacement increased the ash, protein, fat, total phenolic content and antioxidant capacity of GF cakes by 1.5, 1.8, 1.3, 3.5 and 2.9 times, respectively, when compared to the control samples. Statistically, significant increases were found in Ca, P, K, Mg, Fe and Zn contents of cake samples. The cakes containing CF and QF, higher texture and taste-odor scores than control (Aktas & Levent, 2018). According to Gomez et al. (2007), hydrocolloids can contribute to the improvement of the textural quality of the final products.

11. Sensory quality

It seems that cereals or legumes can change the sensory properties of GF cake and muffin products in particular aroma, taste and texture (Gao et al., 2018). Rothschild et al. (2015) investigated the effects of roasted quinoa on the sensitive properties of GF cakes. They reported that roasted quinoa flour causes the highest sensory score in terms of GF cakes appearance, color and texture (Majzoobi et al., 2016). The cakes containing chia flour and quinoa flour, had better texture and taste-odor scores than control (Aktas & Levent, 2018). Cakes containing Lupine at 40% had desirable sensory properties compared to cakes containing 20% buckwheat (Sapone et al., 2012). Preichardt et al. (2011) found that both corn and rice flour can be used in GF cakes formulation. The corn flour provides suitable characteristics such as yellow color and natural flavor. Rice flour has very little flavor, but when mixed with corn flour, the taste of the cake can be increased without the need for flavor and color additives. During storage, cake crumbs remain softer by increasing the added starch content in the formulation. Sensory evaluation of cakes showed the acceptance of all formulations, but cakes containing 20% resistant starch were most preferred (Witczak et al., 2016). According to the results of the Kumar study, fortified cakes with encapsulated fish oil exhibit better oxidative stability, with colorful properties and optimal texture. More research is needed to determine the factors affecting appearance such as tissue analysis and sensory evaluation. Encapsulated fish oil-in-milk emulsion by ultrasonication that was spray-dried with sodium caseinate as wall material is permanently stable (Santhanam et al., 2015). Herranz et al. (2016) research showed that improvement in sensory quality of chickpea flour-based gluten-free batters was due to an increase in xanthan gum. Addition of xanthan gum increases the specific volume, making the cakes softer and retarding their staling. It also improves the sensory characteristics of GF cakes (Preichardt et al., 2011). The concentrations of 0.3% and 0.4% of xanthan gum produced a cake with favorable characteristics with high acceptance by consumers. The cakes were physically, chemically and sensory similar to the control cake made with wheat flour only. The cake satisfies the needs of a bakery product for celiac patients (Turabi et al., 2008). By increasing the content and size of the CPP particles, the sensory scores are increased (Majzoobi et al., 2016).

12. Volume

Cake expansion is highly dependent on starch gelatinization temperature, and higher batter expansion is obtained at higher gelatinization temperatures (Gomez et al., 2010). production and release of carbon dioxide gas is an important part of the cake expansion mechanism when the batter initially enters the oven, affecting the volume and eating quality of the finished product (Gallagher, 2008). Lower viscosity of the batter during heating causes lower volumes of final products (Shelke et al., 1990), while higher viscosity increases the volume of cake and crumb grain (Herranz et al., 2016). The finest flours produced batters with an air distribution in smaller and uniform bubbles, induced higher volume in sponge cakes (Marston et al., 2016). Sorghum flour that is treated under dry heating produces cakes with the largest volume and most cells per cutting area. Unprocessed flour produces products with low volume, dense texture, and poor crumb properties. With increasing heat, starch granules can absorb more water, thus increasing the viscosity of flour. Expansion of starch granules prevents cake collapse during cooling by getting the void spaces at lower temperatures and gas pressure in the cells. Use of heat denatures proteins and enzymes while promoting batter expansion. The viscosity difference is related to the ability of the cake to become spongy and reduce the contraction during the cooking (Marston et al., 2016). GF muffin, cake or cupcake recipes usually contain rice flour as the main ingredient (Gularte et al., 2012) or other starch sources such as corn, potatoes or wheat (Ronda et al., 2011). Until now the authors only pointed out that whole or partial replacement of wheat flour (WF) with chickpea flour (CF) could affect the quality of cakes and found that the volume of cakes decreased when the CF amount increased (Shelke et al., 1990). An increase in GF layer cake volume has been reported by Gularte et al. (2012) by addition of 20% soluble and insoluble fibers. Levent and Bilgicli (2011) reported that there is a positive effect of fiber rich Lupine flour (up to 20%) and buckwheat flour (at 5% level) on GF cake volume (Levent & Bilgicli, 2011). Gorgonio, (2011) measured the volume of batter produced by the addition of 40% pumpkin seed flour (PSF). The authors reported that the supplemented cakes had a comparable volume than the control cake (Gorgonio et al., 2011). Similarly, HI-MAIZE resistant and tapioca starches (Tsatsaragkou et al., 2015) and potato starch (Yildiz & Dogan, 2014) can be used to reduce the batter density (less elastic and thinner), hence increasing the volume and uniform pore of rice cake (Gao et al., 2018). However, El-Hadidi reported that the addition of high levels of resistant starch decreased volume and increased cake weight (Al Shehry, 2016).

13. Symmetry

In Majzoobi et al. (2016) study, by increasing the content and size of the CPP particles, in spongy cake batter based on rice and corn flour, the symmetry index increased. In this study, flour (rice and corn flour, 1:1, w/w) was replaced with 0, 10, 20 and 30% CPP. The finest flours produced batters with greater symmetry index both in sponge and layer cakes (Marston et al., 2016). Finer rice flour fractions were demonstrated to produce cakes with a higher symmetry index (de la Hera et al., 2013). The authors pointed out the effect of total or partial replacement of wheat flour (WF) with Chickpea Flour (CF) on the quality characteristics of the two types of cakes and found that the symmetry of the cakes decreases when CF is increased (Shelke et al., 1990). Levent and Bilgicli (2011) reported that the addition of buckwheat flour has an increasing effect on GF cake's symmetry.

14. Specific volume

Singh found a decrease in specific volumes of muffins after combining black carrot fiber (Singh et al., 2016). Kim and Shane (2014) had shown that the distribution of flour particle size affects the characteristics of GF brass (rice) cakes. By reducing particle size, the amount of damaged starch granules increases, which increases water acceptance capacity, solubility and lightness, while decreasing crude protein and yellowness accordingly. The final viscosity of rice flour increases due to its smaller particle size. The same trend could be observed for the specific volume of cupcakes (Witczak et al., 2016). Research was also carried out on the effect of particle size on rice-based cakes. The data displayed interesting results, coarser flour produced batter with a high specific volume however the baked cake had a low specific volume. It was suggested that this was a consequence of large bubbles created during mixing which caused coalescence and then bubble loss during baking producing a lower volume cake. Overall, finer rice flour fractions were demonstrated to produce cakes with a higher cake specific volume, and lower crumb firmness (de la Hera et al., 2013). The chemical, physical, and sensory characteristics of GF cakes prepared with rice and corn flour and with different concentrations of xanthan gum have shown that the cakes formulated with xanthan gum displayed improved quality characteristics such as increased specific volume (Preichardt et al., 2011). Xanthan gum helps in retention of CO_2, and it increases the specific volume of bakery products. Because of these characteristics, xanthan gum has been used in several research studies (Nadeem et al., 2013). Xanthan gum also makes cakes softer and retarding their staling (Preichardt et al., 2011). According to Tubariet al. (2008), cakes prepared with xanthan gum do not collapse in the oven. Cakes specific volume also increased with an increase in "resistant starch" (RS) level and was maximized for 15% RS (de la Hera et al., 2013). The finest flours produced batters with lower specific volumes (Marston et al., 2016).

15. Nutritional Quality

Many studies have been conducted to improve the nutritional quality of the GF bakery products including cakes. Gularte et al. (2012) added three kinds of dietary fibers such as inulin, guar gum, oat fiber and their combination in GF layer cake. They found that the combination of oat fiber–inulin resulted in higher quality product (Gularte et al., 2012). The free radical scavenging activity of chia seed was even greater than many potentially potent natural antioxidant sources; The antioxidant activity of chia seed was greater than *Moringa oleifera*, sesame extract cake (Ullah et al., 2016). Biscuits, pasta, cereal, snacks and yoghurt and cakes are usually supplemented with chia seed (Borneo et al., 2010). Singh et al. (2015) used *Jambolan fruit* pulp (JFP) in GF cakes to enhance their nutritional value and quality. The incorporation of JFP and xanthan gum increased batter viscoelasticity, greenness, cohesiveness, resilience, water activity (a_w), total phenolic content, total flavonoid content, and (DPPH) and (ABTS) inhibition of the muffins. Sensory analyses revealed that JFP incorporation improved the consumer acceptability of the muffins. Singh et al. (2016) showed that 6% black carrot pomace dietary fiber concentrate and 0.5% xanthan gum can result in fiber-rich and high-quality GF muffins. The positive effects of CPP on the nutritional quality of GF cake are mainly related to high fiber, protein, sugar and ash. Changes in the size of CPP particles did not have a significant effect on many properties of the cakes (Majzoobi et al., 2016). Replacement of 50% corn starch with amaranth flour in sponge cake increased protein content by 40% and triplication of dietary fiber content compared to control sponge cake. Replacing 65% corn flour with linseed meal in carrot cake increased protein content by 30% and doubled dietary fiber content compared to carrot cake (Majzoobi et al., 2016). Coconut cake with a contribution of linseed meal instead of 50% of rice paste had more protein (60%), total dietary fiber (seven times) and soluble fraction (10 times) (Gambus et al., 2009). In addition, Quinoa Flour improves nourishing and technological properties and sensory features. According to Bozdogan study, it may be concluded that adding 50% quinoa flour is successful in formulating a GF cake without any adverse effect (Bozdogan et al., 2019). Levent and Bilgicli (2011) observed that debittered Lupin could increase the protein content of GF cakes more than buckwheat. In addition, higher levels of calcium and magnesium were also found in the Lupin containing cake. CF and QF replacement increased the ash, protein, fat, total phenolic content and antioxidant capacity of GF cakes by 1.5, 1.8, 1.3, 3.5 and 2.9 times, respectively, when compared to the control samples. Statistically significant increases were found in Ca, P, K, Mg, Fe and Zn contents of cake samples ($p < 0.05$) (Aktas & Levent, 2018). The analysis of fish-oil-enriched cakes revealed the presence of relatively good amounts of health-beneficial EPA[2] and DHA[3], demonstrating the potential of fortified cakes with encapsulated fish oil, which can be considered as one of the options to deliver omega 3 fatty acids to enhance dietary intake (Santhanam et al., 2015). Oat beta-glucan isolate (Ronda, Perez-Quirce et al., 2015), rice bran (Phimolsiripol et al., 2012), potato flour (Shih et al., 2006), pseudocereals (Alvarez-Jubete et al., 2009), and *Green Plantain* have been added to increase dietary fiber content of GF products (Sarawong et al., 2014). The content and quality of the bioactive compounds present in these plants are higher than in popular cereals (Gambus et al., 2004). The replacement of 50% corn starch by amaranth flour in the sponge cake resulted in an increase in protein content by 40%, and triplication of the dietary fiber content compared to the control sponge cake (Gambus et al., 2004). Linseed may be a good supplement for GF products due to its unique chemical composition (20% digestible protein, 30% water-soluble dietary fiber, 40% fat rich in unsaturated fatty acids (Tarpila et al., 2005). The final instructions should consider nutrition and technology issues. The replacement of 65% corn flour by linseed meal in carrot cake increased the protein content by 30% and doubled the amount of dietary fiber content in comparison with the control carrot cake. Coconut cakes with a share of linseed meal instead of 50% rice paste had more protein (by 60%), total dietary fiber (seven-fold), and its soluble fraction (ten-fold) (Gambus et al., 2004). Other interesting raw ingredient is Buckwheat, which contains readily available proteins, minerals, organic acids and Buckwheat based products were used for dietary purposes as well as for celiac disease (Wijngaard & Arendt, 2006).

16. Functional additives

Hydrocolloids, proteins, emulsifiers and fibers are the main additives in GF cakes and muffins. A recent study by Mir et al. (2015) used water chest nut flour with carboxy methylcellulose (CMC) (1%) to control moisture content and texture of GF cakes. When carrot pomace powder (CPP) was used as a fiber additive in a rice and corn based GF cake product, texture hardness increased compared to the control (Majzoobi et al., 2016). Muffin containing black carrot pomace had an increased total dietary fiber content, decreased L* and b* values and decreased water activity (Singh et al., 2016). Turabi et al. (2010) used different types of gums in GF rice cakes. While xanthan gum and xanthan–guar blend were used to increase the crumb porosity of GF eggless rice muffins (Singh et al., 2015). Herranz et al. (2016) used xanthan gum to produce a chickpea flour-based GF muffin with similar hardness to wheat

[2] Eicosapentaenoic acid
[3] Docosahexaenoic acid

gluten muffins. Hojjatoleslami and Azizi (2015) showed that an addition of tragacanth (0.5%) and xanthan (1%) gums to GF cakes reduced texture stiffness and maximized moisture content. Non-starch polysaccharides often create harder textures in GF products than non-GF foods, although addition of fibers can increase slowly digestible starch content (Gularte et al., 2012). Gularte et al. (2012) have shown that the addition of inulin to GF layer cakes slows the release of reducing sugars and, hence, lower postprandial blood glucose levels.

17. Color

An increase in cake crust redness and decrease in lightness and yellowness with incorporation of soy protein isolate to cake formulation have been reported (Majzoobi et al., 2016). However, these protein isolates may find applications in case of GF chocolate muffins/cakes where dark color of chocolate would mask color imparted by the protein isolates (Shevkani & Singh, 2014). Some studies showed the effect of the total or partial replacement of wheat flour (WF) with Chickpea Flour (CF) on the color of the cakes which decreases when CF is increased (Shevkani & Singh, 2014).

18. Mixing method

Bean et al., (1983) performed the production of layer cakes from 100% rice flour, and found that flour hydration, with a highly stirred method, improved cake properties. They assumed that the intense mix of rice flour and water released some starch granules from the endosperm and increased their functionality. Additionally, high speed mixing can turn into a "gel" protein that increases the crumb grain size of the cake (Gallagher, 2008). It was also observed that mixing times had a positive effect on the amount of CO_2 production. Two reasons for this have been suggested: Priority, more mixing time, creates more oxygen that allows the yeast to be preferred under aerobic conditions. Second, more mixing time allows amylase to be used to produce maltose, which is the reserved food source for yeast after sucrose is consumed during proofing. The longer proofing duration (90 min) is required for a sample containing 110% water, compared to a sample containing 80% moisture (50 min) (Gomez et al., 2013). These researchers examined the effects of mixing speed, mixing time, mixing attachment, mixing duration and proofing time on a GF dough and batter (containing 80% and 110% water). They found that more water additions led to batter like consistencies, and needed a mixing method similar to that of cakes, that is, lower mixing speed but longer mixing time, and using a whip wire mixing attachment to incorporate more air and bubbles into the batter (Gomez et al., 2013).

19. Overall acceptability

The main problem facing a coeliac patient is the daily challenge of finding healthy and palatable foods that do not contain gluten. These foods still have to be desirable in flavor, color, and texture (Preichardt et al., 2011). The researchers showed that, among all treatments, overall acceptability was highest for the 10 percent level, followed by 5 and 15 percent of quinoa. The cakes made from rice and oats flour supplemented with quinoa flour were found to be highly acceptable. All of these products were highly liked with an overall acceptability mean score for cakes (7.54 ± 0.15) (Kaur & Kaur, 2017). Another study showed that the cake, produced with 50% quinoa flour, had the best quality for both taste and overall acceptability (Bozdogan et al., 2019). Majzoobi et al. (2016) had shown that supplementation of GF cake batter by different percentages of carrot pomace powder (CPP) has significant positive effects on the characteristics of batter and cake and sensory attributes of cakes in terms of crust and crumb color, taste, texture and overall acceptability. Therefore, addition of CPP with the tested particle sizes up to 30% can be done to improve the quality of GF cakes. All of the GF products supplemented with buckwheat flour, amaranth flour and linseed meal received good or very good consumer scores (Gambus et al., 2004).

20. Conclusion

In recent years, there has been increasing attention in the production of healthier and more nutritious GF foods. Elimination of gluten in GF bakery products results in inferior quality, as gluten plays a crucial role in providing the desired texture, sensory attributes and overall quality. Therefore, the production of superior GF products is a challenge in food industry. This is mainly related to the restricted GFD of patients with coeliac leading to lower fiber and nutrient intake as well as excessive, low quality fat contents. Application of some natural alternatives such as rice, corn, pseudocereals like quinoa, linseed, amaranth, also some natural additives like gums, emulsifiers, dietary fibers, in GF products can improve their physicochemical, nutritional and technological properties. This is vital to provide a supplemented snack as a cake for protecting of gluten sensitive patients with their health approaches. Accordingly, more studies would be accomplished to improve the nutritional quality of GF bakery products including cakes.

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