Effect of Modified Oat Starch and Protein on Batter Properties and Quality of Cake

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ABSTRACT

Starch and protein separated from oat were chemically modified using cross-linking and acetylation protocols for starch, and deamidation and succinylation for protein isolate. Cross-linking decreased swelling power of starch, whereas syneresis increased, but cross-linking does not have a significant effect on gelatinization temperature. Acetylation increased swelling power, but gelatinization temperature and syneresis diminished. Deamidation and succinylation increased nitrogen solubility index, emulsion activity, foaming capacity, and water and oil binding capacity. Emulsion stability did not change with deamidation and it diminished with succinylation, while foaming stability decreased with both treatments. Acetylated starch and two types of modified proteins were substituted for 5, 10, 15, and 20% of oat flour to bake cake samples and then physical properties of the cakes were measured. Acetylated starch increased batter viscosity, cake volume, and whiteness of cake crust. Increased level of deamidated protein produced cakes with lower batter viscosity, higher volume, and darker color (increase in redness). Application of higher levels of succinylated protein led to higher batter viscosity and lightness, and lower cake volume. Therefore, substitution of deamidated protein and acetylated starch can improve cake properties.

For decades and in most parts of the world, oats were used as livestock feed. However, the nutritionally favorable attributes of oats such as high protein, fat, and fiber content have now aroused considerable interest in increasing utilization of oats for human consumption (Lapvetelainen and Aro 1994). The interest in oats has increased due to its soluble fiber content that produces a unique lowering effect on blood cholesterol and can prevent coronary heart disease. Moreover, several other health-promoting effects such as weight control, alleviating intestine disorder, and hormone-mediated cancer prevention also have been reported (Han et al 2008). According to Thompson (2003), consumption of oats is safe for adults with celiac diseases. Among oat constituents, starch constitutes ≈60% of the grain. In studies conducted so far, considerable differences have been observed between the physicochemical properties of oat starch and other cereal starches. Development of modified starches such as cross-linked and acetylated starches also have been investigated for more than a century and a number of applications in the food industry were discovered (Kaur et al 2006). Acetylation of starch is an important substitution method that has been applied to starch to impart the thickening needed in food applications. Acetylated starches have improved properties over their native counterparts and have been used for stability and resistance to retrogradation (Sodhi and Singh 2005).

Unlike other cereals, protein concentration in oat groats is high, typically 15–20%. Utilization of proteins in food systems depends largely on their physicochemical properties, often defined as functionality. Although oat protein products possess good emulsifying and binding properties, further improvement of functional properties, particularly those that are poor at normal or slightly acidic pH levels (Ma 1983), is desirable. Viscosity and stability of cakes that contain high levels of sugar and water must be increased to obtain a porous structure that does not collapse. When modified starch is used, some changes in cake baking performance may occur depending on the gelatinization temperature of the system (Karauglu et al 2001). Chemical modification improved some functional properties such as solubility, foaming capacity, and emulsifying activity of native protein isolate that can improve cake quality because soluble and foamable proteins are needed to retain the air incorporated in the batter. To our knowledge, there are few or no reports on oat cake quality, particularly after substitution of modified starch and protein in formula In this study, the physicochemical and functional properties of native and modified starch and protein were determined, as were the effects of substituting acetylated oat starch and deamidated and succinylated oat protein isolates on physical characteristics of cakes prepared from oat flour.

MATERIALS AND METHODS

Oats were grown in the Lavark experimental field of Isfahan University of Technology, Iran. The seeds were dehulled and ground in a disk mill.

Starch Isolation at Alkaline pH

Oat flour (100 g) was stirred for 30 min at 25°C with 500 mL of 0.02*M* sodium hydroxide and then centrifuged (1,400 × *g*). The sediment was slurried with water (500 mL) and the mixture was filtered through a nylon bolting cloth (50 μm). The filtrate was neutralized with 1*M* hydrochloric acid and the mixture was centrifuged. The supernatant was discarded with the tailings scraped from the top layer of the starch. The starch was washed with water (3×, 200 mL), collected by centrifugation, and dried overnight in a forced-convection oven at 40°C (Lim et al 1992).

Preparation of Cross-Linked Oat Starch

Cross-linking of oat starch used two different concentrations of $POCl_3$. For this treatment, starch (15 g, dry basis) was stirred slowly in distilled water (24 mL) containing 0.3 g of Na_2SO_4 and adjusted to pH 11.5 with 0.5*M* sodium hydroxide. Phosphoryl chloride was added at levels of 0.5 and 1 g/kg (based on dry weight of starch) using a micropipette; the reaction vessel was sealed and the temperature was maintained at 25°C. Starch reacted with $POCl_3$ for 1 hr with stirring. After that, the starch slurry was neutralized to pH 5.5 with diluted HCl (0.1*M*). After sedimentation, the starch was washed free of acid three times with distilled water and oven dried at 40°C (Kaur et al 2006).

Preparation of Acetylated Oat Starch

Starch (100 g) was dispersed in distilled water (225 mL) and stirred for 1 hr at 25°C. Sodium hydroxide (3%) solution was used to adjust the suspension to pH 8.0. Acetic anhydride (6 g) was added drop-wise to the stirred slurry and maintained at pH 8.0–8.4 with 3% NaOH solution. This reaction was continued for

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