Journal of Food Science and Agricultural Technology (2019) 5 (Spcl. Iss.): 55-60

Journal of Food Science and Agricultural Technology

International peer-reviewed scientific online journal

Published online: http://rs.mfu.ac.th/ojs/index.php/jfat

Original Research Article

Effect of sheet forming method on the qualities of gluten-free rice wonton sheet

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ARTICLE INFO

Article history:

Received 31 July 2018

Received in revised form 31 December 2018

Accepted 08 January 2019

Keywords:

Rice flour

Wonton sheet

Gluten free

Texture

ABSTRACT

Wonton sheet is square yellow thin sheet made from wheat flour, alkaline salt (eg. Na_2CO_3 and K_2CO_3), salt (NaCl) and water. Wonton sheet is usually used to wrap meat filling and it is cooked by either boiling, frying or steaming. However, gluten protein from wheat flour in wonton sheet is harmful to coeliac disease patients. Rice is one of the most appropriate cereal grain for producing gluten-free products. However, rice flour is lack of gluten, so the rice dough could not be formed by normal method like wheat flour. This research aimed to study effect of wonton sheet forming methods on physical properties, cooking properties, and frying properties of gluten free rice wonton sheet. Chai Nat 1 (CN1) rice flour was used as raw material. Two sheet forming methods were compared in this work. First, rice flour slurry with high water content was steamed in flat tray to form a thin rice wonton sheet. The other method is to knead gelatinized rice dough with ungelatinization rice flour, and then sheet into thin wonton sheet. Raw wanton sheet made by steaming rice slurry method was more suitable to wrap the filling than that of kneading and sheeting method. However, wonton sheet formed by steaming rice slurry method was broken after boiling. In contrast, wonton sheet formed by kneading and sheeting method had good cooking quality with low cooking loss (5.55±0.77%). Elongation (%) of boiled wonton sheet formed by kneading and sheeting method was significantly lower than that of commercial wonton sheet ($p \leq 0.05$). Total oil content (%) of fried rice wonton sheets from both methods were lower than that of commercial sample. It can be concluded that the kneading and sheeting method is more suitable to produce the gluten-free wonton sheet than steaming rice slurry method, and the kneading and sheeting method should be used for producing no filling fried wonton.

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Published by School of Agro-Industry, Mae Fah Luang University

ISSN: 2408-1736

INTRODUCTION

Wonton sheet is square yellowish sheet made from wheat flour, salt and alkaline salt. Wonton sheet is usually used to wrap meat filling and it is cooked by either boiling, frying or steaming. Good properties of raw wonton sheet should be thin, flexible for wrapping the filling and yellowish. However, gluten protein from wheat flour, containing in wonton sheet, is harmful to coeliac disease patients. Nowadays, number of coeliac disease or gluten intolerance patients have been increased. The celiac disease patient should avoid to eat food containing gluten.

Rice is one of the most cereal which is suitable for making gluten free products due to its naturally gluten-free and bland taste. However, since rice is lack of gluten, it could not be formed a dough by normal method as wheat flour. Several researches reported on the use of hydrocolloids, emulsifiers, non-gluten proteins, to improve process and qualities of gluten-free product (Yalcin and Basman, 2008; Kim et al. 2014). However, the use of those food additives is unpreferable by consumer. Thus, the use of special method to produce gluten free products were reported. Yalcin and Basman (2008) mixed the gelatinized flour with ungelatinized flour to create the rice noodle. Marti and Pagani (2013) used extrusion-cooking process to produce gluten-free pasta. The steaming rice slurry method was used to produce rice noodles (Hormdok & Noomhorm, 2007 ; Sangpring et al, 2015 ; Klinmalai et al, 2017). Unfortunately, there is no report on the suitable method to produce gluten-free rice wonton without the use of food additives. Therefore, this work aimed to study the effect of sheet forming method on the qualities of gluten free rice wonton sheet in order to find the suitable method to form the rice wonton sheet. Two sheet forming methods, namely, steaming rice slurry, and kneading and sheeting method, were compared. The commercial wheat wonton sheet was used as control. The suitable wonton sheet forming method which gave a comparable qualities of raw, boiled and fried rice wonton sheet to the commercial wonton sheet was selected.

MATERIALS AND METHODS

Materials

High amylose rice grain (Chai Nat 1 cultivar) which was received from Nakhon Ratchasima rice research center, Thailand, was used in this work. The rice grains were soaked in water for 14 h and then wet milled according to method of Sangpring et al, (2015). Rice flour was sieved through a 0.150 mm sieve, and then it was packed in polyethylene bags and kept at -18°C until use.

Preparation of rice wonton sheet

Steaming rice slurry wonton sheets were prepared as follows. Rice flour was mixed with distilled water and adjusted to 64% moisture content (wet basis). Sodium chloride and sodium carbonate were added to rice flour slurry at 1.5 g / 100 g flour and 1 g / 100 g flour, respectively. The slurry were poured onto a stainless tray and then it was steamed at 100°C. The tray with the wonton sheet was cooled at room temperature and the sheet was removed from the tray and cut into 7.62 cm×7.62 cm pieces. A thickness of each wonton sheet was 0.65±0.05 mm.

Kneading and sheeting rice wonton sheets were prepared by mixing the gelatinized rice flour with the ungelatinized part at the ratio of 1:1 as follows. The gelatinized rice dough was prepared by mixing rice flour with distilled water and adjusted its moisture content to 55% wet basis. Sodium chloride (1.5 g / 100 g flour) and sodium carbonate (1 g/100 g flour) were added to the dough, then it was steamed. The gelatinized dough was mixed with the ungelatinized flour using pasta making machine (Marcato, Italy). A thickness of sheet was 0.65±0.05 mm and the sheet was cut into 7.62 cm ×7.62 cm pieces.

Moisture content measurement

Moisture content of all wonton samples were measured using hot air oven according to the method of AOAC standard methods (2000) at 105°C to gain a constant weight. Measurements were conducted at least in triplicate.

Cooking time

Optimum cooking time of wonton sheets were determined according to AACC standard methods No. 66-50 (1999). Raw wonton sheet was boiled in distilled water at 100°C. Optimum cooking time is the time when the white centre just disappears.

Cooking loss

Cooking loss was determined according to AACC standard methods No. 66-50 (1999). Raw wonton sheet was cooked until its optimum cooking time. The boiled water was collected and dried at 105°C to gain a constant weight. Cooking loss was calculated based on weight of raw wonton sheet according to Eq. (1).

$$\text{Cooking loss (\%)} = \frac{\text{Weight of dry matter in boiling water}}{\text{Weight of raw wonton sheet}} \times 100 \qquad (1)$$

Textural properties

Textural properties of raw, boiled, and fried wonton sheet were measured with texture analyzer (TA. XT PLUS, Stable Micro Systems, UK). The firmness and extensibility of raw wonton sheet were measured immediately after forming. For tensile test, wonton sheet was cut into 1 cm×15 cm strands. The wonton strand was wounded around parallel rollers for spaghetti noodle testing rig (A/SPR). The maximum force (g) and distance at break were determined at a test speed of 3 mm/sec according to Potisate (2005). At least, 10 raw wonton strands were measured for a replicate. This experiment was done in triplicate. The elongation at break (%) was calculated according to Eq. (2).

$$\text{Elongation (\%)} = \frac{\text{Distance at break}}{\text{Initial distance of wonton sheet strand}} \times 100 \qquad (2)$$

Firmness of raw wonton sheet was measured following the method of AACC 16-50 (AACC, 1999). A wonton sheet (4 cm×4 cm) was placed on plastic state. A light knife blade (A/LKB) probe was set up perpendicular to the wonton sheet. The maximum force was determined at a pre-test speed of 1 mm/sec, a test speed 0.2 mm/sec, and 70% strain. At least, 10 raw wonton sheets were measured for a replicate.

The boiled samples were prepared as follows. The raw wonton sheet was cut into 1 cm×15 cm strands for tensile test and 4 cm × 4 cm pieces for firmness test. They were boiled at 100°C at their optimum cooking time. Tensile and firmness test of boiled wonton sheet were measured according to the methods mentioned above.

Stickiness of boiled wonton sheet was measured according to Martinez et al, (2007) with pasta firmness stickiness HDP/PFS rig.

Raw wonton sheet samples were cut into 5 cm×5 cm pieces and boiled at its optimum time. The maximum force (N) was determined at a pre-test speed 0.5 mm/s, test speed 0.5 mm/s, post-test speed 10 mm/s, compression force 49.03 N, compression time 3 s, and return to distance 10.0 mm. At least, 10 boiled wonton sheets were measured for a replicate.

The fried wonton sheets were prepared as follows. Raw wonton sheets (7.62 cm×7.62 cm) were fried at 180°C for 1 min. They were cooled at room temperature for 30 s then blotted by tissue paper for 15 s per side. The fried wonton sheet was placed on the sample holder (hollow cylinder) equipped with a Crisp Fracture Rig (HDP/CFS) with ¼" rounded end probe. Hardness (N) and Crispness (Number of peaks) of fried wonton were determined at a pre-test speed 1.0 mm/s, test speed 1.0 mm/s, and post-test speed 10.0 mm/s according to guidance of Stable Micro System. At least, 10 fried wonton sheets were measured for a replicate.

Total oil content

Fifteen fried wonton sheets were mashed into small pieces (less than 2 cm× 2 cm) by rolling pin in plastic bag. The total oil content of fried mashed wonton sheets was measured using Soxtex (1043 Extraction Unit, Tecator, Sweden) according to the modified method of AACC standard methods 35-25 (1999).

Statistical analysis

Data were expressed as means ± standard deviation. Mean values were compared by variance (ANOVA). Differences among treatments were detected with the SPSS software (version 12.0 for Window) using Duncan's multiple range tests (p≤0.05).

RESULTS AND DISCUSSION

Raw wonton sheet

Both rice forming methods, namely steaming rice slurry and kneading and sheeting method, were able to form rice wonton sheet. However, the wonton sheet made by steaming rice slurry method was transparence and had pale color. This may be because its high moisture content. In contrast, the appearance of kneading and sheeting raw rice wonton sheet was close to the commercial wheat wonton.

Firmness of raw kneading and sheeting rice wonton sheet was the highest among samples (Table 1). This may be because the gelatinized rice dough was not elastic and soft as gluten in wheat flour.

Moreover, the microstructure of kneading and sheeting wonton sheet was dense and rigid (data not shown). This coincided with the result of Jitrakbumrung and Therdthai (2014) which reported that hardness of rice flour bread was higher than wheat flour bread. In contrast, firmness of steaming slurry rice flour wonton sheet was the lowest. This may be attributed to its highest moisture content.

Elongation (%) of all wonton sheet were not significantly difference (p>0.05). This means that the extensibility of rice flour wonton sheets were comparable to the commercial wheat wonton. However, the kneading and sheeting raw rice wonton had numbers of crack on the sheet after folding. It may be because of its rigid packing microstructure. On the other hand, the steaming rice slurry wonton sheet had less numbers of crack on sheet after folding. It may be because of the strong formation of amylose network.

Boiled wonton sheet

Since a steaming rice slurry wonton sheet was broken to several pieces during boiled (Fig 1e), it can not be measured their properties after boiling.

Cooking time of a kneading and sheeting rice wonton sheet was longer than a commercial wonton sheet (Table 2). This may be because wheat starch had lower pasting temperature than rice flour (Martínez and Gómez, 2017). Cooking loss is usually defined as the mass of solids to cooking water during boiling (Kruger et al, 1998). High cooking loss is undesirable as it represents high solubility of starch, resulting in turbid cooking water, low cooking tolerance, and sticky mouthfeel (Bhattachaya et al, 1999). The cooking loss of kneading and sheeting wonton was less than 10% and it was non significant difference from the commercial wheat wonton (p>0.05) (Table 2). This indicated that the rice wonton sheet made from kneading and sheeting method had comparable cooking properties to the commercial wheat wonton.

Boiling decreased firmness and tensile strength but increased elongation of all wonton sheets. This means that the wonton sheet became softer and flexible after boiling. Elongation of a boiled kneading and sheeting rice wonton sheet was lower than wheat wonton because rice flour wonton has no gluten. The boiled kneading and sheeting wonton sheet had a higher firmness and tensile strength than commercial wheat flour. This is similar to results of raw wonton sheets (Table 2).

Table 1. Moisture content and textural properties of raw wonton sheets

samples	Moisture content (%)	Tensile strength (kPa)	Elongation (%) ^{ns}	Firmness (kPa)
Steaming rice slurry	58.05 ±0.09a	34.93 ± 3.56c	48.02 ± 2.92	255.43 ± 3.73c
Kneading and sheeting	33.51±0.31b	237.78 ± 15.18a	46.05 ± 1.00	1342.87 ± 98.12a
Commercial wheat wonton	32.47 ±0.49c	73.27 ± 1.17b	46.15 ± 3.33	471.57 ± 43.07b

a,b,c values followed by the different letter in the same column are significantly different (p≤0.05).
ns = non-significant

Table 2. Moisture content of boiled wonton sheets

samples	Moisture content (%) ^{ns}	Cooking time (mm)	Cooking loss (%) ^{ns}
Kneading and sheeting	66.15±1.30	2.33±0.29a	5.55±0.77
Commercial wheat wonton	68.59±1.33	1.33±0.29b	6.02±0.73

a,b,c values followed by the different letter in the same column are significantly different (p≤0.05)
ns = non-significant

Table 3. Textural properties of boiled wonton sheets

samples	Tensile strength (kPa)	Elongation (%)	Firmness (kPa)	Stickiness (kPa)
Kneading and sheeting	166.44 ± 10.63a	50.80±4.34b	169.48 ± 1.54a	39.12 ±3.62b
Commercial wheat wonton	42.74 ± 0.69b	64.79±2.29a	117.51 ± 1.95b	378.58 ± 31.69a

a,b,c values followed by the different letter in the same column are significantly different (p≤0.05)

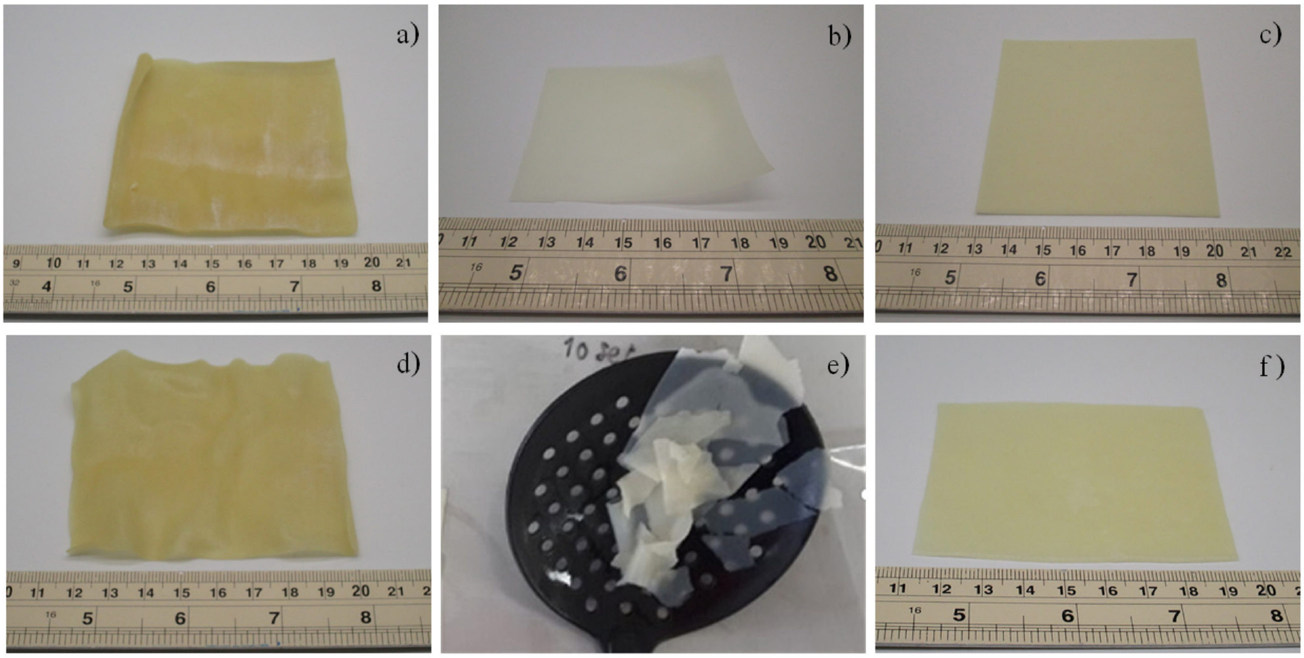

Figure 1. Appearance of raw and boiled wonton sheets. a) raw commercial wheat wonton sheet ; b) raw steaming rice slurry wonton sheet ; c) raw kneading and sheeting rice wonton sheet ; d) boiled commercial wheat wonton sheet ; e) boiled steaming rice slurry wonton sheet ; f) boiled kneading and sheeting rice wonton sheet

Table 4. Moisture content and total oil content of fried wonton sheets

samples	Moisture content (%)	Total oil content (%)
Steaming rice slurry	6.11 ± 0.48a	26.35 ± 3.48b
Kneading and sheeting	3.27 ± 0.26b	27.71 ± 1.37b
Commercial wheat wonton	2.72 ± 0.65b	43.07 ± 1.670a

a,b,c values followed by the different letter in the same column are significantly different (p≤0.05)

Fried wonton sheet

Fried steaming rice slurry wonton sheet had the highest moisture content (Table 4). This related with its highest initial moisture content of raw wonton sheet (Table 1). Chen and Moreila (1997) reported that the difference initial moisture content of raw tortilla chips affected on moisture content of final product after frying at 180°C less than 50 s.

The stereomicrographs of fried rice wonton sheets showed that the structure of both fried rice wonton samples were dense and rigid (Fig 2b, 2c), and amount of bubbles were less than commercial wheat sample (Fig 2a). This may be because the rigid structure of high amylose rice flour wonton suppressed the formation of bubbles during frying. Since the steaming rice slurry wonton sheet had more dense structure than that made from kneading and sheeting method, there were lots of small bubbles inside the wonton sheet, while there were large bubbles in the wonton sheet made from kneading and sheeting method. Therefore, the appearance of kneading and sheeting fried rice wonton sheet was close to the commercial wheat wonton than that made by steaming rice slurry method. The inside of bubbles of commercial wheat sample contained lots of oil droplet. This related with the higher total oil content of wheat fried wonton than that made from rice flour (Table 4). The lower oil content of rice wonton sheet may relate with their lower amount of bubbles. This coincided with the result of Nakamura and Ohtsubo (2010) that the high amylose rice flour had lower total oil content than low amylose rice flour, waxy rice flour, and wheat flour batter.

Fried steaming rice slurry wonton sheet had the lowest hardness and crispiness (Fig 3). This may be attributed to its high moisture content (Table 4). Fried kneading and sheeting rice wonton had hardness and crispiness values more than the fried commercial wheat flour wonton sheet. This is consistent well with the sensory result of fried tempura batter from high amylose rice flour which had higher crispness than low amylose rice flour and wheat flour (Nakamura and Ohtsubo, 2010).

CONCLUSION

Boiled wonton sheet made from kneading and sheeting method had good cooking quality and its total oil content (%) of fried rice wonton sheet was lower than that of commercial sample. Therefore, the kneading and sheeting method was more suitable to produce the gluten-free wonton sheet than the steaming rice slurry method. However, the kneading and sheeting method developed in this work may be used only for producing no filling fried rice wonton sheet because the raw wonton sheet still had numbers of crack after folding. In order to use this wonton sheet for wrapping, the further study on improvement of its wrapping ability is necessary.

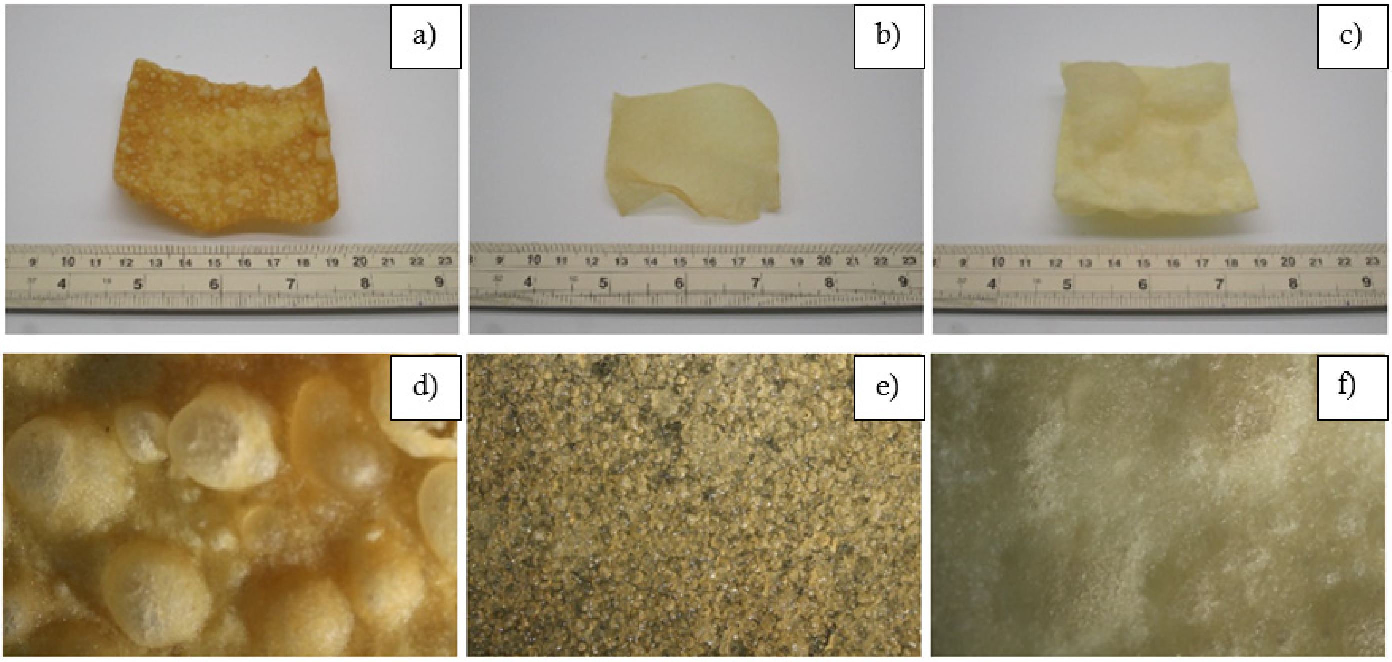

Figure 2. Appearance and Stereomicrographs of fried wonton sheets. Appearance : a) commercial wheat wonton sheet ; b) steaming rice slurry wonton sheet ; c) kneading and sheeting rice wonton sheet. Stereomicrograph (10x) : d) commercial wheat wonton sheet ; e) steaming rice slurry wonton sheet ; f) kneading and sheeting rice wonton sheet

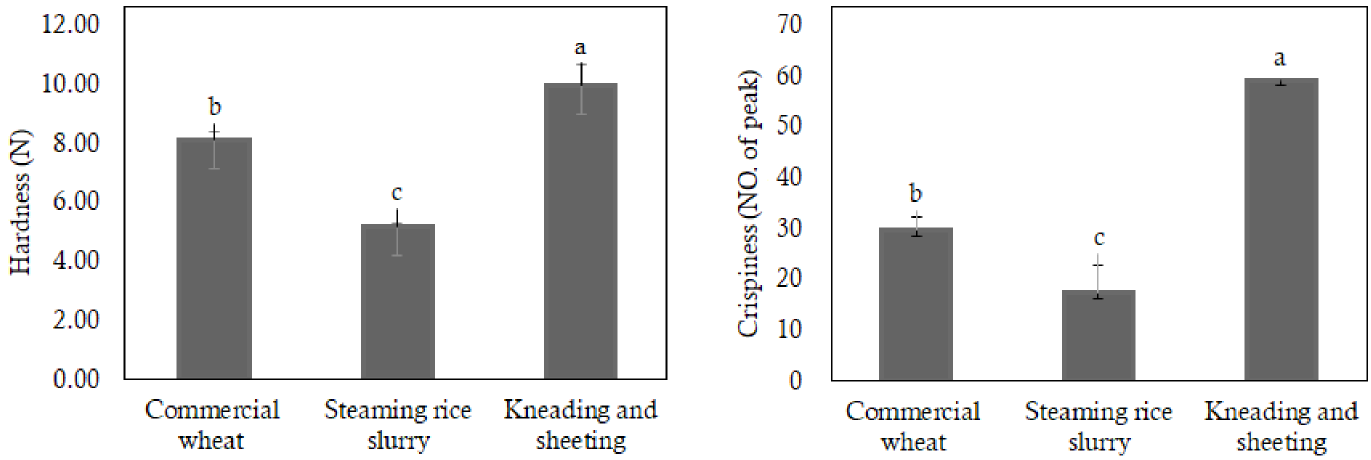

Figure 3. Figure 3. Hardness and cripiness of fried wonton sheets

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