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The effects of acetylated potato starch and sodium carboxymethyl cellulose on the quality of instant fried noodles

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ABSTRACT

The objective of this study has been to investigate the effects of two ingredients i) acetylated potato starch (APS) and ii) sodium carboxymethyl cellulose (CMC) on the textural attributes and eating quality of instant noodles. Using low-protein soft wheat flour (Australian Soft) as the base material, samples of noodles incorporating varying proportions of APS and CMC were evaluated for product texture, colour and fat uptake. The variables were studied using a central composite design and textural characteristics were assessed using the TA-XT2, colour by the Minolta Chroma Meter. The results were analyzed by response surface methodology and showed that the two variables enhance the hardness and reduce adhesive values of cooked instant noodles. Electron microscopy also demonstrated the development of a more continuous network structure within the noodles. The addition of CMC had weakened the noodle inner structure and reduced the cohesiveness values of the cooked instant noodles. In contrast, APS provides hardness but does not affect cohesiveness. Marginal observable difference was found in product colour for the various treatment combinations, with a slightly dull appearance, viz less white and less yellow compared with the control. Trials to produce the lowest fat uptake rating indicated that 10% APS was optimal. The results may provide a basis for modifying formulations for use with low-protein soft wheat flours to provide eating quality and colour attributes to meet the preferences of specific customer groups. The conclusion of this study is that the combined use of APS and CMC primarily affects the textural attributes of hardness and adhesiveness rather than the other quality parameters of instant noodle that have been assessed. In addition, APS has the potential to enhance the performance of low-protein soft wheat flours for instant noodle manufacture.

1. Introduction

Wheat noodles are a staple food in most Asian countries and it can be estimated that noodles account for more than 12% of global wheat production (FAO, 2005; Nagao, 1995). Instant noodles are one of the most popular wheat noodles. In 2005, approximately 85 billion servings of instant noodles were eaten, and worldwide consumption continues to increase (International Ramen Manufacturers Association, 2006).

Texture is one of the primary quality parameters for instant noodles and can be expressed as rubbery, firm and smooth (Kubomura, 1998). To achieve desirable texture, starch is commonly incorporated at levels of 5–15%. Starch contributes greatly to the textural properties of many foods and is widely used in food and industrial applications as a thickener, colloidal stabilizer, gelling agent, bulking agent and water retention agent (Singh, Kaur, & McCarthy, 2007). However, the use of native starches is limited by their lack of stability under the conditions of temperature, shear, pH and refrigeration commonly applied to processed foods (Liu, Ramsden, & Corke, 1999). Retrogradation of starch leads to undesirable changes in product texture, and to overcome these, modified starches such as acetylated starch are widely used. Acetylated starches have many positive characteristics including low gelatinization temperature, high swelling and solubility as well as stability under freeze-thaw conditions (Liu et al., 1999).

Research on rice starch has indicated that acetylation increases solubility, swelling power and viscosity but decreases gelatinization temperature (Jae, Jung, & Man, 1993). Other studies indicated similar conclusions using acetylated starches from cassava (Aiyeleye, Akingbala, & Oguntimein, 1993; Moorthy, 1985) and *Xanthosoma violaceum* (Pereira-Pacheco, Nieto-Lopez, & Escobar-Espinosa, 1994). Fang (1999) also mentioned that acetylated potato starch (APS) can be used to improve noodle elasticity. Chen, Schols, and Voragen (2003) demonstrated that when up to 20% of

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wheat flour was replaced by acetylated starches prepared from potato or sweet potato in white salted noodle (WSN), the cooking loss decreased, while the softness, stretchability and slipperiness increased significantly. The current study, investigating instant noodles made with low-protein flour will complement current knowledge on the incorporation of APS.

Another research issue has been the problems associated with the frying stage. The continuous processes of steaming and frying of instant noodles enable starch to gelatinize followed by dehydration resulting in noodles with porous structure and unique flavours (Rho, Seib, Chung, & Chung, 1986; Wu, Kuo, & Chen, 1998). Deep frying, however, also has negative impacts on food quality. The high residual oil content, the presence of oil-derived compounds (Ziaiifar, Achir, Courtois, Trezzani, & Trystram, 2008) in noodles and their potential health impact have raised concerns from both manufacturers and consumers. High fat contents are not essential to achieving good product quality, are uneconomical for the manufacturer as increased operating costs are incurred and the resultant product contributes to high fat intakes. The research challenge is therefore to improve the frying process by controlling and lowering the final fat content of the fried noodles, without affecting the product quality.

Past researchers have identified several factors that generally affect fat uptake during frying. These include initial moisture content (Pinthus, Weinberg, & Saguy, 1993), product shape and composition, porosity (Pinthus, Weinberg, & Saguy, 1995), oil quality (Blumenthal, 1999), product and oil temperature, frying duration (Fan & Arce, 1986) and frying method. In addition, incorporating hydrocolloids into the formulation is a convenient method of reducing fat content without varying equipment design (Priya, Singhal, & Kulkarni, 1996). Hydrocolloids are multifunctional ingredients that provide flexibility, functioning as fat replacers, water binders, texturizers and adhesives (Gurkin, 2002). Studies on fried foods with hydrocolloids have shown the reduction of fat uptake, e.g. use of film forming agents (Olson & Zoss, 1985), powdered cellulose derivatives and alginates (Pinthus et al., 1993), and sodium carboxymethyl cellulose (CMC) (Priya et al., 1996). Follow up studies have confirmed the role of CMC in reducing fat content and fat uptake in various batters and coatings include sev (Annapure, Singhal, & Kulkarni, 1999) and boondis (Priya et al., 1996) during frying. Ang and Miller (1991) found that the ability of CMC to reduce fat uptake in fried foods was linked to its hydrophilic character. This is attributed to the thermal gelation of this hydrocolloid at the frying temperature, which creates an oil-resistant film around the fried product, thereby lowering the fat absorption (Ang & Miller, 1991). Recent research indicated that CMC added to amaranthus spaghetti gave lower stickiness values and gave better cooking performance (Chillo, Laverse, Falcone, & Del Nobile, 2007).

There has been limited study on the effects of APS and CMC on the eating quality of instant noodles. Another issue is that of the characteristics associated with the flour proteins as they impact upon noodles. Generally, for instant noodles, flours having medium to strong attributes, typically corresponding with protein contents in the range of 10–12%, are used. Flours with protein less than 10% give a softer texture and the resultant products are less acceptable for most consumers. The current research has been developed in the context of the ready availability of lower protein flours having less elastic and more extensible dough properties, which are best suited to the production of biscuits. Accordingly, the dual objectives of this study have been specifically to investigate the effects of APS and CMC on the attributes of instant noodles made from low-protein soft flour (Australian Soft, AS).

2. Materials and methods

2.1. Materials

Commercial Australian Soft (AS) wheat flour, milled from Soft 1 varieties (containing no Rosella) was obtained from Allied Mills, Melbourne. Flour composition was 14% moisture, 0.42% ash, 8.80% protein content and 5.19% damaged starch. The APS-Perfectamyl AC was kindly provided by National Starch Food Innovation (NSW, Australia). This product was designed for the improvement of noodle texture. Food grade CMC evaluated here was purchased from Akzo Nobel Cellulosic Specialties (Amersfoort, The Netherlands). All other chemicals were of reagent grade.

2.2. Instant noodle preparation

The instant noodle dough was formulated by mixing 80–100% flour, 0–20% APS, 1% salt (NaCl), 0.2% alkaline salt (potassium and sodium carbonate mixed 6:4), 35% distilled water and 0–1% CMC. APS was mixed with AS flour in the mixer (Kenwood KM210, Britain) for 30 s prior to use. The salt, alkaline salt and CMC were dissolved completely before use. The CMC colloidal dispersion and water containing dissolved salts were mixed over a period of 30 s at speed 1 with wheat flour blend (250 g). The mixer was then operated for 1 min (at speed 1) and 4 min (at speed 4) until the resultant dough became crumbly. After 1 and 3 min, mixing was discontinued briefly to allow incorporation of small dough pieces adhering to the sides of the mixing bowl. The crumbly dough was then placed into a resealable plastic bag and allowed to rest at room temperature (~22 °C) for half an hour. The crumbly dough was then kneaded to form a dough ball and passed through the roller unit of a pasta machine (Imperia, Ambrogio di Torino, Italy) with the regulating knob set at position no. 1 (2.5 mm gap). The resultant sheet was folded in half and passed through the rollers. Typically three passes were required in order to give a uniform sheet which held together as a single dough piece. The thickness of the sheet was reduced stepwise by passing between the rollers of the pasta machine.

To make instant noodles, the dough sheet was further passed through the pasta machine with the roller gap gradually reduced to approximately 1.0 mm. The dough sheet was then passed through the cutter attachment. These were then placed uniformly into a steam pan which was transferred into a preheated (100 °C) steamer, and steamed for 2 min to allow starch to swell and gelatinize. The final step was frying and for this hydrogenated palm oil (Jasper International Pty Ltd., Australia) was used at a temperature of 150 °C and the frying time was 45 s. The steamed noodle strands were placed loosely in a wire basket and the basket was immersed in the preheated oil. The hydrogenated palm oil was replaced after two samples of noodles had been fried. The fried noodle strands were allowed to cool at room temperature (~22 °C) and excess oil was drained from the surface. The cooled samples were placed into resealable plastic bags for storage and subsequent analysis. Noodle thickness was measured after the cutting and frying stages using a dial caliper (Mitutoyo, Japan).

2.3. Cooking of noodles

Fried instant noodle strands (30 g) were added to 1 L of boiling water and were cooked to the optimum cooking time using the procedure described by Oh, Seib, Deyoe, and Ward (1983). After cooking, the noodles were cooled in running tap water (~17 °C) for 1 min. The drained noodles were then stored in a covered plastic container at room temperature (~22 °C) for 10 min before the texture profile analysis (TPA).