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The Stickiness of Fresh Noodle after Steaming Process

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Abstract. This research aims to study stickiness of fresh noodles after steaming process. The experimental procedures started with studying gelatinization, glass transition and surface characteristics of the fresh noodles after steaming for 0, 3, 5, 10, 15, 20, 30, 60 and 90 min. Then, temperatures of the fresh noodle were determined. Finally, force that was required to separate fresh noodles strips were investigated. Results showed that the fresh noodles were in rubbery state after steaming for less than 3 min. Moreover, after the steaming, gelatinization of the fresh noodle was not presented. Surfaces of the fresh noodles strips were not locked together after being placed in the overlap. The separation force of the fresh noodles strips was decreased with an increase of time after steaming. The separation force of the fresh noodles strips was the highest when the state of the fresh noodle was rubbery.

1. Introduction

Noodles are one of the staple foods in many Asian countries [1]. After rice, noodles are considered a popular consumable food [2, 3] due to its appealing flavours and readily available for purchasing. At present, there are many types of noodles, depending on manufacturing formulations, shapes, and processes [1, 4]. Fresh noodles are one of the favourite noodles due to their flavour, texture, and nutritional properties [5, 6]. Production of the fresh noodles starts with mixing starch to obtain slurry and steaming to form noodle [1, 7]. To prevent stickiness of the noodles, oil is used to coat the noodles before placing the noodle overlap. Then the noodles are cooled down and cut into the noodle strips according to the required sizes. Although, oiling step of the noodle production process is useful to prevent stickiness of the noodle strips [1], but the oiling has negative effect on consumer's long term heath. Therefore, understanding the stickiness mechanisms of the fresh noodles after steaming process would be beneficial as the anticipated results will secure appropriate approaches to the reduction of the coating oil usage in the production process.

Nowadays, many mechanisms such as liquid bridging, solid bridging, and micro-mechanical interlocking are reported as the likely causes of the stickiness originated in amorphous materials such as starch and sugar [8, 9, 10, 11]. Liquid and solid bridging are related with phase transition of the amorphous material. When glass transition is generated, state of the material changes from glassy to rubbery, the surface of the amorphous material becomes sticky. When the amorphous materials banded together, liquid bridge is then found between the amorphous materials [9, 11]. As for solid bridging, solid bridge is found when the materials is melting or approaching gelatinization [11, 12, 13]. Some solid materials are dissolved internally until reaching external surface of the material and forms solid bridges between pieces of such materials. In case of micro-mechanical interlocking, this process is found when the surface of the materials become rough. Consequently, the rough surface can become locked together [14, 15].

At present, understanding of the stickiness mechanism of the fresh noodle remains limited. Therefore, this research was purposed to study the stickiness mechanisms of the fresh noodles after steaming. Glass transition, gelatinization and surface characteristic of the fresh noodles after steaming were also investigated. Subsequently, force used for the separation of the fresh noodles strips was evaluated. The relations between the stickiness mechanisms (glass transition, gelatinization and surface characteristic) and the separation force of the fresh noodles strips were studied in order to establish the possible stickiness mechanism of the fresh noodles.

2. Material and Methods

2.1. Noodle preparation
Fresh noodle production processes started by mixing 28 g of rice starch, 12 g of cassava starch and 60 g of water together. Then, 80 g of starch slurry was pour into a 12 × 12 inch tray and then steamed at a temperature of 100^{o}C for 2 min. The thickness of the fresh noodle was 0.8 mm.

2.2. Experimental procedures
To investigate the stickiness mechanisms of the fresh noodles, glass transition and gelatinization of the fresh noodles after steaming were determined. Moreover, surface characteristics of fresh noodle after steaming were studied to ascertain the micro-mechanical interlocking between the fresh noodle strips.

2.2.1. Determination of glass transition and gelatinization temperatures of the fresh noodles. To determine the glass transition and gelatinization temperatures, fresh noodles were suddenly cooled down to a room temperature after steaming for 0, 3, 5, 10, 15, 20, 30, 60 and 90 min. Then, the glass transition and gelatinization temperatures were analysed using DSC (DSC2, Mettler Toledo, Switzerland). The fresh noodle were heated from -50 to 180^{o}C at a heating rate of 10^{o}C/min.

2.2.2. Study of surface characteristics of the fresh noodles. Analysis of the surface characteristics of the fresh noodle was carried out by using optical microscope (HRM-300, Huvitz, Korea). Three visual appearances characteristic including the front, side, and the distance between the fresh noodle strips were investigated.

2.2.3. Measurement of fresh noodle temperatures after steaming. The temperatures of fresh noodles after steaming at cooling time of 0, 3, 5, 10, 15, 20, 30, 60 and 90 min was measured using the thermocouple type K (Omega, U.S.A.).

2.2.4. Determination of separation forces of the fresh noodles strips. The fresh noodles strips that have been left to cool after steaming for 0, 3, 5, 10, 15, 20, 30, 60 and 90 min were placed together in an overlap. To analyze the separation forces of the fresh noodles strips, the texture analyzer (CT3 4500, Brookfield, U.S.A.) was used. TA-NTF probe was used at 2.00 mm/s of speed.

3. Results and Discussions

3.1. The relation between the glass transition and stickiness of fresh noodle after steaming process
The glass transition temperature of the fresh noodle is shown in figure 1. The result revealed that after steaming for more than 3 min glass transition temperatures of the fresh noodle increased with increasing of time after steaming. Normally, water act as a plasticizer. When the moisture content of a material is decreased, glass transition temperature is significantly increased [16, 17]. Therefore, the increasing of

glass transition of the fresh noodle may be perceived as the difference of moisture content of the fresh noodle after steaming. After steaming, the remaining water was evaporated by overheat. Therefore, moisture content of the fresh noodle may be decreased with increasing of time after steaming.

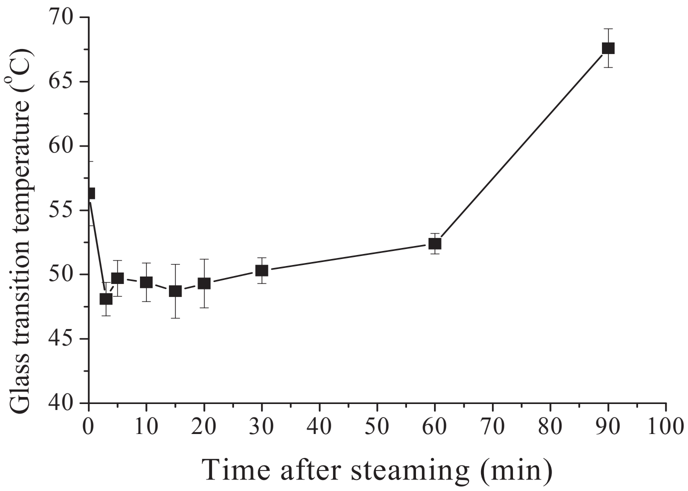

Figure 1. Glass transition temperatures of fresh noodle after steaming process.

The differences between fresh noodle temperature and its glass transition temperature (T_{noodle} - T_g) is showed in figure 2. This value was used to describe the state of the fresh noodle. The positive values indicated that fresh noodle were in the rubbery state, while the negative value indicated that fresh noodles were in the glassy state. Higher negative value state of fresh noodles resulted in a higher glass characteristic [11]. As in figure 2, the result indicated that the fresh noodle was in rubbery state after steaming for less than 3 min and then changed to the glassy state when the time after steaming was increased.

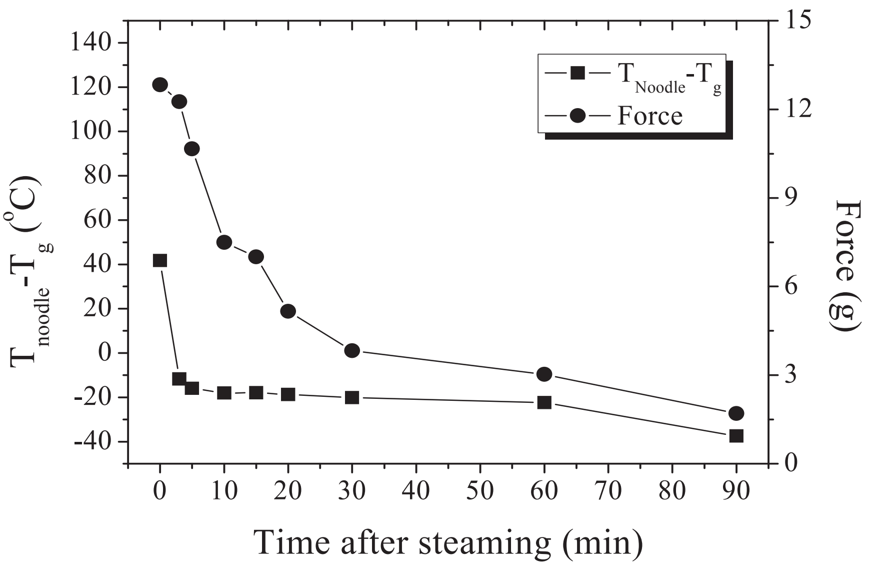

Figure 2. The relations between the difference of noodle and glass transition temperatures and the separation forces of the fresh noodles strips after steaming.

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From figure 2, the results also show that the separation force that was used to separate fresh noodles strips was continuously decreased when the time after steaming was increased. The separation force of the fresh noodles strips after steaming for 0 min was the highest. The results revealed that, at this time, the fresh noodles has the highest stickiness. Upon comparison between the state of fresh noodle and the separation force used to divide the fresh noodles strips, the results appeared to suggest that the fresh noodles were sticky when its state was rubbery or the fresh noodle had low glass characteristics. Therefore, the glass transition and the formation of liquid bridges may be one of the mechanisms that affects the stickiness of the fresh noodle after steaming.

3.2. Gelatinization of fresh noodle after steaming process

For gelatinization temperatures of fresh noodle strips after steaming, the results indicated that the gelatinization temperature cannot be detected under the said measured conditions. This may be due to the fresh noodle were completely gelatinized during the steaming. Therefore, the formation of a solid bridge may not affect the stickiness of fresh noodles.

3.3. Characteristics of fresh noodle strip after steaming

Figure 3 shows the front and side views of the fresh noodle strip and its morphology between two fresh noodle strips at time after steaming for 0 min. The front be viewed in figure 3(A) presented that starch granules could be gelatinized to form swollen granules. This result was found to be in agreement with the results of the gelatinization temperatures in table 1. For the side view in figure 3(B), the surface of the fresh noodle strips appeared to be smooth. Lock together formation were not detected. Moreover, spaces were found between the two fresh noodle strips as per figure 3(C). The results indicated that micro-mechanical interlocking may not be the cause of the stickiness mechanism of the fresh noodle. Only liquid bridges may be found in the spaces between the two fresh noodle strips.

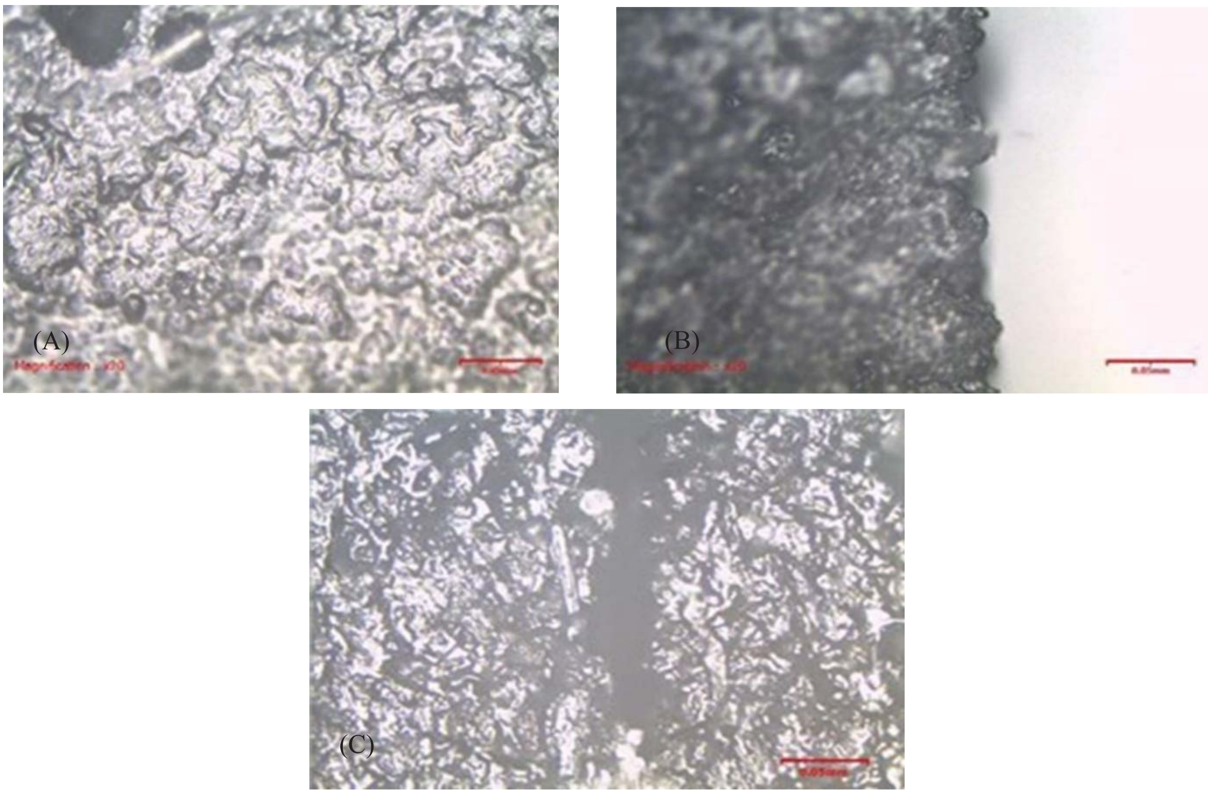

Figure 3. Morphology of fresh noodle strips at time after steaming for 0 min (20x) (A) front view (B) side view (C) between two noodle strips.

4. Conclusion

The experimental results showed that fresh noodle strips may be subjected to gelatinization during the steaming. After the steaming, the fresh noodles were in the rubbery state. When the time after steaming was more than 3 min, the state of the fresh noodle changed from rubbery to glassy state. Moreover, after steaming, the surface of the fresh noodle strips were smooth and could not be locked together. Therefore, the possible stickiness mechanism of the fresh noodles after steaming was due to liquid bridging.

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