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Preparation and evaluation of chili powder-enriched layered noodles

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ABSTRACT

Chili powder-enriched dough was sandwiched between two dough layers prepared from (a) wheat flour, (b) wheat flour plus resistant starch flour and (c) wheat flour plus soy protein isolate (SPI) and microbial transglutaminase (MTGase), and these were used for preparing wheat flour control (LN-C), wheat flour-resistant starch (LN-F) and wheat flour-SPI-MTGase (LN-S) noodles, respectively. All cooked noodles were assessed for physical properties, starch digestibility and capsaicin-retaining abilities. Compared to other noodles, the LN-S noodles exhibited the highest tensile strength and elasticity, and the highest capsaicin retaining ability at pH 7.4. However, at pH 1.2 the capsaicin-retaining ability of all noodles was similar. The predicted glycemic indices (pGIs) of LN-F and LN-S noodles were similar ($P > 0.05$), and were significantly ($P < 0.05$) lower than that of LN-C noodles. In conclusion, the resistant starch flour helped to lower pGI of the layered noodles, but it was not effective at retaining capsaicin. The occurrence of additional cross-linking between protein matrices of LN-S noodles could be a factor that had impaired structural integrity and retarded the diffusion of capsaicin from the capsaicin-enriched dough.

1. Introduction

Capsaicin, the main pungent compound in chili peppers has potential to be used as an anti-obesity ingredient. The boosting of heat generation is initiated via the activation of the sympathetic nervous system after ingesting the capsaicin (Kang et al., 2010; Westerterp-Plantenga, Diepvens, Joosen, Berube-Parent, & Tremblay, 2006). This was followed by the increasing secretion of catecholamine from adrenal medulla (Yoshioka et al., 1999) and expression of certain fat degrading proteins (Joo, Kim, Choi, & Yun, 2009). The energy intake could be decreased through the promotion of the feeling of satiety (Reinbach, Smeets, Martinussen, Moller, & Westerter-Plantenga, 2009; Westerterp-Plantenga, Smeets, & Lejeune, 2005). A decrease in the liking of food as well as heat and burning sensations in the mouth cavity could be felt at a capsaicin dose of 1–10 mg (Craft & Porreca, 1992; Yoshioka, St-Pierre, Suzuki, & Tremblay, 1998; Yoshioka et al., 2004). However, it is a higher dose of capsaicin (10–30 mg) that is effective for the prevention and treatment of obesity (Reinbach, Martinussen, & Moller, 2010; Yoshioka et al., 1999, 2004). This means that the incorporation of an ample amount of capsaicin to achieve anti-obesity functions may yield a product that is too spicy for most consumers.

In this paper, a redesigned yellow alkaline noodle (YAN) is proposed as a functional product to carry the functions of capsaicin-carrier. The new noodle is termed “layered noodle”, that is prepared by sandwiching a capsaicin-enriched dough (CED) layer with two gastro-resistant dough layers. If a high amount of chili powder is directly incorporated into a typical noodle, a large portion of capsaicin (i.e., the functional ingredients) of chili could be leached out from the noodle during preparation. Sandwiching the CED with two gastro-resistant layers will help to retain the capsaicin in the noodle matrix. During eating, many Asian consumers prefer to slurp down the noodles rather than chewing them extensively. Thus, the capsaicin that is held within the CED and sandwiched between the two layers of the noodle should not cause excessive pain to the consumers. Capsaicin is expected to be released in a controlled-manner in the gastro-intestinal tract where its health-enhancing functions are exerted.

The gastro-resistant materials to be used for preparing the sandwiching noodle layers should have controlled-release properties and slow digestion capability to enable the noodles to retain capsaicin for longer. Fibersym® is a modified resistant wheat starch from MGP Ingredients Inc., which contains a high content (76%) of dietary fiber. High fiber products have been shown to exert positive effects on the human health, including reducing the glycemic response, the levels of serum cholesterol, the risk of coronary

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disease and enhancing weight management. (Appleby, Thorogood, Mann, & Key, 1998; Rigaud, Ryttig, Angel, & Apfelbaum, 1990). Some studies have shown that the organoleptic qualities of products enriched with resistant starch are better than those with traditional fiber, that could be due to its low water-holding properties, white and smooth appearance and bland flavor (Sanz, Salvador, & Fiszman, 2008). Another alternative is through the use of a protein (such as soy protein isolate, SPI) that is cross-linked via a cross-linking agent (such as microbial transglutaminase, MTGase). The cross-linking reaction catalyzed by the MTGase enzyme (Nonaka et al., 1996) occurred between the γ-carboxyamidegroup of peptide-bound glutamine residues (acyl donors) with a variety of primary amines (acyl acceptors) (Motoki & Seguro, 1998). Incorporation of MTGase into the mixture of SPI and wheat flour has been reported to lower the predicted glycemic index (pGI), strengthen the dough network and enhance the gastro-resistant properties (Gan, Cheng, & Easa, 2008; Gan, Ong, Wong, & Easa, 2009). Thus the rationale for incorporating the resistant starch and cross-linked protein is to affect the retainability of capsaicin, i.e. by making the outer layers more gastro-resistant. The reduction in GI means that the noodles are more resistant to digestion, thus would retain more capsaicin.

There is no study that describes neither the preparation of layered noodles nor the evaluation on the use of these ingredients in the layered noodles. Thus, the objective of this study was to evaluate the physical properties, in-vitro starch digestibility and capsaicin-retaining ability of layered noodles prepared by sandwiching the capsaicin-enriched dough (CED) with dough layers made from Fibersym® or SPI and MTGase.

2. Materials and methods

2.1. Materials

Basic ingredients for noodle making, which includes wheat flour (Prestasi Flour Mill Sdn. Bhd, Port Klang, Malaysia), pure chili powder (brand: Alagappa, manufactured by Alagappa Flour Mill Sdn. Bhd, Georgetown, Malaysia) and *kansui* reagent with 36% of Na_2CO_3 (Tong Foong Sauce Factory Sdn. Bhd, Georgetown, Malaysia), and commercial yellow alkaline noodles (brand: Cap Ibu, manufactured by Naga Food Sdn. Bhd, Sungai Buloh, Malaysia) were purchased Tesco Stores (M) Sdn. Bhd. (Georgetown, Malaysia). The food grade soy protein isolate (SPI) was purchased from Sim Company Sdn. Bhd. (Georgetown, Malaysia). Resistant starch powder (Fibersym® RW) and Microbial Transglutaminase-K (Activity: 4 unit/100 mg) were donated by Connell Bros. Company (M) Sdn. Bhd. (Shah Alam, Malaysia) and Ajinomoto (M) Berhad (Kuala Lumpur, Malaysia), respectively.

All chemicals used in this study were of analytical grade, except for acetonitrile and capsaicin standard used for capsaicin content determination, which are HPLC grade. All the chemicals were purchased from Sigma–Aldrich (M) Sdn. Bhd. (Petaling Jaya, Malaysia).

2.2. Noodle preparation

Capsaicin-enriched dough (CED) and sandwiching dough were prepared based on the formulation shown in Table 1. Powder materials for dough preparation were initially mixed with a mixer (KitchenAid, St. Joseph, USA) for 2 min. *Kansui* reagent and salt were dissolved in distilled water and added to the flour mixtures. The suspension was mixed with speed 1 for 8 min and then sheeted on a noodle machine (Nanjing Hope, HP-150F, Jangsu, China) with an initial gap setting at width 1 (~3 mm). The dough sheets were subjected to the sheeting process for two more times, with each time folding the dough sheet longitudinally to ensure homogeneity. Subsequently, the dough sheets underwent sheeting process (without folding in between gap setting) with gap setting at width from 2 (~2.5 mm) to 6 (~1.7 mm).

Table 1
Formulation of capsaicin-enriched dough (CED) and dough layers for noodle preparation.

Ingredients[b] (g)	Types of dough[a]			
	Dough-C	Dough-F	Dough-S	CED
Wheat flour	100	90	95	50
Distilled water	45	45	45	40
SPI	–	–	5	–
Fibersym®	–	10	–	–
Salt	1	1	1	1
Kansui reagent	1	1	1	1
MTGase	–	–	0.5	–
Chili powder	–	–	–	50

[a] Dough-C, Control dough; Dough-F, Fibersym® dough; Dough-S, SPI & MTGase dough; CED, capsaicin-enriched dough.
[b] SPI, soy protein isolate; MTGase, microbial transglutaminase.

The final step in the making of layered noodles involved the sandwiching of the CED sheet with two sandwiching dough layers, followed by another sheeting process but without the folding step in between gap setting. The sheeting was carried out using the same noodle machine but with gap setting set at width 4 (~2.1 mm), 5 (~1.9 mm) and 6 (~1.7 mm). Then the obtained dough sheets were slit and the noodles were incubated at 40 °C for 4 h. After incubation, the layered noodles were steamed for 2 min in a steamer and then allowed to shape and dry at 60 °C for 5 h using a hot air dryer (AFOS, Mini Kiln, Hull, UK) before being stored in a plastic bag at room temperature prior to cooking and further analysis. Unless otherwise stated, the layered noodles were cooked in boiling water at a ratio of 1:50 (one part of noodle in 50 parts of water) until the disappearance of white core (~7.5 min) and then cooled at room temperature before analysis.

2.3. pH

The pH of the noodle samples were measured using Delta 320 pH meter (Mettler-Toledo, Greifensee, Switzerland), calibrated with buffer solutions of pH 4.0 and 10.0. Samples (10 g each) were mixed with 100 mL of deionized water (18.2 MΩ-cm) and homogenized for 5 min. Homogenate was allowed to rest for 30 min prior to filtering with filter paper (GE Healthcare, Whatman No. 41, Maidstone, UK).

2.4. Color

A spectrophotometer (Konica Minolta, CM-3500d, Osaka, Japan) equipped with D65 illuminant was used to record the color of the layered noodles. Before use, the instrument was calibrated with plate sets CR-A47 and a white plate. The *CIE* L^*, a^* and b^* color scale was measured through round glass optical cells to express the results of the color. L^* represents lightness (0–100), whilst a^* and b^* indicate the red-green and blue-yellow coordinates, respectively. Measurements were made in triplicate at 3 random locations of the noodle surface.

2.5. Tensile strength and elasticity

The measurements of tensile strength and elasticity of the layered noodles were carried out using a Texture Analyzer (Stable Micro Systems, TA-TX2, Surrey, UK) fitted with a 2.5 kg load cell. Rig calibration was performed before the analysis using the load cell