Effects of Thermal treatment on functional properties of flour and gluten free baking products

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Abstract:

A great variety of physical techques is available for modification of performance flour that are used in gluten-free products. these methods include different milling systems, particle size classification and a variety of thermal treatments. The present study reviews heat techniques and indicates its effects on gluten free flours functionality. Promising strategies and processing parameters that might improve the incorporation and stabilization of gas in gluten-free dough are presented. By studying the literature from 1990 to 2016 concluded that low heat process such as drying can modify starch granules, denature proteins, inactivate enzymes, reduce microbial load and even improve taste and aroma. These changes can improve flour suitability for production gluten-free products. Thermal treatments are also usually necessary in flours with high fat content, such as oat or whole grain flours, especially whole rice flours with the aim of inactivating enzymes which can developed rancidity such as lipases and lipoxygenases. Referring to the fact that these changes depends on the treatment conditions, such as temperature and moisture, hydrothermal treatments are mainly classified in two groups: those performed below gelatinization temperature, preserving the integrity of starch granules; and those treatments done above gelatinization temperature and therefore irreversibly destroyed the molecules and starch granule. For bread and other bakery products ,a delayed gelatinization may also extend the period of loaf expansion, increase the volume of breads and enhance their quality. HMT (heat-moisture-treatment) flours and starches also have a high emulsifying ability, which can improve air keeping in doughs and increase the bread tendency. However, the studies on the addition of these flours in breads are not same. Thus, further studies on the effect of the moisture thermal treatment on gluten-free flour and formulations could be useful.

Keywords: physical treatment, thermal, flour,free gluten, bread

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introduction

A growing demand for gluten-free products is caused by an increasing number of diagnosed celiacs, but also by a trend to eliminate any potentially allergenic proteins in a diet. The removal of gluten from food products based on wheat has a significant impact on their structure and texture. It is not an easy task to adjust a recipe for gluten-free products, which would give a product with sensory attributes, nutritional value and consumer acceptance comparable to traditional food. Traditionally, the industry has approached the use of native flours, without modification, whose properties depend on grain characteristics and composition as well as the milling system used. Nevertheless, flours obtained from traditional methods can be subjected to different physical treatments, which range from a simple sieving to complex hydrothermal treatments which can modify flour functionality and their adequacy to the different gluten-free elaborations. In this review the different modalities of dry and wet thermal treatments on flour properties have been discussed. The study concludes by explaining the utility and the potential uses of these thermal treatments on gluten-free products.

Thermal treatments

Flour can be exposed to thermal treatments of different level. A simple heating process can produce dehydrated flour, which could be necessary to preserve flours for longer times, especially in the case of flours with moisture higher than 15%. Moreover, as a effect of the drying treatment, sometimes flour functionality can be modified. Thereby, thermal treatments, depending on their roughness, can modify starch granules, denature proteins, inactivate enzymes, reduce microbial load and even improve taste and aroma. Also, these changes can affect flour suitability for production gluten-free products. Thermal treatments are also usually necessary in flours with high fat content, such as oat (Decker et al., 2014) or whole grain flours, especially whole rice flours (Orthoefer and Eastman, 2004), with the aim of inactivating enzymes which can developed rancidity such as lipases and lipoxygenases. Those high amounts of lipids and lipid-metabolizing enzymes may lead to a reduced shelf life of these flours, and to a decrease in bread-making quality (Tait and Galliard, 1988), sensory acceptability (Galliard and Gallagher, 1988; Hansen and Rose, 1996), and nutritional value (Pomeranz, 1992) of gluten-free products. It is known that the type of treatment subjected to oat flours' affects their bread-making properties in combination with wheat flours (Zhang et al., 1998). However, there are no investigations relating directly to the different hydrothermal conditions on the quality of gluten-free products.

Nevertheless, there is a lack of studies on how the different drying conditions, such as the type of drying, temperature used, duration, air velocity, tray loading and many other factors, affect the functional properties of those flours and their adequacy to different glutenfree products.

Effects of heat-moisture-treatment on Structural modifications

To the present, thermal treatments with the aim of drying or enzyme inactivation have been done. However continuous developments of gluten-free foodstuff and their higher quality requirements force the adaptation of gluten-free flours to the appearing needs in terms of functionality. The modification of the functionality of starchy ingredients by hydrothermal treatments is becoming of great interest, as in many cases it is possible to achieve those properties of chemically modified starches while keeping the clean label (Jacobs and Delcour, 1998), without artificial ingredients and chemicals. When heating is performed with enough amount of water (previous hydration of flour or starch), morphological changes within starch granules take place. The extent of these changes depends on the treatment conditions, such as temperature and moisture. Hydrothermal treatments are mainly classified in two groups: those performed below gelatinization temperature, preserving the integrity of starch granules; and those treatments done above gelatinization temperature and therefore irreversibly destroyed the molecules and starch granule.

Starch granules, being partially crystalline structure, are prone to modest molecular reorganization when held in an excess of water (above 40%water [w/w]) at temperatures above the glass transition temperature (Tg) but below the gelatinization temperature (annealing). This causes softening of the amorphous granular regions and a resultful crystallite growth and/or perfection (Biliaderis, 2009). A similar hydrothermal process, known to persuade major structural mutations in granular starches, this is introdused heat-moisture-treatment (HMT). HMT involves heating starch at around 25% moisture at

100° C for several hours without fostering a complete starch gelatinization. HMT of cereal flour, legume and tuber starches increases the gelatinization temperature, the water binding capacity and in most cases granule susceptibility to enzymecatalysed hydrolysis. However, Lorenz and Kulp (1981, 1983) observed that the magnitude of these changes are dependent on the moisture content and starch type. Moreover, those effects were particularly marked with potato and other tuber starches, which become more like wheat starch in terms of rheological properties (Biliaderis, 2009) improving their baking performance (Lorenz and Kulp, 1981), whereas the functional properties of cereal starches usually degrade (Hoover and Vasanthan,1994). Since starch swelling and solubility as well as its water binding capacity can vary as a effect of the annealing and HMT conditions (mainly moisture and temperature) and the starch type, there might be a competition for the available water between starch gelatinization and protein denaturation processes during heating. Moreover, this could affect the structural and the textural attributes of the final gluten-free product. For bread and other bakery items,a delayed gelatinization may also prolong the period of loaf expansion, increase the volume of breads and enhance their quality. HMT flours and starches also have a high emulsifying ability, which can improve air keeping in doughs and increase the bread tendency (Kurahashi and Hizukuri, 1998). However, the studies on the addition of these flours in wheat breads are not same. whereas a greater softness with annealed starches has been reported (Larsson and Eliasson, 1997), Miyazaki and Morita (2005) did not observe an improvement of breads with HMT corn starch. Thus, further studies on the effect of the moisture thermal treatment on gluten-free flour and formulations could be useful.

Effects of high temperatures of extrusion on gelatinization process

When starches or flours are subjected to hydrothermal treatments carried out above gelatinization temperature, the molecular order of the starch granule undergoes irreversible breakage, known as gelatinization (known as pre-gelatinization), making starch more disposed to swell and thicken in the present of water (Mason, 2009; Martínez et al., 2014a, 2014b, 2015). In industries gelatinization of starch can be carried out in various approaches, such as drying a paste by atomization or heated drums; but one of the most adequate alternatives is extrusion (Chiu and Solarek, 2009; Doublier et al., 1986; Hagenimana et al., 2006). Extrusion can involve exposing flours to high temperatures and mechanical shearing with enough amount of water to produce gelatinized starch. Besides gelatinization of starch, this treatment allows breakage of the amylose and amylopectin chains (dextrinization), denaturation of proteins, inactivation of enzyme and Maillard reactions, the extent of which are dependent on the intensity of the extrusion (Mercier and Feillet, 1975; Wen et al.,1990). These changes modify the physicochemical characteristics of flours. The functional modification of gelatinised flours, and especially their higher water binding capacity, can be taken into account in bread-making for increasing dough consistency and reducing the typical dryness of breads. Thereby, Defloor et al. (1991) observed that a mixture of extruded starches and emulsifying agents improved the quality of breads prepared with a mixture of tapioca and soya and a high level of hydration. Sanchez et al. (2008) found that the addition of extruded rice flour improved bread volume and crumb structure, but this effect was more noticeable when the waxy varieties of rice were used. However, the latter authors had to increase the quantity of water in the formula when using extruded flours in order to compensate their higher consistency. The effect of the substitution of rice flour by extruded non-acidified and acidified rice flour has also been tested (Clerici and El-Dash, 2006; Clerici et al., 2009).they did not use hydrocolloids in their bread-making process and bread specific volume was excessively low in all cases. Later, Martínez et al. (2013b) observed how the substitution of native rice flour by extruded rice flour, in breads, increased bread volume, decreased initial hardness and delayed bread staling. Martínez et al. (2014c) observed that an increase of the severity of the extrusion conditions led to an increase of the viscoelastic moduli and dough consistency of glutenfree breads when incorporating extruded flour. Moreover, it was necessary to add larger amounts of water to achieve a constant consistency and therefore increasing the bakery product (Martínez et al., 2013a). The disruption of the starch granules (gelatinization) during extrusion also increase their chemical reactivity towards hydrolytic enzymes (Martínez et al., 2015b). The different susceptibility to enzymatic hydrolysis, especially by amylases and glucoamylases, gives rise to different profile of oligosaccharides. This starch hydrolysis sugars are the fermentation substrates of bread-making and one of the principal compounds that participate in Maillard and Caramelisation thermal reactions that occur during baking (Hee Cho and Peterson, 2010; Salim-ur-Rehman et al., 2006). Sugars also influence the stickiness of doughs with a positive correlation (Every and Ross, 1996). Added to that, they are correlated with changes in the staling rate of bread, by delaying it (Gerrard et al., 1997). Therefore, gelatinised flours should also be considered as a function of their different starch hydrolysis susceptibility by different enzymes, such as amylases, glucoamylases or even other starch-catalysing enzymes such as cyclodextrin glycosyltransferase (CGTase) or transglicosidase, with a view to generating new molecules for specific non-gluten cereals or cereal based products.

Conclusions

Gluten-free flour can be physically modified through different milling systems, particle size classification and a variety of thermal treatments. Among these treatments, thermal treatment are applied in order to increase stability of flour and its shelf life whereas on the other hand new functionalities are pursued. Thereby, the flour obtained after these treatments differs in their functional properties, such as water absorption capacity, thickening power, emulsifying properties, pasting properties and chemical reactivity towards enzymes, among others. Each of the flours adapt differently to the distinct manufacturing of bakery products. In this way, the election of the proper flour or the addition of little amounts of some of these flours can improve some of the characteristics of the gluten-free bakery products, such as their volume, texture or shelf life. It could allow manufacturing products of better quality. However, studies on these applications are scarce and their deepening is still necessary.

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