LWT - Food Science and Technology 63 (2015) 122–128

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

In vitro starch digestibility of noodles with various cereal flours and hydrocolloids

Hye Lim Jang [a], In Young Bae [b, *], Hyeon Gyu Lee [a, **]

[a] Department of Food and Nutrition, Hanyang University, 17 Haengdang-dong, Seongdong-gu, Seoul 133-791, Republic of Korea
[b] Department of Food Fermentation, Far East University, Gamgok, Eumseong, Chungbuk 369-700, Republic of Korea

A R T I C L E I N F O

Article history:
Received 27 November 2014
Received in revised form
27 February 2015
Accepted 10 March 2015
Available online 18 March 2015

Keywords:
Cereal flour
Hydrocolloid
Noodle
In vitro starch digestibility

A B S T R A C T

The effects of hydrocolloid type (guar gum, sodium alginate, xanthan gum) and addition levels (0%, 2%, 4%) on the retardation of *in vitro* starch digestibility were investigated in noodles made by various cereal flours (wheat, whole wheat, buckwheat) and their cooking and textural qualities were evaluated. The predicted GI (pGI) of noodles made by wheat or whole wheat flour was significantly decreased by adding hydrocolloids. However, the pGI of buckwheat flour-based noodles with hydrocolloids was slightly increased. Nonetheless, adding hydrocolloids in all noodles positively modified cooking quality regardless of flour type. The hydrocolloids addition in wheat flour-based noodles produced noodles with improved cooking quality and a texture similar to control noodle while still providing reduced starch hydrolysis and pGI. Thus, the nature of flours, the levels and type of hydrocolloids, and their appropriate combination can be used to control *in vitro* starch digestibility and noodle quality.

1. Introduction

Hydrocolloids, which are classified as either thickening or gelling agents, can be added to foods for improving the stability and texture of foods (Chung, Liu, & Lim, 2007). Their high polymeric nature and the interactions among polymer chains results in the improvement of mouth feel and viscosity when they are dissolved or dispersed in food systems (Yaseen, Herald, Aramouni, & Alavi, 2005). In particular, the rheological and pasting properties of starches can be modified by the combination of hydrocolloids (Bárcenas, 2009; Lazaridou, Duta, Papageorgiou, Belc, & Biliaderis, 2007). Moreover, several hydrocolloids retard the starch digestibility in human upper intestines, thus providing health benefits as dietary fibers due to their high water solubility and inhibitory effects against digestive enzymes (Chung et al., 2007). The change of starch digestive pattern in the presence of hydrocolloids has been reported in cooked white rice made with hydrocolloids (Chung et al., 2007), rice dough with alginate (Koh, Kasapis, Lim, & Foo, 2009), and cooked potatoes with guar gum (Bordoloi, Singh, & Kaur, 2012). However, xanthan gum significantly increased the starch hydrolysis in corn and potato starches (Gularte & Rosell, 2011). Although the impact of hydrocolloids on starch hydrolysis varied depending on the starch origin and food type, there is less information on the comparison of starch digestive behavior by flour source, starch origin, and hydrocolloid type and level in a real food model.

Noodles, one of the main carbohydrate-based foods, are the major source of wheat products in the Asian diet and almost 40% of wheat cultivated in Asia is consumed in the form of a noodle (Janto, Pipatsattayanuwong, Kruk, Hou, & McDaniel, 1998). The presence of hydrocolloids increases the eating experience by improving hardness, cutting force, gumminess, and chewiness in noodle-making (Lim & Hwang, 1999). In addition, rice noodles in the presence of hydrocolloids showed improved properties in appearance, textural profile, and starch digestibility (Koh et al., 2009). The glycemic index (GI) is a measure of how quickly blood glucose levels rise after eating a particular type of food. Generally, whole grain foods are classified as being in the low GI group, whereas refined grains belong in the high GI group. Bae, Lee, Ko, and Lee (2013) confirmed these facts by showing that the flours from buckwheat and whole wheat were more effective than wheat flour at lowering starch hydrolysis in paste and cakes under *in vitro* starch digestion. GI values of food models can vary in accordance with the raw materials used as a starch source and can be lowered by the presence of hydrocolloids in food-processing (Gularte &

* Corresponding author. Tel.: +82 43 880 3160; fax: +82 43 879 3730.
** Corresponding author. Tel.: +82 2 2220 1202; fax: +82 2 2281 8285.
E-mail addresses: iybae@kdu.ac.kr (I.Y. Bae), hyeonlee@hanyang.ac.kr (H.G. Lee).

http://dx.doi.org/10.1016/j.lwt.2015.03.029
0023-6438/

Rosell, 2011). Although hydrocolloids are valuable for making healthier noodles and have the appropriate qualities to serve as functional ingredients in the noodle making process, there is scarce systematic information about the impact of their interaction in starch-hydrocolloid blends.

Therefore, the retardation of starch digestibility in noodles made by three different flours from cereals (wheat, whole wheat, and buckwheat) was investigated depending on the type and levels of hydrocolloids (guar gum, sodium alginate, xanthan gum; 2% and 4%). In addition, the cooking and textural qualities of the noodles were evaluated as a function of the nature of flours and the levels and type of hydrocolloids.

2. Materials and methods

2.1. Materials

All-purpose wheat flour and granulated salt were obtained from CJ Co. (Seoul, Korea). Whole wheat flour was purchased from the backse-mil agricultural association (Dae-gu, Korea). Buckwheat flour was purchased from the chung-bori agricultural association (Go-chang, Korea). Alginic acid sodium salt from brown algae (A-2158, low viscosity), guar gum (9000-30-0), and xanthan gum (11138-66-2), which are widely known for improving noodle quality, were obtained from Sigma–Aldrich (St. Louis, MO, USA). Pancreatin from porcine pancreas (P7545, activity 8XUSP/g) and amyloglucosidase (A9913) were obtained from Sigma–Aldrich (St. Louis, MO, USA). The total starch assay kit (K-TSTA) and glucose oxidase-peroxidase assay kit (GOPOD, K-GLUC) were purchased from Megazyme International Ireland Ltd. (Bray, Ireland).

2.2. Water hydration property

The hydration properties of flour-hydrocolloid mixtures were investigated according to the modified method of Lee and Inglett (2006). The hydration properties were determined by mixing three flours with each of the hydrocolloids at two levels (2% and 4%), and the hydration properties of the flours were also assessed in the absence of hydrocolloid. After mixing each sample (0.25 g), the sample was suspended in 10 mL distilled water and left to rest at room temperature for 30 min before centrifuging (718 × *g*, 30 min). The supernatant was then dried in a 105 °C oven until a constant weight was reached and the residue was weighed.

$$\text{Water absorption index (WAI)} = \frac{\textit{Wet sediment weight}}{\textit{Dry sample weight}}$$

$$\text{Water solubility (WS)} = \frac{\text{Dry supernatant weight}}{\textit{Dry sample weight}} \times 100$$

$$\text{Swelling power (SP)} = \frac{\textit{Wet sediment weight}}{\textit{Dry sample weight}} \times \frac{1 - WS(\%)}{100}$$

2.3. Noodle preparation

The noodles were prepared following the methods described by Yoo, Kim, Yoo, Inglett, and Lee (2012). The noodle formulation consisted of 30 g of flour (wheat flour, whole wheat flour, or buck wheat flour), 0.6 g of salt (2% based on flour weight) (CJ Co. Ltd., Seoul, Korea), and distilled water. Three kinds of hydrocolloids were added to each of the three flours at the levels of 2% and 4%, based on flour weight. Control samples included no hydrocolloids. Water levels of the noodle formulations including wheat flour, whole wheat flour, and buckwheat flour were 12.0, 16.5, and 16.5 mL, respectively. These ratios were based on knowledge that noodle sheets are properly formed if the water level is at least 55% (Cheigh, Ryu, & Kwon, 1976; Park & Baik, 2002). All ingredients were mixed at speed 1 for 2 min with scraping down every minute by a Kitchen Aid food processor (St. Joseph, MI, USA), followed by hand kneading for 2 min. The dough was sheeted by a sheeting roller (1.5 mm gap) and cut into noodle strands (4 mm × 10 cm) by a noodle-making machine (Bestknife, China). Then, the noodles were dried by air for 24 h.

2.4. Cooking property

The cooking properties of noodles were determined as described in the AACC-approved method (AACC, 1976). Noodles (10 g) were added to boiling water (500 mL). After boiling for 10 min, the cooked noodles were left to stand for 5 min to drain and were then weighed. For drying the noodles, cooked noodles were kept at 40 °C overnight. The cooking water (10 mL) was put into an aluminum dish and dried to a constant weight in a 105 °C oven. The cooking loss was expressed as a percentage of solid loss during cooking. In addition, the turbidity of the collected water was measured at 675 nm. Noodle samples were prepared in duplicate. Cooking loss (%), water absorption (%), and swelling index were calculated as follows.

$$\text{Cooking loss (\%)} = \frac{\textit{Weight of dried residue in cooking water}}{\textit{weight of raw noodles}} \times 100$$

$$\text{Water absorption (\%)} = \frac{(\textit{Weight of cooked noodles} - \textit{weight of raw noodles})}{\textit{weight of raw noodles}} \times 100$$

$$\text{Swelling index} = \frac{(\text{Weight of cooked noodles} - \text{weight of cooked noodles after drying})}{\textit{Weight of cooked noodles after drying}}$$