Food Research 5 (5) : 43 - 54 (October 2021)
Journal homepage: http://www.myfoodresearch.com

FOOD RESEARCH

MINI REVIEW

A review on the recent applications of gluten-free flour, functional ingredients and novel technologies approach in the development of gluten-free bakery products

[1]Ronie, M.E., [2]Zainol, M.K. and [1,*]Mamat, H.

[1]*Food Technology and Bioprocessing Program, Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia*
[2]*Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu*

Article history:
Received: 9 December 2020
Received in revised form: 18 January 2021
Accepted: 2 April 2021
Available Online: 31 August 2021

Keywords:
Gluten-free flour,
Bread,
Biscuit,
Cake

DOI:
https://doi.org/10.26656/fr.2017.5(5).721

Abstract

Gluten is detrimental to people who suffer from gluten-related disorders. Recently, the upsurge in demand for gluten-free products can be traced not only from the population that suffered from gluten-related disorders but also people who prioritize healthy lifestyles and practising gluten-free diets. One of the most challenging tasks in the development of gluten-free products is their quality. The purpose of this review is to describe the application of gluten-free flours in common bakery products such as bread, cakes, and biscuits. This article does summarize some functional ingredients such as hydrocolloids, protein, and enzymes and also the applications of novel technological approaches including high-pressure treatment, sourdough fermentation and extrusion technology. Overall, different approaches utilized in the improvement of gluten-free bakery products will lead to various quality outcomes.

1. Introduction

Gluten is a functional ingredient, and it is very well-known for its viscoelasticity characteristic in various food products (Brockow *et al.,* 2015), especially in bread because it helps in the rising process and development of air bubbles resulting in a porous structure (Woomer and Adedeji, 2020). Besides, gluten proteins are characterized by high proline and glutamine content which has the ability to cross the epithelial barrier and stimulate the immune system subsequently trigger an allergic reaction or autoimmune response such as celiac disease (Ortiz *et al.,* 2017). Therefore, regardless of avoiding raw food containing gluten, gluten-free (GF) consumers have to avoid many more products containing gluten as a functional ingredient.

According to Codex Alimentarius International Food Standards, GF foods can be derived from naturally GF ingredients or any ingredients containing wheat, barley, rye or crossbred varieties of these grains that undergone specific processed in order to remove gluten with a gluten level not exceeding 20 milligrams per kilogram. In general, GF products are designed as a valuable choice for people suffering from gluten-related disorders (GRDs). GRDs comprise three different conditions, to be specific celiac disease, allergy to wheat and non-celiac gluten sensitivity (Roszkowska *et al.,* 2019). In fact, the only effective treatment to avoid triggering the effect of gluten-related disorders is by eliminating any gluten food sources completely out of their diet.

As highlighted by Gujral *et al.* (2012), the elimination and restriction of gluten from diets have increased dramatically in recent years. The upsurge in demand for GF products can be traced not only from the increased diagnosis of GRDs but as well among consumers who prioritize a healthy lifestyle and exercise on the GF diet since they believed that the GF diet was generally healthier (Croall *et al.,* 2019). To be expected, the consumption of GF products will keep an increase in the future (Forbes, 2015).

Nevertheless, commercially available GF bread are incompetent compared to gluten-containing bread in terms of quality and acceptability (Naqash *et al.,* 2017). This is one of the most challenging tasks in the development of GF products, due to the shortage of alternative ingredients that can imitate the functional properties of wheat protein which are responsible in contributing viscoelasticity in the wheat dough (Roman *et al.*, 2019). As a solution, scientific literature has dealt with the function of few alternate ingredients that capable of improving the GF bakery products, such as alternative starches and flours, hydrocolloids, proteins, enzymes and lipids (Naqash *et al.,* 2017; Roman *et al.*, 2019).

In the present article, the application of alternative

*Corresponding author.
Email: *idamsah@ums.edu.my*

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GF flours for bread, cakes, and biscuits are reviewed. This article also covers the functional ingredients that are typically used in GF bakery products such as hydrocolloids, protein, and enzymes. Finally, the recent novel technologies approach, including the application of the high-pressure treatment, sourdough fermentation and extrusion technology that have been implemented in the production of GF bakery products were also focused on this article.

2. Gluten-free flour used in bakery products

2.1 Gluten-free bread

In recent years, there have been several studies have focused on the application of pigmented rice flour in the development of GF bread (Thiranusornkij *et al.,* 2018; Gusmão *et al.,* 2019; Thiranusornkij *et al.,* 2019). The reason to choose pigmented rice flour is due to its good source of phytochemical compounds and good eating quality (Kraithong *et al.*, 2018). On the other hand, another GF cereal such as millet is also used for making GF bread. Nevertheless, Habiyaremye *et al.* (2017) have revealed that millet has an undesirable effect on the final product due to its astringent flavour and somehow because of its poor functional properties of the protein, however according to Tomić *et al.* (2019) incorporation of proteins and enzymes can improve the technical quality of it. Furthermore, GF bread made from sorghum usually produces small volume and brittle crumb bread (Schober *et al.,* 2005). According to Trappey *et al.* (2014), this is due to the inability of protein content in sorghum to set structure in bread.

Besides, another alternative GF flour is made from pseudocereals. Liu *et al.* (2019) reported that the addition of amaranth in GF bread has shown to improve the water holding capacity, viscoelasticity, and micronutrient contents. In addition, Southgate *et al.* (2017) analysed that buckwheat capable of enhancing the quality of bread in terms of insoluble fibre content, specific volume, cell's circularity of bread loaves, cells number and most important it does not affect the sensory properties of the final product.

Despite the few types of flour mentioned above, legumes such as chickpea and soybean are also potential ingredients in the development of GF bread. In general, chickpea is rich in protein and contain essential amino acids (glutathione), vitamins, minerals, dietary fibre (Yamsaengsung *et al.*, 2010) and phenolic compounds (Xiao *et al.,* 2014) which can increase nutrients in GF bread. However, some drawbacks that were observed on the quality of chickpea bread are typically related to losses in volume and poor bread texture (Yamsaengsung *et al.*, 2010; Ragaee *et al.,* 2011). As well as soybean flour, it has been proved that this flour is rich in protein, vitamins (A, B, C and D) and minerals (calcium and phosphorus) (Serrem *et al.*, 2011). A study conducted by Taghdir *et al.* (2017) has shown that the addition of 15% soybean flour successfully enhanced the quality of bread, sensory properties as well as nutritional profile of the final product.

2.2 Gluten-free cakes

In the bakery industry, a cake can be categorized into two groups known as (1) angel and sponge cakes and (2) layer and pound cakes (Itthivadhanapong and Sangnark, 2016). Generally, rice flour is one of the ingredients that can be used to substitute wheat flour in the making of GF cakes. The study conducted by de la Hera *et al.* (2012) found that the finest particles of rice flour are capable of producing batters with low specific volume, small and uniform bubbles. In general, low specific volume batters will lead to the cake with high volume and symmetry index. Nevertheless, in the study of Itthivadhanapong and Sangnark (2016), the authors reported that the substitution of black glutinous rice flour had increased the specific gravity, lower the specific volume and overall had greater firmness, gumminess and chewiness compared to a cake made from wheat flour. Buckwheat is another GF cereal that has been studied in the making of GF cakes. According to Levent and Bilgiçli (2011), high addition of buckwheat flour in the range of 15% to 20% capable of improving the uniformity and symmetry index of the cake, but adversely affected the softness of the crumb.

As well as lupin flour, one of the legume source flour is also studied by the same authors, Levent and Bilgiçli (2011) reported that the volume and softness of the cakes could be enhanced by incorporating 20% of lupin flour. In addition, it has the ability to improve crust yellowness and significantly increases the protein content, fat, and mineral contents of the final products. On the other hand, Dhen *et al.* (2016) has reported that the quality of GF cakes capable of being improved with the usage of soy flour, to be specific the quality of final products is affected by the usage quantity and size particle of the flour. Generally, soy flour successfully decreased the hardness and slowed down the rate of staling during storage.

Apart from that, pseudocereals are another group of good GF sources that can be used in the making of GF cakes. The previous study by Bozdogan *et al.* (2019) has reported that the addition of 50% quinoa flour has successfully improved the batter stability, homogeneity, mechanical strength, nutritional and sensory properties, improved specific volume as well as the viscosity of the batter with the increasing usage of quinoa flour. Moreover, Shevkani *et al.* (2015) explained that quinoa flour is able to bind more water compared to potato and rice starch hence resulting in an increment of the viscosity value. This is due to the higher protein content

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in quinoa flour that could lead to the increment of viscosity value (Turkut *et al.,* 2016). Other than that, amaranth flour is another potential GF source that can be used in the development of GF cakes. In the recent study conducted by Estiri and Naghipour (2019), it has been investigated that 20% amount of amaranth flour plus 0.5% mandab gum had presented the highest specific volume, porosity, improved moisture content and lowest firmness for 2 hours and within one-week storage period.

2.3 Gluten-free biscuits

The replacement of wheat flour with GF flour in biscuits is a lot easier compared to bread due to the incidental role of gluten. In recent years, there has been increasing interest in the study on the effect of composite GF flours in the development of biscuits. Man *et al.* (2014) reported that it is relevant to blend different types of GF flours such as rice flour, maize flour, and soy flour because they found that blending various types of flour significantly increased the nutritional profile especially with the addition of up to 40% of soy flour and demonstrated no undesirable effect on sensory properties of the final products. Besides, the previous study performed by Inyang *et al.* (2017) has reported that the increment in the percentage of red kidney bean flour up to 40% into the composite of unripe banana-sweet potato flour caused a decrease in bulk density, water absorption capacity and swelling index but unfortunately increased the oil absorption and foaming capacity. In addition, in terms of the physical properties, the incorporation of red kidney bean flour had improved the thickness although, decreased the weight, length, width and spread ratio of the GF biscuits. On the other hand, Korus *et al.* (2017) carried out a study on the effect of cornflour and hemp flour in the partial substitution of cornflour. Generally, both of the studied flours effectively increased the nutritional value compared to GF biscuits made from 100% corn flour and also enhanced the hydration properties of mixtures and oil absorption capacity. Another study on the development of GF biscuits from peanut-millet composite flour carried by Alhassan *et al.* (2019) found that the studied flours effectively increased the nutritional data in terms of the protein and ash content as compared to wheat flour biscuits plus the final products was overall acceptable for its sensory evaluation.

Moreover, the earlier studies performed by Tosi *et al.* (1996) and Hozova *et al.* (1997) have reported that whole amaranth flour is not only capable of producing GF biscuits with high protein content but also high energy value as compared to the average GF biscuits. In addition, according to the study by Alvarez-Jubete *et al.* (2010), the crispness of GF biscuits made from buckwheat flour possessed the highest level of crispness then followed by quinoa and amaranth flour plus, the most preferred GF biscuits are the formulation containing buckwheat and amaranth flour. Hence, by observing the trend of research, it can be concluded that early studies mostly focused on the usage of a single type of GF flour as compared to recent studies. Table 1 presents the summary of the effect of different GF flours on bread, cake and biscuit.

3. Functional ingredients to improve gluten-free bakery products

3.1 Hydrocolloids

Hydrocolloids are typically used as a thickening and gelling agent in order to aid the quality and shelf life of food products (Woomer and Adedeji, 2020). The most typical hydrocolloids used in the development of GF bread are hydroxypropyl methylcellulose (HPMC) and xanthan gum (XG) (Masure *et al.*, 2016; Roman *et al.*, 2019). This is due to the capability of HPMC in improving batter consistency, bread textural properties (Morreale *et al.*, 2018) and generating higher specific volume for GF bread (Belorio and Gómez, 2020). Whereas the addition of XG potentially yielding a good crumb structure and higher specific volume in the final products (Vidaurre-Ruiz *et al.,* 2019). Additionally, XG is also capable of decreasing the hardness and enhancing elasticity in both fresh and stored bread (Mohammadi *et al.,* 2014). However, other hydrocolloids such as carboxymethyl cellulose (CMC), guar gum, pectin and agarose have been used as gluten substitutes in the manufacturing of GF bread which provided promising final bread quality (Wang *et al.,* 2017)

Apart from that, hydrocolloids are useful in the making of GF cakes in order to improve the texture and outcome of final products (Preichardt *et al.,* 2011). Over recent years, there were a lot of studies conducted on the application of various hydrocolloids in the development of GF cakes; however, XG was constantly studied in most of the research performed. Generally, it has been found that XG capable of increasing the firmness and chewiness of GF cakes (Andrade *et al.*, 2018), stabilized dispersions due to the capability to prevent particle sedimentation (Fitzpatrick *et al.,* 2013) and potentially improved the viscoelasticity of batter (Itthivadhanapong *et al.*, 2016). Anyway, other hydrocolloids like carrageenan, locust bean gum, arabic gum, HPMC, and guar gum are also analysed in the study of Itthivadhanapong *et al.* (2016) and Meng and Kim (2020a). Mostly, those hydrocolloids are capable of enhancing the specific volume and softness of GF cakes.

In the case of GF biscuits, although gluten does not play a primary role in the formulation of this product, it has been observed that lack of gluten in biscuits generally lead to low quality (Engleson and Atwell, 2008). Therefore, to obtain better quality, hydrocolloids

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Table 1. Summary of different types of GF flours used in bread, cakes, and biscuits

Bakery products	Gluten-free flours	Effect in bakery products	References
Bread	GF cereals		
	Millet	● Undesirable effect due to astringent flavour	Habiyaremye *et al.* (2017)
	Sorghum	● Small volume; brittle crumb bread	Schober *et al.* (2005)
	Pseudo-cereals		
	Amaranth	● Increased water holding capacity, viscoelasticity, micronutrients profile	Liu *et al.* (2019)
	Buckwheat	● Increased insoluble fibre, specific volume, cell circularity, cell numbers and no negative effect on sensory properties	Southgate *et al.* (2017)
	Legumes		
	Chickpea	● Improved nutrient content; decreased in volume and produced poor texture	Yamsaengsung *et al.* (2010); Ragaee *et al.* (2011); Xiao *et al.* (2014)
	Soybean	● Improved quality, sensory properties, and nutritional content	Taghdir *et al.* (2017)
Cakes	GF cereals		
	Finest particles rice flour	● Produced batters with low specific volume, small, uniform bubble	de la Hera *et al.* (2012)
	Black glutinous rice	● Increased specific gravity, firmness, gumminess, chewiness	Itthivadhanapong and Sangnark, (2016)
	Buckwheat	● Improve the uniformity and symmetry index of cakes; decreased softness of the crumb (15% to 20% of buckwheat flour)	Levent and Bilgiçli (2011)
	Legumes		
	Lupin	● Enhanced volume and softness of cakes (20% of lupin flour); improved the crust yellowness and nutrient contents	Levent and Bilgiçli (2011)
	Soy	● Decreased the hardness; slow down the rate of staling	Dhen *et al.* (2016)
	Pseudo-cereals		
	Quinoa	● Enhanced the batter stability, homogeneity, mechanical strength, nutritional, sensory properties, specific volume, and viscosity of the batter (50% of quinoa flour)	Bozdogan *et al.* (2019); Shevkani *et al.* (2015)
		● Increased specific volume, porosity; improved the moisture content (20% amaranth flour + 0.5% mandab gum)	
	Amaranth		Estiri and Naghipour (2019)
Biscuits	Composite		
	Rice, maize and soy	● Increased the nutritional content; no undesirable effect on sensory properties	Man *et al.* (2014)
	Red kidney bean, unripe banana and sweet potato	● Decreased bulk density, water absorption capacity, swelling index; increased the oil absorption and foaming capacity; improved thickness; decreased the weight, length, width and spread ratio (40% red kidney bean flour)	Inyang *et al.* (2017)
	Acorn and hemp	● Increased the nutritional value; enhanced the hydration properties of mixtures and oil absorption capacity	Korus *et al.* (2017)
	Peanut and millet	● Increased protein and ash content; acceptable for its sensory evaluation.	Alhassan *et al.* (2019)
	Non-composite		
	Amaranth	● Produced high protein and energy content biscuits	Tosi *et al.* (1996); *Hozova et al.* (1997)
	Buckwheat	● Greatest crispness	Alvarez-Jubete *et al.* (2010)

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are used as an alternative way to achieve the desired quality. Basically, XG is one of the most incorporated hydrocolloids in the development of GF biscuits, followed by guar gum and tragacanth gum (TG). The study performed by Thejasri *et al.* (2017) reported that those hydrocolloids (XG, guar gum and TG) have increased the sensory qualities, moisture content, diameter, thickness, weight, and lowered the fracture strength properties of GF biscuits. Last but not least, arabic gum, carrageenan and HPMC also have been studied and found capable of improving certain quality properties (Sarabhai *et al.,* 2017).

3.2 Protein

The addition of protein-based ingredients is capable of improving the nutritional profile, functional properties and eating quality of final products (Deora *et al.,* 2014). In general, soy protein isolates (SPI) and egg white are common protein sources that are usually studied in the formulation of GF bread. It has been reported that SPI leads to lower volume and dense crumb structures (Horstmann *et al.*, 2017). According to Masure *et al.* (2019), batters added with SPI possess a high viscosity and poor stabilization of gas cells resulting in low volume and non-uniform bread crumb structure. Whereas the incorporation of egg whites possesses strong, cohesive behaviour, high foaming capacity and capability to stabilize the formation of gas bubbles during bread making (Han *et al.,* 2019). On the other hand, several studies performed by Horstmann *et al.* (2017) and Han *et al.* (2019) found that egg whites have the ability to increase bread softness as well as the specific volume of GF bread. Apart from that, other protein sources such as lupin, carob, pea, and potato also have been investigated by Horstmann *et al.* (2017), in conjunction with the study, only the incorporation of carob, lupin, and pea present GF bread with higher volume, larger cell pores and softer bread crumb.

Besides, in the development of GF cakes, whey protein concentrate, and egg white protein are popular among the other functional ingredients. Sahagún *et al.* (2018) and Ammar *et al.* (2020) have reported that both of the animal protein sources capable of improving volume, springiness, cohesiveness with low baking loss, nonetheless both of the protein sources increased the hardness of the final products. Apart from that, it has been found that animal proteins are more effective in enhancing springiness and cohesiveness as compared to plant protein (Sahagún *et al.,* 2018). Nevertheless, the study performed by Bravo-Núñez *et al.* (2020) discovered that the combination between the egg white and whey protein had increased the density of cake batters due to the antagonistic effect in emulsifying capacity and stability. However, other protein sources such as marine fish collagen have been reported capable of enhancing cell density, specific volume, springiness, and decreased hardness of GF rice cakes (Meng and Kim, 2020b).

On the other hand, the effect of the addition of protein in GF biscuits has also been studied over the past years. In general, the most applied protein ingredients in GF biscuits are soy protein and canola protein due to the efficient protein content that could provide beneficial effects to the final products (Gerzhova *et al.,* 2016). Aly and Saleem (2015) reported that soy protein successfully increased the diameter, thickness, and volume even though, decreasing the specific volume of the final products. Moreover, the increment of soy protein percentage will lead to an improvement in the hardness and adhesiveness of GF biscuits. Likewise, canola protein also has the capability of increasing the diameter and thickness which indicates having a good gas holding capacity of dough, nevertheless this protein decreased the spread ratio and hardness of biscuits (Gerzhova *et al.,* 2016). Besides, the addition of other proteins in GF biscuits could affect the quality of the final product, to be specific such as milk protein (Gallagher *et al.,* 2005) and safflower protein isolate (Ordorica-Falomir *et al.,* 1991). Overall, the findings on the effect of protein as functional ingredients in GF biscuits are still scarce.

3.3 Enzymes

Enzymes have been useful in the baking industry because of their ability in modifying and enhancing the functional, nutritional, and sensory properties of bakery products. Bender and Schönlechner (2020) predicted that cross-linking enzymes such as transglutaminase (TGase) are the most popular enzymes utilized in the development of GF bread. This is due to the potential of TGase in improving the viscoelasticity behaviour of dough by enhancing the ability to retain gases resulting in good expansion, higher volume, and softer crumb (Gusmão *et al.,* 2019; Manhivi *et al.,* 2020). Besides, another common enzyme used in baking is the protease enzyme. Generally, proteases can enhance the gas holding capacity and bread quality, to be a specific increasing volume of bread and crumb springiness while decreasing hardness, chewiness, and cohesiveness of the crumb (Azizi *et al.,* 2020; Sarabhai *et al.,* 2020). Furthermore, other enzymes such as α-amylase and cyclodextrin glycosyltransferase (CGTase) are the enzymes that are rarely used in GF baking. Both enzymes serve the function of extending the process of retrogradation, starch hydrolysing and increased shelf life of GF bread (Gujral *et al.,* 2003). However, both enzymes are capable of affecting the quality of final products such as softening crumbs and also increase the volume of bread (Basso *et al.,* 2015).

Apart from that, enzymes are also incorporated into GF cakes. Similarly, TGase is the most studied enzyme

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in the development of GF cakes. Saeidi *et al.* (2018) reported that the addition of TGase had increased the porosity of the cell, nevertheless decreased the volume of GF cakes. In contrast, Yildiz and Dogan (2014) reported that TGase significantly improved the cake volume. This might be due to different concentrations used between those two studies, as Yildiz and Dogan (2014) mentioned that a higher concentration of TGase would lead to a decrease in cake volume. In addition, another study conducted by Rahim and Nouri (2020) evaluated that TGase can increase the adhesiveness as well as the hardness of GF cakes. Moreover, other enzymes such as cellulase and hemicellulase were analysed by Aghaesmaeili *et al.* (2020), and it has been reported that hemicellulase was effective in the improvement of cohesiveness plus, both of the enzymes can increase the water absorption ability in GF sponge cakes. However, lipase is also capable of providing a positive effect on the final product, such as maintaining and improving the softness of cakes (Colakoglu and Özkaya, 2012).

As for GF biscuits, Altındağ *et al.* (2015) have evaluated the effect of TGase in the development of semi -sweet GF biscuits. It has been found that TGase increased the fracturability value and moisture content of final products. According to Beck *et al.* (2011), the increased moisture level is due to the deamination of glutamine which produces glutamic acid residues, a negatively charged group that induces the ability of protein in water binding. Nonetheless, TGase has been reported capable of decreasing the hardness of final products (Altındağ *et al.,* 2015). In general, the study on the application of enzymes in the development of GF biscuits seems very limited. This might be due to the application of enzymes that are more reliable in other GF bakery products such as bread and cakes.

4. Novel technologies approach in gluten-free bakery products

High-pressure processing (HPP) is a non-thermal process that consists of treating food with high pressures to modify functional properties of starch and protein in order to create novel structures and textures (Vallons *et al.,* 2011). HPP basically can improve the formation of protein networks (Kieffer *et al.,* 2007) and capable of inducing starch gelatinization consequently increased batter viscoelasticity (Vallons *et al.,* 2011). The application of HPP in the range of 100 to 1000 MPa has been investigated and could alter the functional properties of GF flours (Ahmed *et al.,* 2007). In fact, swelling properties induced by HPP are influenced by factors such as applied pressure, time, the temperature of treatment, type, and concentration of starch (Stolt *et al.,* 2000). On the other hand, HPP is also capable of enhancing bread crumb volume (Hüttner, 2010) and slowing down the staling process (Vallons *et al.,* 2011). Overall, the findings on the effect of HPP treatments are still limited; therefore, further studies on this method are expected in the future in order to optimize the impact of this treatment on different GF flours and other GF bakery products.

Furthermore, sourdough fermentation is considered one of the novel technological approaches in improving the functional properties of GF products. Basically, sourdough is made from a mixture of flour, water and other ingredients which are fermented by yeasts and lactic acid bacteria (LAB) (Capriles and Arêas, 2014). It has been well known that this process could enhance the rheological properties of batters or dough (Jekle *et al.,* 2010; Nami *et al.,* 2019), bread's volume and texture (Axel *et al.,* 2015; Aguilar *et al.,* 2016), nutritional values (Svensson *et al.,* 2010) and prolong the shelf life of bread (Lacaze *et al.*, 2007). The positive effects presented by sourdough fermentation generally associated with the by-products produced by LAB during the fermentation process, to be specific volatile and antimicrobial compounds, lactic acid, and exopolysaccharide (EPS) (Moroni *et al.,* 2009). EPS can be classified as hydrocolloid replacer, which possessed the ability to improve the rheological properties of dough (Galle *et al.,* 2012). With the presence of by-products, dough properties can be enhanced by modifying the main structure building components such as starch and arabinoxylans, increased the solubility of the protein, and activating endogenous enzymes such as proteases and amylase which lead to the softer crumb structure (Bender and Schönlechner, 2020).

On the other hand, extrusion treatment is another method that can help to enhance the quality of GF bakery products. It has been shown that extrusion processing of starch-based food will result in a transformation in the functional properties in terms of rheological behaviour of flour slurry, water solubility (WS) and water absorption index (WAI) (Jafari *et al.*, 2017). In conjunction, several studies have proven the effect of extruded quinoa, rice-corn and buckwheat flour in the development of GF bread lead to an increase in a specific volume and decreased bread firmness (Murgueytio and Santacruz, 2020), improved WAI, WS and damaged starch (Yaghbani *et al.,* 2019) and increased the formation of the starch network (Cheng *et al.,* 2020), respectively. Nevertheless, extrusion treatment also reported to have a positive impact on cookie quality (Paesani *et al.,* 2020a) and helps in stabilizing foam in biscuits dough (Lisovska *et al.,* 2020). Conversely, Paesani *et al.* (2020b) found that this treatment caused a detrimental effect in GF layer cakes by decreasing the specific volume and increasing the hardness of cakes.

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5. Conclusion

As to be expected, the demand for GF food keeps on growing in the future. Although the development of GF food remains a technological challenge, research continues to discover new strategies and approaches that may provide a better solution to GF product development. As described in this review, single or combination usage of GF flours consist of GF cereals, pseudocereals and legumes are applicable in the development of GF bread, cakes and biscuits, even though these ingredients cannot completely replace and fully imitate the outcome of non-gluten free bakery products.

However, in the present articles, recent studies have shown that the manufacturing of GF bakery products presented promising impact with the aid of functional ingredients such as hydrocolloids, protein and enzymes in fulfilling some deficiencies in GF products to obtain good physical and eating qualities. Apart from ingredients, the application of novel technologies delivers further solutions for the production of good quality GF products. High-pressure treatment exhibits potential in the formation of protein network and starch gelatinization, whereas sourdough fermentation could enhance the rheological properties of batters or dough, bread's volume and texture, nutritional values as well as prolong the shelf life of bread, lastly extrusion technology that capable of improving starch gelatinization which leads to better functional properties and structural attributes.

Therefore, future efforts should be more focused on novel technologies strategies, especially on the high-pressure process, and extrusion technology seems both processes are promising in terms of product quality and time efficiency. Yet, findings are still very limited, particularly in gluten-free bakery products other than bread.

Conflict of interest

The authors declare no conflicts of interest.

Acknowledgements

The authors acknowledge the financial support by the Universiti Malaysia Sabah (UMS) (SDK0137-2020).

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