Food Chemistry 179 (2015) 85–93

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Quality assessment of noodles made from blends of rice flour and canna starch

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ARTICLE INFO

Article history:
Received 18 November 2014
Received in revised form 22 January 2015
Accepted 24 January 2015
Available online 31 January 2015

Keywords:
Rice noodles
Canna starch
Dietary fiber
Short-chain fatty acids
Butyric acid

ABSTRACT

Canna starch and its derivatives (retrograded, retrograded debranched, and cross-linked) were evaluated for their suitability to be used as prebiotic sources in a rice noodle product. Twenty percent of the rice flour was replaced with these tested starches, and the noodles obtained were analyzed for morphology, cooking qualities, textural properties, and capability of producing short-chain fatty acids (SCFAs). Cross-linked canna starch could increase tensile strength and elongation of rice noodles. Total dietary fiber (TDF) content of noodles made from rice flour was 3.0% and increased to 5.1% and 7.3% when rice flour was replaced with retrograded and retrograded debranched starches, respectively. Cooking qualities and textural properties of noodles containing 20% retrograded debranched starch were mostly comparable, while the capability of producing SCFAs and butyric acid was superior to the control rice noodles; the cooked noodle strips also showed fewer tendencies to stick together.

1. Introduction

The rice noodle—produced from rice flour or rice flour mixed with other components, such as cassava starch, modified starch or hydrocolloids—is one of the most popular varieties of Asian noodles, and is widely consumed throughout Southeast Asia (Bhattacharya, Zee, & Corke, 1999; Hormdok & Noomhorm, 2007). Rice noodles are high in carbohydrates and calories but low in dietary fiber (DF) and resistant starch (RS) (Puwastien, Raroengwichit, Sungpuag, & Judprasong, 1999). Presently, consumers are more concerned with the health effects of DF as well as RS in carbohydrate-rich foods. Accordingly, various aspects related to DF/RS – for example, potential sources, digestion and fermentation, physiological effects, qualities of food products, acceptability by consumers, etc. – have been extensively researched.

A number of studies related to noodle qualities have investigated the potential of adding fiber sources to noodles made from wheat. However, much less information is available regarding rice noodles, perhaps due to the more severe effect of DF on their textural qualities. According to the report of Srikaeo, Mingyai, and Sopade (2011), noodles made from rice flour replaced with 20% unripe banana flour, canna flour or commercial modified corn starch had significantly higher RS content (2.5%, 3.6% and 8.8%, respectively) than noodles made from rice flour only (1.0%). Recently, Wandee et al. (2014) showed that rice noodles incorporated with 15% cassava pulp and 5% pomelo peel contained much higher total dietary fiber (TDF) content (14.4%) than the control (3.0%), while their textural properties were comparable. However, there have been no reports on the physiological effects and fermentability of rice noodles enriched with DF/RS, either *in vivo* or *in vitro* studies.

RS is the total amount of starch and the products of starch degradation that are not digested in the small intestine and pass into the colon, similar to dietary fiber (Englyst, Kingman, & Cummings, 1992; Topping & Clifton, 2001). RS is fermented by colonic microflora, producing short-chain fatty acids (SCFAs) and gas (H_2, CO_2 and CH_4). The fermentation rate and relative molar ratio of SCFAs are dependent on the amount and type of RS (Annison & Topping, 1994). SCFAs – mainly acetic, propionic and butyric acids – are absorbed and metabolized in various organs, leading to different physiological effects. Butyric acid is completely metabolized in the colonic epithelial cells, and therefore has been shown to play an important role in the maintenance of colonic health (Topping & Clifton, 2001). *In vitro* studies as well as animal studies indicate that butyric acid has the potential to reduce risk factors that are

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http://dx.doi.org/10.1016/j.foodchem.2015.01.119
0308-8146/

involved in the development of colorectal cancer (inhibiting proliferation while increasing differentiation and apoptosis) (Brouns, Kettlitz, & Arrigoni, 2002).

Canna starch, a kind of starch extracted from rhizomes of the edible canna plant (*Canna edulis* Ker.), is mostly used for preparing transparent starch noodles, a traditional food of Southeast Asia. High resistance of canna starch granules to enzyme hydrolysis has been reported by Hung and Morita (2005), Srichuwong, Sunarti, Mishima, Isono, and Hisamatsu (2005), and Puncha-arnon, Puttanlek, Rungsardthong, Pathipanawat, and Uttapap (2007). Canna starch and its derivatives have been reported to contain a significant amount of RS. Native, acetylated, hydroxypropylated, octenyl succinylated, and cross-linked canna starches gelatinized at 100 °C for 10 min were found to contain 20.8%, 33.8%, 43.5%, 51.3% and 35.3% RS, respectively (Juansang, Puttanlek, Rungsardthong, Puncha-arnon, & Uttapap, 2012). Wandee, Puttanlek, Rungsardthong, Puncha-arnon, and Uttapap (2012) prepared retrograded starch (RS type 3) from canna starch by gelatinization and then stored the gels at different times and temperatures. Under suitable conditions, the thermally stable RS fraction in canna starch could be increased from 1.9% to 16.8%. Bernabé, Srikaeo, and Schlüter (2011) reported that fermentation of raw canna starch with fresh human feces as inoculum produced significantly higher total SCFAs and butyric acid compared with banana, potato, mung bean and taro starches. However, there has been no information on the quality and fermentability of rice noodles incorporated with canna starch and its derivatives. Therefore, this study aimed to assess the potential of canna starch and its derivatives (retrograded, retrograded debranched, and cross-linked) as sources of DF in dried rice noodles.

2. Materials and methods

2.1. Raw materials

Commercial rice flour containing 22% amylose (dry weight basis; dwb) was purchased from Patum Rice Mill and Granary Public Co. Ltd., Pathum Thani, Thailand. Eight-month-old rhizomes of edible canna plants were obtained from the Rayong Field Crops Research Center, Rayong, Thailand; the starch was isolated according to a procedure described by Puncha-arnon et al. (2007). Amylose content of canna starch determined according to the method of Jayakody and Hoover (2002) was 23.9% (dwb). Cross-linked canna starch (CL) was prepared following the method of Emrat (2007), using 0.2% w/w sodium trimetaphosphate as a cross-linking agent. Retrograded canna starch was prepared by autoclaving starch at 121 °C for 120 min and then storing gel at 4 °C for 3 days (Wandee et al., 2012). A similar procedure, except that gelatinized starch was debranched with pullulanase enzyme (64 PUN/g starch) for 24 h prior to storage, was used to obtain retrograded debranched canna starch.

2.2. Dried noodle preparation

40 g (dwb) of flour mixes were prepared by mixing rice flour with 20% of native, retrograded, retrograded debranched, or cross-linked canna starches. Water was then added to each flour mix to obtain a slurry with a concentration of 40% w/v. 30 ml of slurry was spread evenly on a stainless tray (11.4 × 21.6 cm) and steamed for 1 min. Each noodle sheet was peeled from the tray and dried at 70 °C for 15 min. The noodle sheets were stacked, covered with cheesecloth and allowed to rest for 3 h at room temperature, then cut into strips 3.0 mm wide. The noodles were further dried in a hot-air oven at 40 °C until the moisture content decreased to 10–12%. Dried noodles were packed in polyethylene bags and kept at room temperature for further quality investigation.

2.3. Analyses of noodles

2.3.1. Determination of water absorption index

In order to obtain information on the ability of each raw material to absorb water, single-component flour/starch (100%) was used to prepare noodles using the procedure described above. It was found that noodles could be produced from a slurry of rice flour, native canna starch or cross-linked starch at a concentration of 40% w/v; however, slurries of retrograded and retrograded debranched starches were too thick, and concentrations of only 15% for retrograded starch and 30% for retrograded debranched starch could be used for noodle sheet formation. The water absorption index of the noodles obtained was determined according to the method of Anderson, Conway, Pfeifer, and Griffin (1969), with a slight modification. Dried noodles were cut into small pieces (3–5 cm length), ground with a Pulverisette 14 variable-speed rotor mill (Fritsch, Idar-Oberstein, Germany) and sieved through a 106 μm screen. A noodle powder sample (0.5 g, dwb) was added to 15 ml of distilled water in a centrifuge tube, then vigorously mixed with a vortex mixer before placing in a shaker at 30 °C for 30 min. After centrifugation at 1127×g for 15 min, the supernatant was carefully removed and the sediment was weighed.

$$\text{Water absorption index (WAI, g/g)} = \frac{\text{wet sediment weight}}{\text{dry sample weight}}$$

2.3.2. Cooking quality analysis

Cooking time of noodles was determined according to the AACC (1995) method for spaghetti, with a slight modification. Dried rice noodles (5 g) were cut into 5-cm lengths and cooked in 200 ml boiling distilled water in a covered beaker. Optimum cooking time was determined by removing a piece of noodle every 30 s and pressing the cooked noodle between two glass slides until the white, hard core of the noodle strand disappeared. At least five measurements were performed for each sample.

Cooking weight and cooking loss of starch noodles were measured according to the AACC method (1995), with a slight modification. At least five replications were done for each measurement. Dried rice noodles (1.0 g) were cut into small pieces (3–5 cm in length) and boiled in 30 ml water until completely cooked. The cooked noodles were then filtered through a nylon screen, rinsed with distilled water, drained for 1 min, and immediately weighed. Cooking weight was determined from the difference between noodle weights before and after cooking, and expressed as the percentage of g cooked noodle/g dried noodle. Cooking loss was determined by evaporating to dryness the cooking water and rinse water in a pre-weighed glass beaker in a hot-air oven at 105 °C, and was expressed as the percentage of solid loss during cooking.

2.3.3. Textural profile analysis

The texture of a 10-cm length of cooked noodle was measured using a texture analyzer (EZTest EZ-S-50N; Shimadzu, Tokyo, Japan) equipped with a pair of noodle elongation jigs (No. 17; Shimadzu). A 15 N load cell was applied to measure the tensile strength of noodles at an elongation speed of 60 mm/min. The initial distance between clamps was set at 10.0 cm. From the force–displacement curve (mm), measurements of tensile stress (N/mm^2; Pa) and elongation (%) were generated using the texture analysis software (Trapezium 2 version 2.24). At least 15 strands of noodles were measured for each sample.

2.3.4. Total dietary fiber (TDF) analysis

TDF content of rice noodles was measured using a TDF assay kit (Megazyme International Ireland, Wicklow, Ireland), following AOAC method 985.29 (AOAC, 2000). Dried noodles were cut into