A Thesis for the Degree of Master of Science

Effect of heating process on the microstructural properties of instant air-dried noodles

열처리 공정이 인스턴트 건면의

미세 구조적 특성에 미치는 영향

August, 2019

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농학석사학위논문

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지도교수 최영진

이 논문을 석사학위 논문으로 제출함

2019년 8월

서울대학교 대학원 농생명공학부

정 성 훈

정성훈의 석사 학위논문을 인준함

2019년 8월

위원장 최상호 (인)

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ABSTRACT

Instant air-dried noodles have been consumed more and more because of low-fat content. There are few studies on instant air-dried noodles so I did research on. Part 1 investigated how the heating process affected noodle microstructure and noodle properties. When the steam process was applied, the more porous internal structure was formed and the cooking loss was reduced. The super-heated steam process was forming the uneven internal structure and increased the cooking loss. In addition, if the boiling and steaming process were applied in Udon, the adhesiveness becomes very low and it became suitable for the stir-fried noodles.

Instant air-dried noodle has difficulty in rehydration due to the tight internal structure. In part 2, the potato starch has been expected to solve this problem because of the excessive swelling capability of potato starch before forming the gluten network. However, this also prevents from forming noodle structure. Previous studies have attempted to solve this problem by changing the composition ratio of dough. Herein to solve this problem, we adjusted the temperature of dough resting for forming a gluten network without excessive swelling of potato starch. The doughs were rested at different temperatures (4°C, 25°C and 45°C) and then compared the characteristics of each dough and the microstructures of the noodle made with each dough. As a result, doughs rested at 25°C and 45°C were able to form noodle structure without swelling problems. Forming rate of the gluten network was 10 times faster at 45°C than 25°C. And it also showed finer and more stable microstructure. In addition, the rehydration time of instant air-dried potato noodles rested at 45°C was decreased by 30% compared to instant air-dried flour noodles. This finding can be useful for the development of noodles with fewer gluten contents.

Keywords: instant air-dried noodle, protein network, low gluten noodle, dough resting, cooking properties, texture properties

Student Number: 2017-23001

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I. INTRODUCTION

In Asian countries, noodles have been widely consumed. Various noodles have been developed according to the use. Among them, instant noodles are widely consumed because they have long shelf life and convenience for cooking than conventional noodles.

Instant air-dried noodles have novelty on customer due to low lipid contents compare to usual instant fried noodles. Instant noodles have short rehydration time, but instant air-dried noodles have difficulty in rehydration because of its tight internal structure. To solve this problem, Li wang change phosphate salt (Wang, Hou, Hsu, & Zhou, 2011) and Abhijeet Arun Gatade using some oil, guar gum, gluten and 1% Kansui solution (Gatade & Sahoo, 2015). However, few researches have attempted to overcome this by modifying the process.

The main components of noodles are starch and protein (Hou, 2010). There are many characteristic factors with starch and protein, but starch swelling properties and paste viscosity are important factors to improve quality (Crosbie, 1991). Huang et al. (2010) studied the high starch swelling properties directly reducing the optimal cooking time: rehydration time (Y.-C. Huang & Lai, 2010). This factor has differences depending on where the starch originated. Commonly used wheat starch has lower swelling power compare to other cereal starches (Swinkels, 1985). The swelling power of potato starch is more than 50 times of wheat starch so it is expected to solve the long cooking time problem.

However, the high swelling power of potato noodle has a negative effect to noodles. Protein network might be damaged by swelled starch. The protein has positive correlation on noodle firmness, elasticity, and smoothness (B. K. Baik & Lee, 2010; S. Huang & Morrison, 1988). Li-Jun Luo studied that heat treatment processes such as steaming can help to form protein networks (Luo, Guo, & Zhu, 2015). Therefore, the disadvantages of air-dried noodles can be overcome by using a dough resting process that is weaker than steaming, which is to form a protein network but not to gelatinize the starch.

Ⅱ. MATERIAL AND METHODS

2.1. Materials

Commercial potato starch was purchased from CJ cheiljedang Co. (Seoul, Korea). Wheat starch was purchased in Tereos-Syral, (Alast, Belgium). Purified salt (>99% sodium chloride) was purchased from Hanju Co. (Ulsan, Korea). Baking soda (99.9% sodium bicarbonate) was obtained from Bread Garden, (Seoul, Korea). Purified wheat gluten was obtained from Roquette Freres SA, (Lestrem, France).

2.2. Potato starch and wheat starch dough preparation

Potato starch and wheat starch was mixed with wheat gluten to 500.0 g of which the addition level was 10%, 7.5%, 5%. The blended powder was mixed with sodium chloride (5.0 g) and sodium bicarbonate (2.5 g) in distilled water (275 g) for 5 min with a rate of 60 rpm by using a Kenwood kitchen machine (KM020, Kenwood Ltd, Havant, UK). The resulted dough was placed in a plastic bag for rest. The resting time was 30, 60, and 90 min at 45°C in a water bath; 30 min at 60°C; 2, 4, and 6 hrs at 25°C; 1, 2, and 3 days at 4°C in the refrigerator. The rested dough was pictured in pressed.

2.3. Oscillatory measurements of potato starch dough

Dynamic rheological tests on a controlled stress rheometer (RheoStress 1, Thermo Scientific™ HAAKE, Karlsruhe, Germany) were conducted using the method described by Kim, Kee, Lee, and Yoo (Kim, Kee, Lee, & Yoo, 2014) with some modifications. The plate diameter was 20 mm and the gap was 3 mm. the rim of the sample was coated with petroleum jelly to prevent water evaporation. Frequency sweep tests were performed from 0.01 to 10 Hz at 30°C to determine the storage modulus (G') and the loss modulus (G'').

2.4. Confocal laser scanning microscopy (CLSM) of potato starch dough

The uncooked dough was cut into strands with the dimensions of 2 x 3 x10 mm (approximately) and was post-stained with a solution of 0.05% (w/w) fluorescein sodium salt and 0.05% rhodamine B in water. Fluorescein sodium salt will preferentially stain starch and rhodamine B will preferentially stain protein. CLSM images, acquired in 1024 x 1024 pixel resolution, were recorded on a Confocal Laser Scanning Microscope (LSM710, Jena, Carl Zeiss Germany). The objective used for all experiments provided a 20 or 40 magnification with a zoom of 10. The samples were sliced with a dissecting blade to create a smooth surface for the CLSM. The excitation/emission wavelengths for fluorescein sodium salt and rhodamine B were 488/518 and 568/625 nm, respectively.

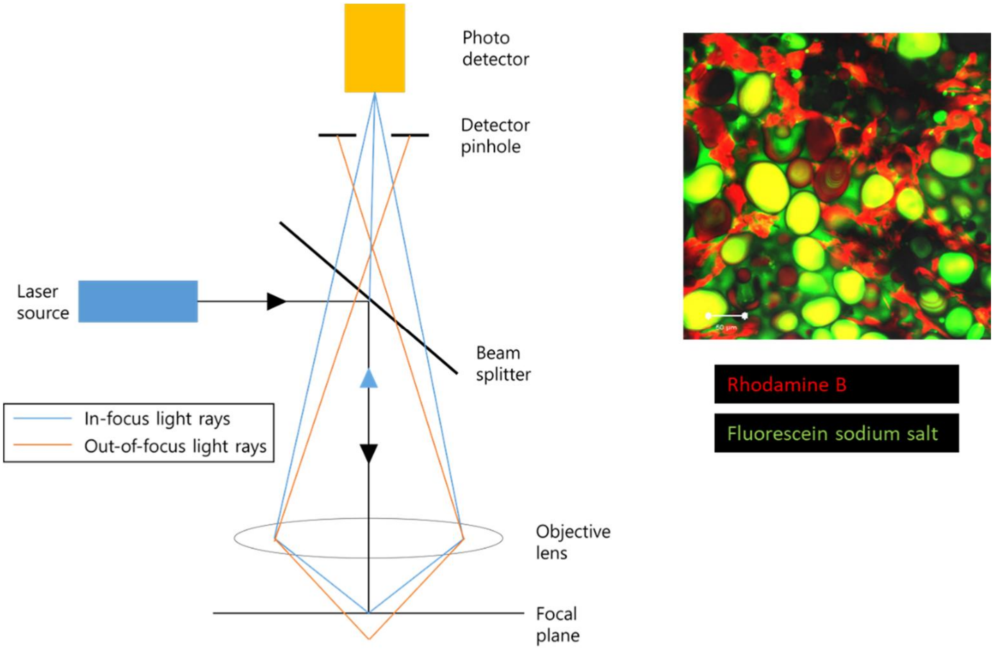


Figure 1. A schematic representation of the confocal laser scanning microscopy.

2.5. Preparation of instant air-dried noodle

In part 1, samples were provided by Pulmuone Corporation (Seoul). The process applied to each sample is shown in Table 1. In part 2, after resting, the potato dough was passed through reduction rolls of noodle machine (Bethel industry, BE-6200, Uijeongbu, Korea) to produce uniform sheet. The roller gap was maintained at 0.2 cm for the last sheeting. The dough sheet was cut into 0.5 × 10 cm (width × length) strands. Noodle strands was steamed in cooker (Daewon home electrics co. Honeymoon, Incheon, Korea) for 5 min and dried in dry oven (Vision sci, VS-1202D2N, Seoul, Korea) at 90°C for 80 min.

Table 1. The heating process of air-dried noodles and Udon

Noodle type	Sample	Steaming (min)	Boiling (min)	Drying		Sterilization (min) at 93°C
				°C	min	
Air-dried	A	-	-	85	8	-
	A’	-	-	115	7	-
	B	6	-	100	10	-
	B’	6	-	130	10	-
Air-semi-dried	S	6	-	85	5	-
	S’	3.25*	-	-	-	-
Udon	U	5	-	-	-	34
	U’	5	7	-	-	34
	U”	-	7	-	-	34

*: Super-heated steam (150°C)

2.6. Size-exclusion high performance liquid chromatography

The protein was extracted according to a modified method of Wagner, Morel, Bonicel, and Cuq (2011). SE-HPLC was performed on a LC system (Shimadzu, Kyoto, Japan). Freeze-dried samples (containing 1.0 mg of proteins) were extracted with 1 mL of a 0.05 mol/L sodium phosphate buffer (pH 7.0) containing 2.0% sodium dodecyl sulphate (SDS). Protein extracts were filtered through a 0.45 mm membrane and loaded on a KW-804 (Showa Denko Co. Tokyo, Japan) size exclusion analytical column (8 mm x 300 mm). The columns were eluted at ambient temperature with 0.05 mol/L sodium phosphate buffer (pH 7.0) containing 2.0% SDS. Chromatography conditions included a flow rate of 0.7 mL/min and temperature of 28°C with protein detection at 214 nm. Degree of networked gluten proteins was calculated from the first peak area and expressed as percentage of the peak area of gluten contents.

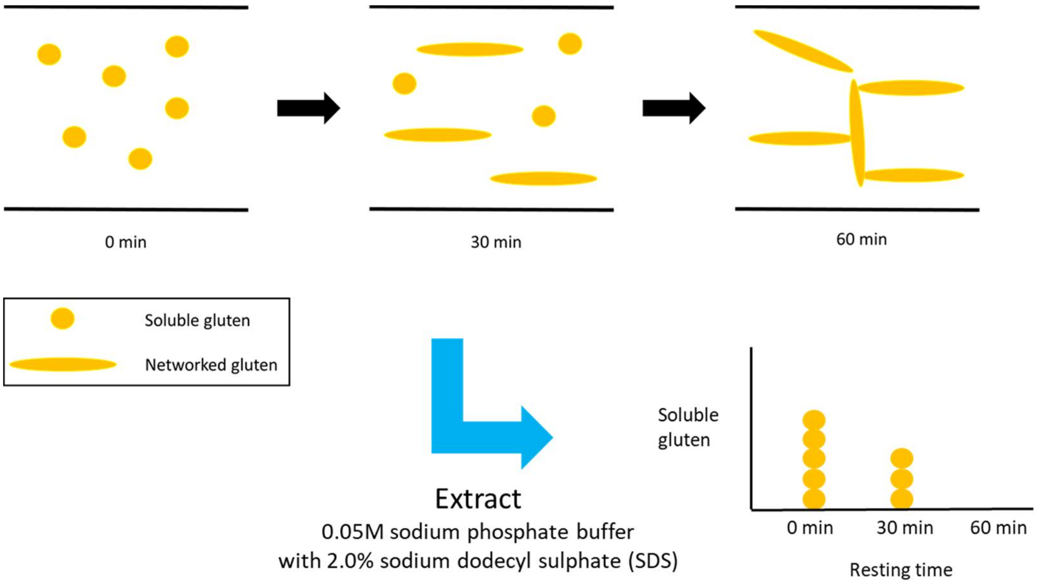


Figure 2. A schematic representation of the high-performance liquid chromatography.

2.7. Scanning electron microscope (SEM)

The samples were freeze dried. Dehydrated samples were coated with platinum particles for 10 min. The images were taken using SEM (Carl Zeiss, SIGMA, UK) at an accelerating voltage of 1.0 kV. The micrographs were taken at 100 and 1000 magnification.

2.8. Cooking property analysis of noodle samples

Cooking time was determined that noodles (2 g) were cooked in water (50 ml) and a strand as removed at 15s intervals and tested by pressing between two microscope slides. The time at which the white core in the strand of noodle disappeared was taken as the optimum cooking time. Cooking loss was determined as described by AACC Method 66-50 (AACC, 2000) with some modification. Cooking water and rinse water was collected in a beaker (pre-dried to constant weight). After that, the beaker was placed into an air oven at 105°C until dryness. The residue was weighed and reported as a percentage of the starting material (calculated by dry basis). At the same time, the heated noodles were removed from the cooking water and drained, and then the weight was evaluated; water absorption was expressed as the mass ratio after and before cooking.

2.9. Texture analysis of noodle samples

Textural properties were measured using a Texture Analyzer (TA-XT2i, Stable Micro Systems, London, UK) after cooking. Measurements were carried out at room temperature exactly 15 min after cooking. The instrument was calibrated using a 5 kg load cell. For TPA analysis, the distance calibration was performed with a return trigger path at 15 mm. Hardness and other values were measured using a 20 mm cylinder aluminum probe and calculated based on texture profile analysis. The settings were: pretest, test and post-test speed, 2.0 mm/s; strain, 75%; interval time, 5 s.

Ⅲ. RESULTS AND DISCUSSION

3.1. Effect of heating process of non-fried noodles

3.1.1. The microstructural properties of instant air-dried noodles

In figure 3, confocal laser scanning microscopy (CLSM) image shows that the starch granules of the sample (B, B') which the steaming process was added are more gelatinization. It can be seen that the green color dyed by fluorescein sodium salt became darker and the shape of the particles disappeared.

In figure 4, the pores in the noodle become smaller as the heat treatment is applied, and the microstructure is dense in the B 'sample which heat process were steaming and drying at 130°C.

In figure 5, the water absorption is increased in heat-treated sample, due to the rigid structure formed by the high-temperature drying. The cooking loss is decreased in the samples (B, B'). During the steaming process, the protein network was formed with starch gelatinization. The formed network prevented escaping of starch, so the loss is reduced.

In figure 6, there is an increasing tendency of cohesiveness, springiness, and resilience in the steamed samples (B, B'), due to the protein network formed during the steaming process. The adhesiveness is reduced in these samples because the number of starch particles outside the noodles was few due to low cooking loss. The hardness of the sample A' was lower than that of A and B' was lower than B because each sample did not form a strong internal structure due to a higher drying temperature than the comparative sample.

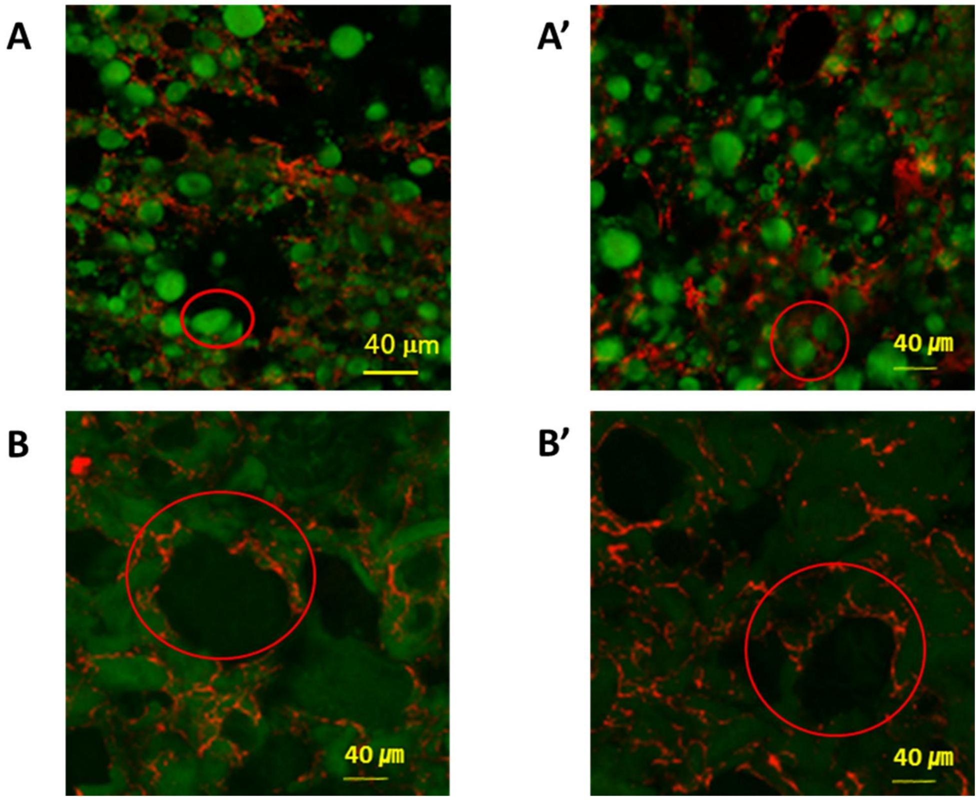


Figure 3. Confocal laser scanning micrographs of instant air-dried noodles. 400x magnification

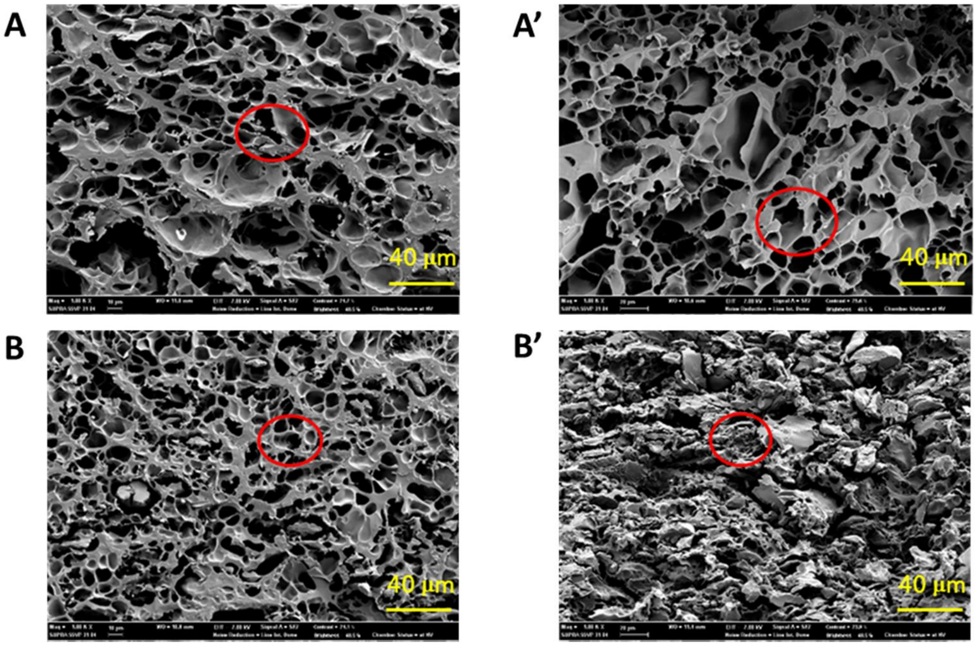


Figure 4. Scanning electron micrographs of instant air-dried noodles. 1000x magnification.

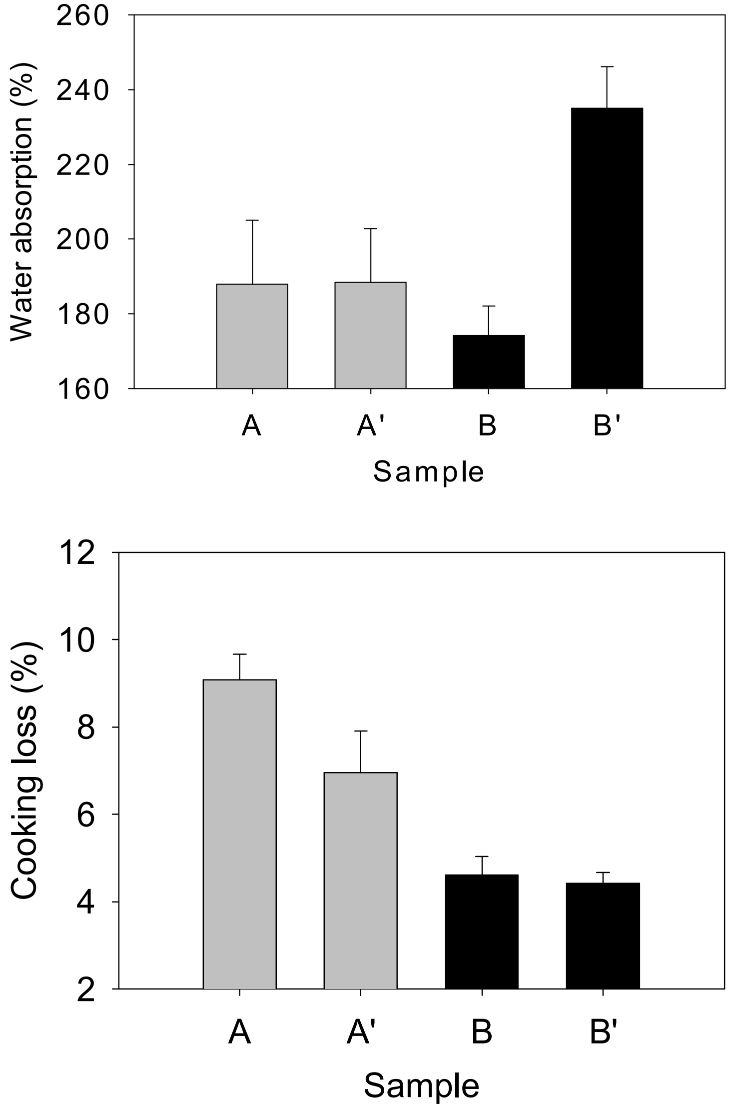
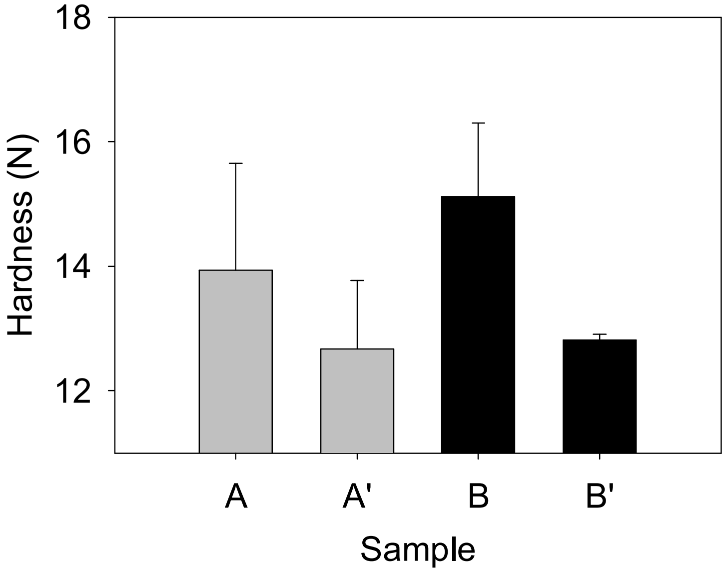
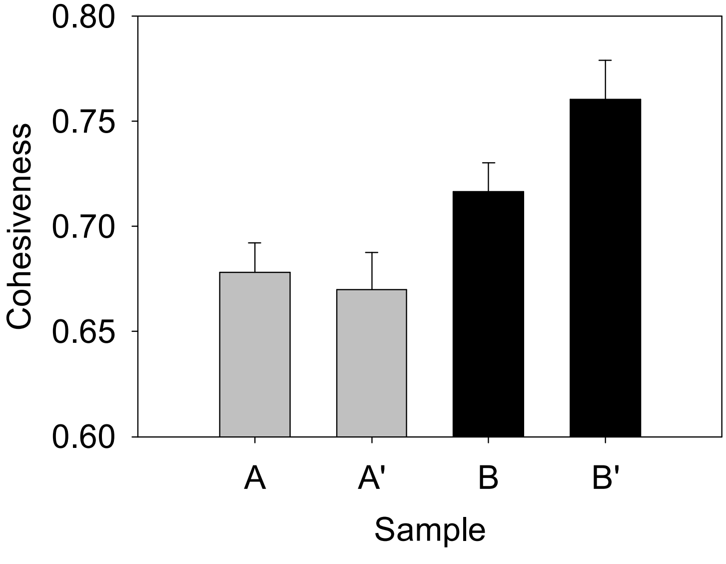
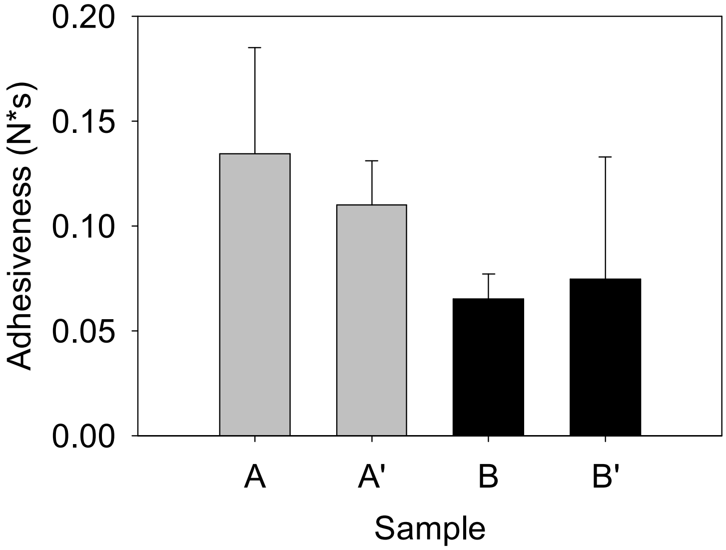
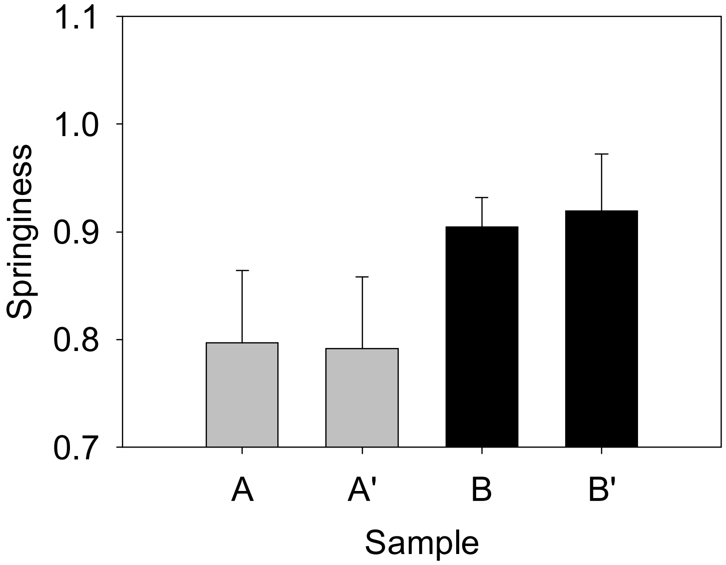


Figure 5. Cooking properties of instant air-dried noodles.


18
16
14
12
Hardness (N)
A
A'
B
B'
Sample


0.80
0.75
0.70
0.65
0.60
Cohesiveness
A
A'
B
B'
Sample


0.20
0.15
0.10
0.05
0.00
Adhesiveness (N*s)
A
A'
B
B'
Sample


1.1
1.0
0.9
0.8
0.7
Springiness
A
A'
B
B'
Sample

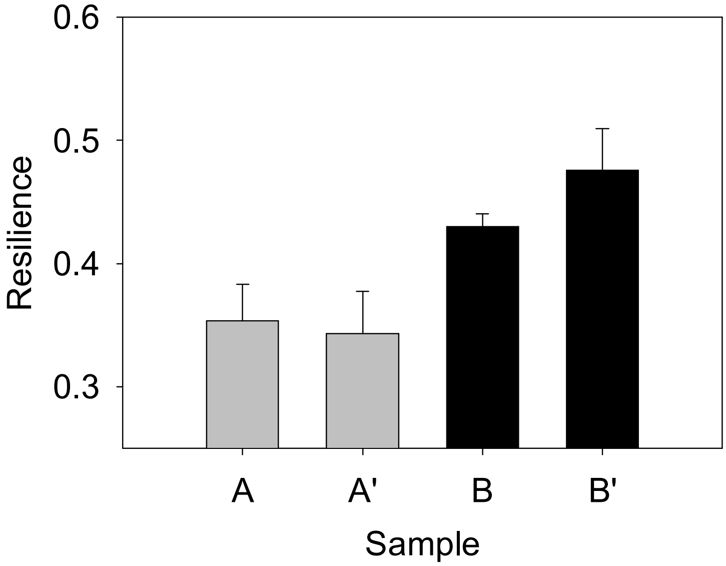


Figure 6. Texture properties of cooked instant air-dried noodles.

3.1.2. The microstructural properties of instant air-semi-dried noodles

In air-semi-dried noodles, samples were compared with drying processes using hot air and super-heated steam. In figure 7, the green color was brighter in the dry noodle using super-heated steam (S'). This means that starch is not sufficiently gelatinized by superheated steam. The non-fully gelatinization of starch can be said to be a characteristic of superheated steam noodles. In figure 8, the SEM image that does not form an even microstructure, the conditions of this process are not optimized.

The internal structure of the noodles was not completely formed by the process that was not optimized. In figure 9, the unfinished internal structure reduced the water absorption of superheated steam noodles compared to other semi-dried noodle and dramatically increased the cooking loss. In addition, instability of internal structure decreased hardness, cohesiveness and resilience, and increased adhesiveness (figure 10).

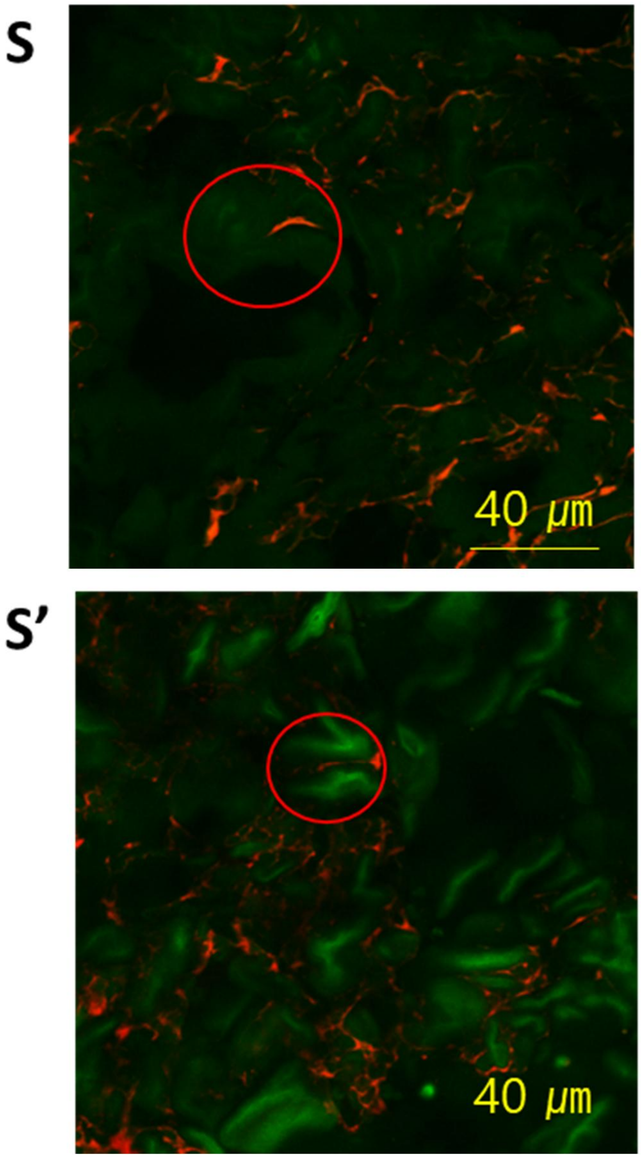


Figure 7. Confocal laser scanning micrographs of instant air-semi-dried noodles. 400x magnification.

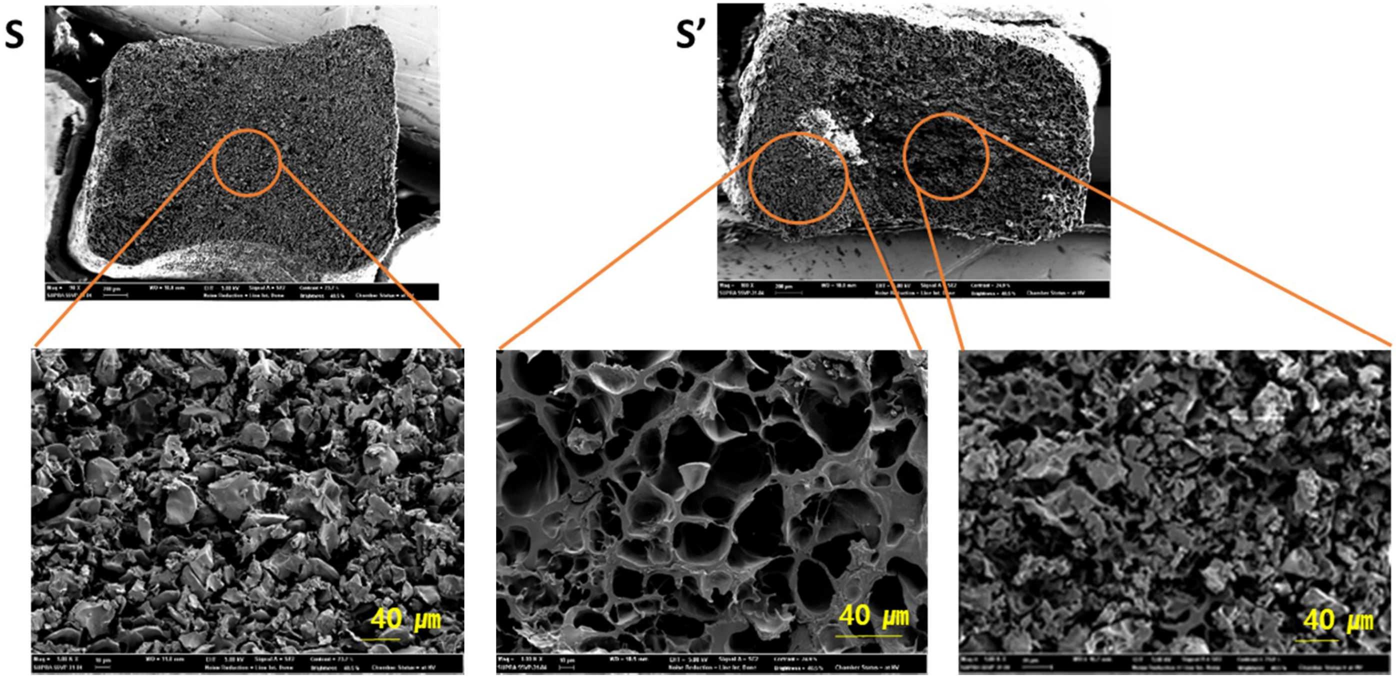


Figure 8. Scanning electron micrographs of instant air-semi-dried noodles. 100x, 1000x magnification.

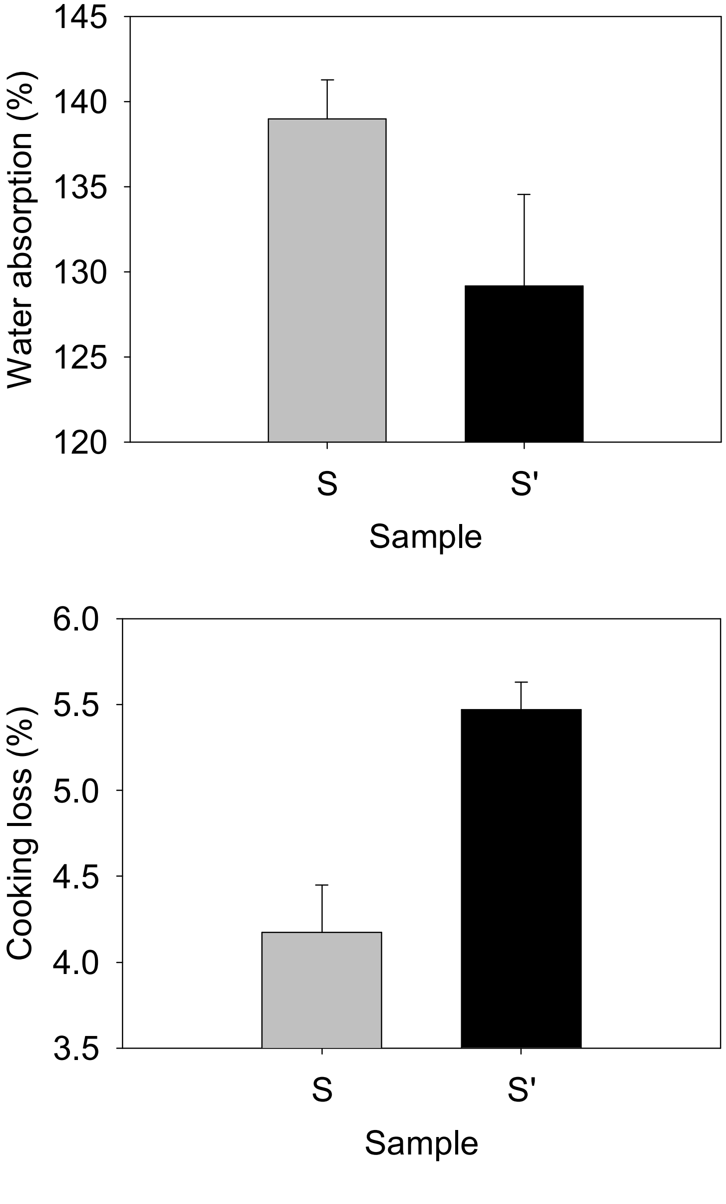
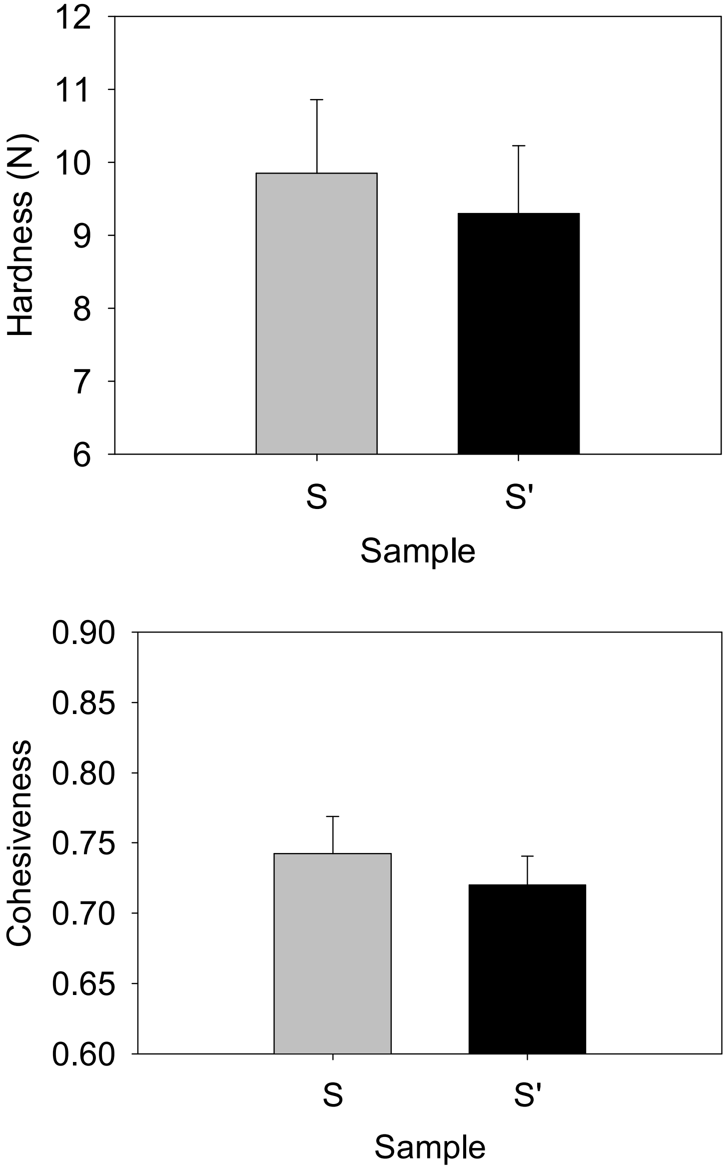
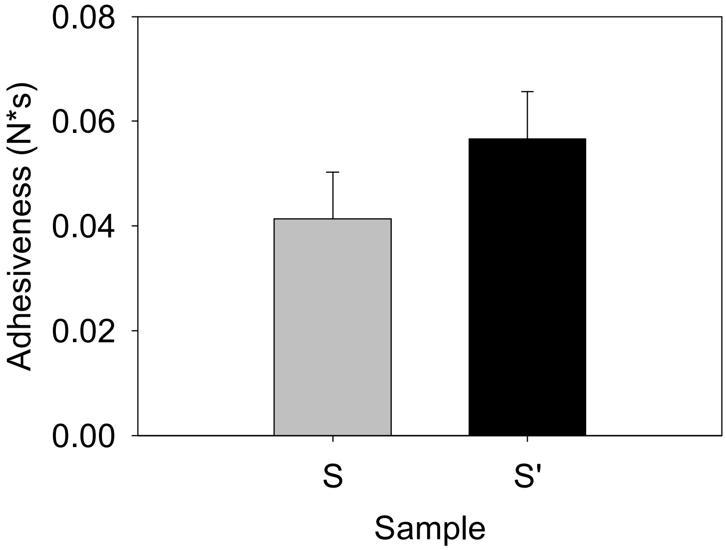
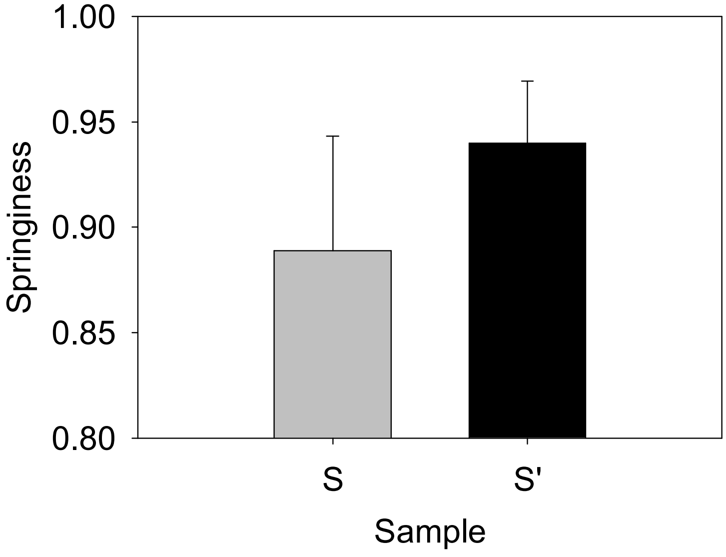


Figure 9. Cooking properties of instant air-semi-dried noodles.


12
11
10
9
8
7
6
Hardness (N)
S
S'
Sample
0.90
0.85
0.80
0.75
0.70
0.65
0.60
Cohesiveness
S
S'
Sample


0.08
0.06
0.04
0.02
0.00
Adhesiveness (N*s)
S
S'
Sample


1.00
0.95
0.90
0.85
0.80
Springiness
S
S'
Sample

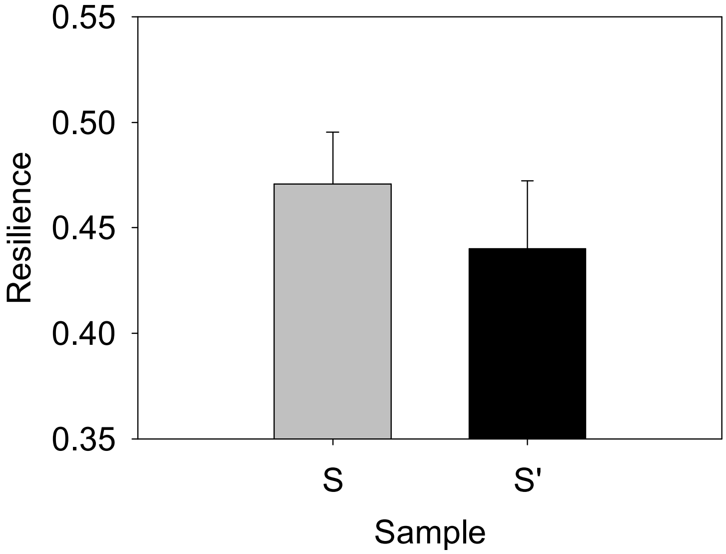


Figure 10. Texture properties of cooked instant air-semi-dried noodles.

3.1.3. The microstructural properties of Udon

The three types of Udon were compared. In figure 11, starch wasn't stained. This is because the starch was gelatinized perfectly and the water inside starch has replaced almost all of the dye. In the SEM image, the internal network of all Udon sampled is well formed (figure 12). In particular, the samples with both the boiling and the steaming process have the most porous structure.

Since Udon has no drying process, in figure 13, the amount of water absorption is much smaller than the previous samples. In addition, the water absorption during the cooking of the sample with the boiling process was small because the moisture content of Udon before cooking was high due to the boiling process which directly contacted the boiling water compared to the steaming process. The cooking loss was also low in the samples due to the boiling process because the starch granules, which could be lost during the cooking, had already been out of noodles by the boiling process.

In Figure 14, the hardness was higher for Udon as much heat processes. The heat treatment in Udon was not strong enough to damage the noodle internal network, so there was no decrease in hardness. For the same reason as the cooking loss, the adhesiveness was low in the sample U' and

U", which is expected to show good characteristics in stir-fried Udon.

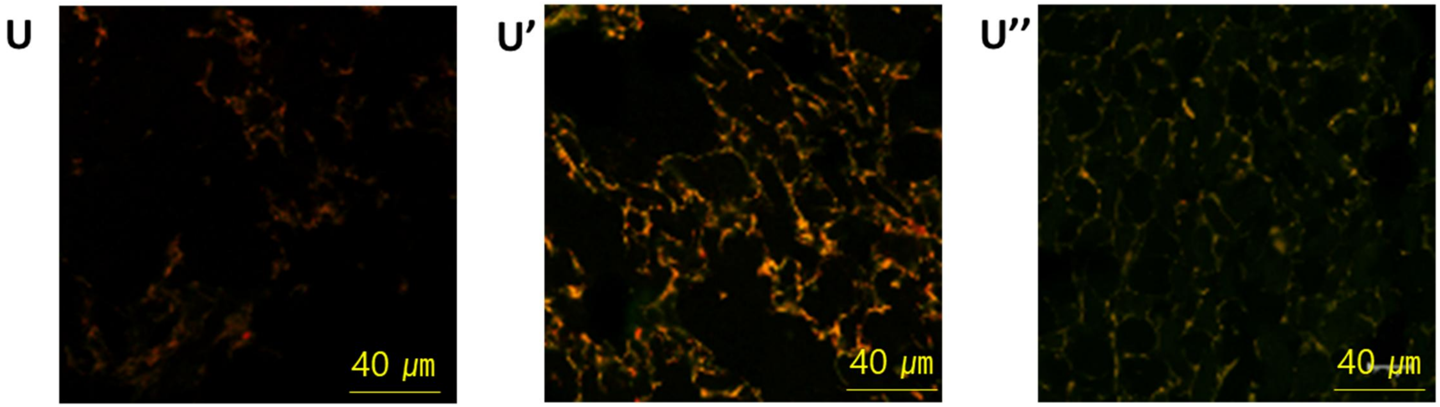


Figure 11. Confocal laser scanning micrographs of Udon, 400x magnification.

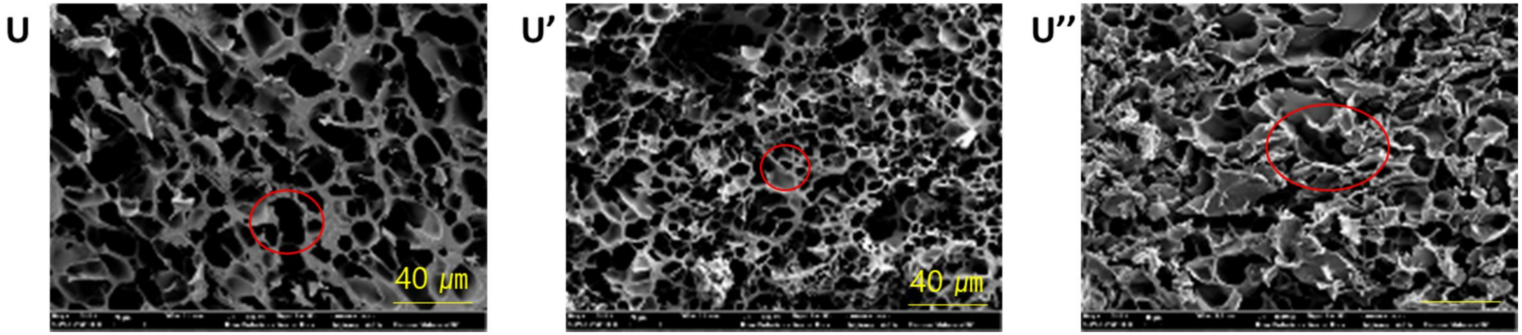


Figure 12. Scanning electron micrographs of Udon, 1000x magnification

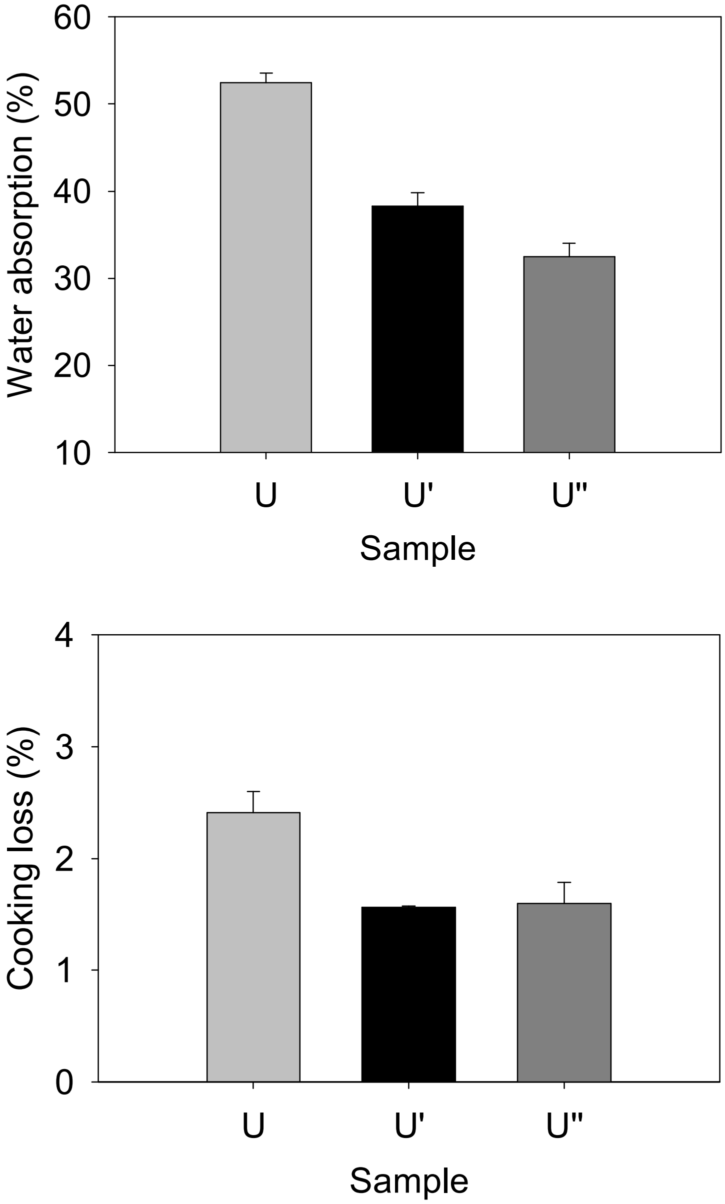
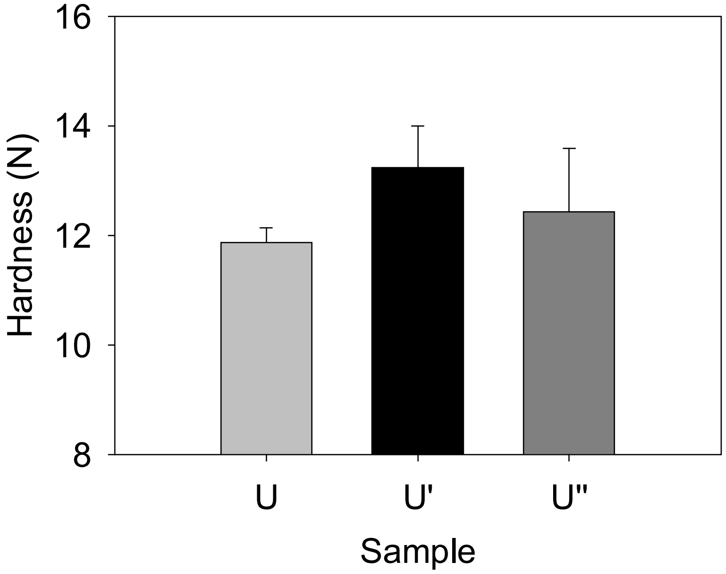
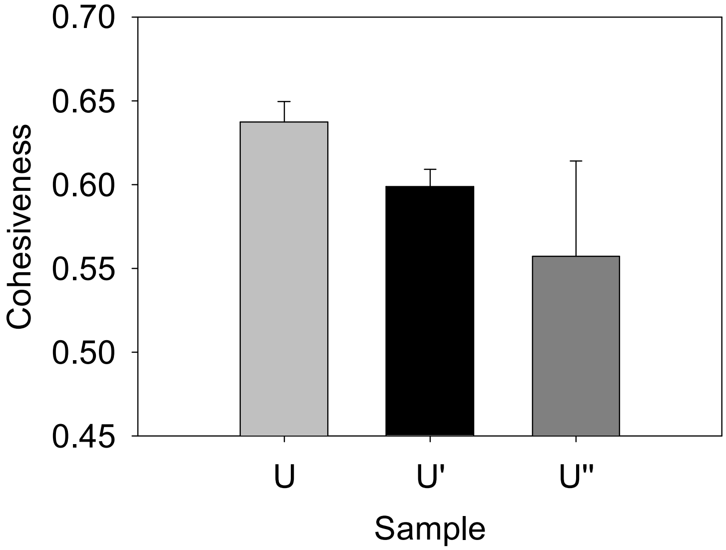
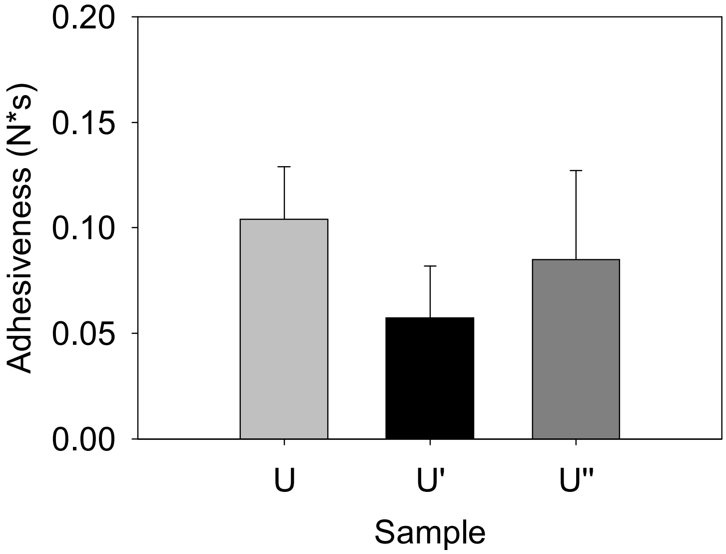
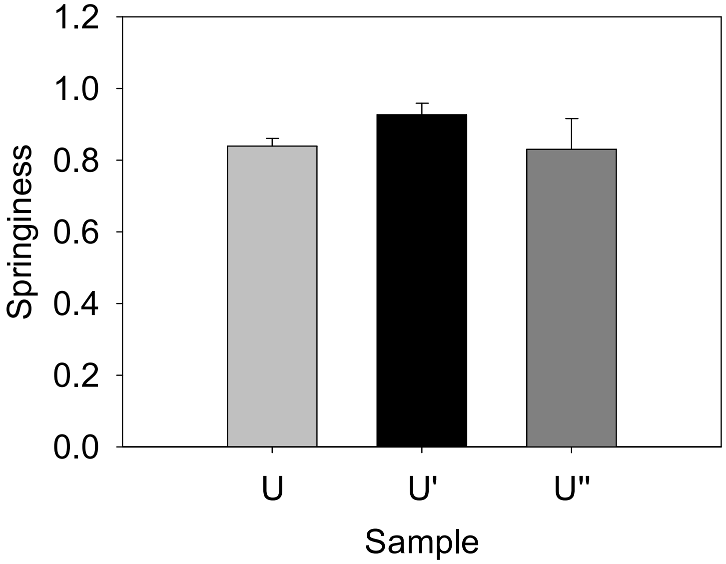


Figure 13. Cooking properties of Udon.


16
14
12
10
8
Hardness (N)
U
U'
U''
Sample


0.70
0.65
0.60
0.55
0.50
0.45
Cohesiveness
U
U'
U''
Sample


Adhesiveness (N*s)
0.20
0.15
0.10
0.05
0.00
U
U'
U''
Sample


Springiness
1.2
1.0
0.8
0.6
0.4
0.2
0.0
U
U'
U''
Sample

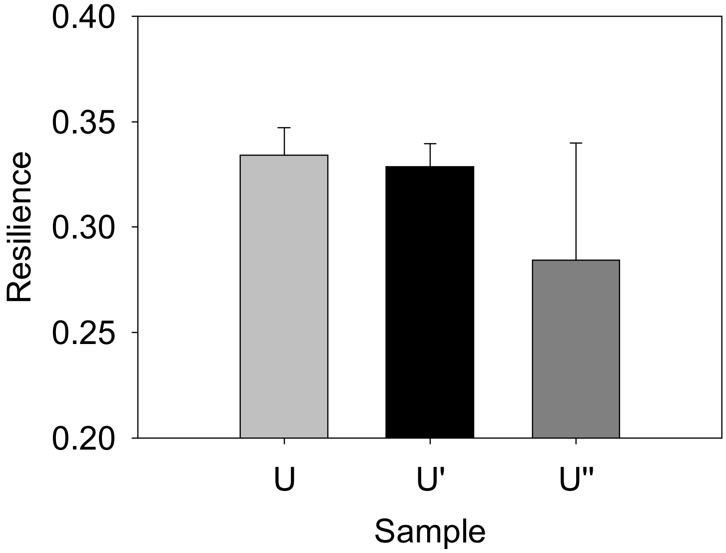


Figure 14. Texture properties of cooked Udon.

3.2. Instant air-dried potato noodles

In pre-tests, I found that potato starch noodles had much shorter cooking time than wheat starch-containing noodles. Also, I revealed the cooking time was decreased as lowering gluten contents (Figure 15). However, when the gluten content was less than 10%, the dough was break and it became difficult to produce noodles (Figure 16). Therefore, I tried to overcome this by adding a heat resting process to the dough.

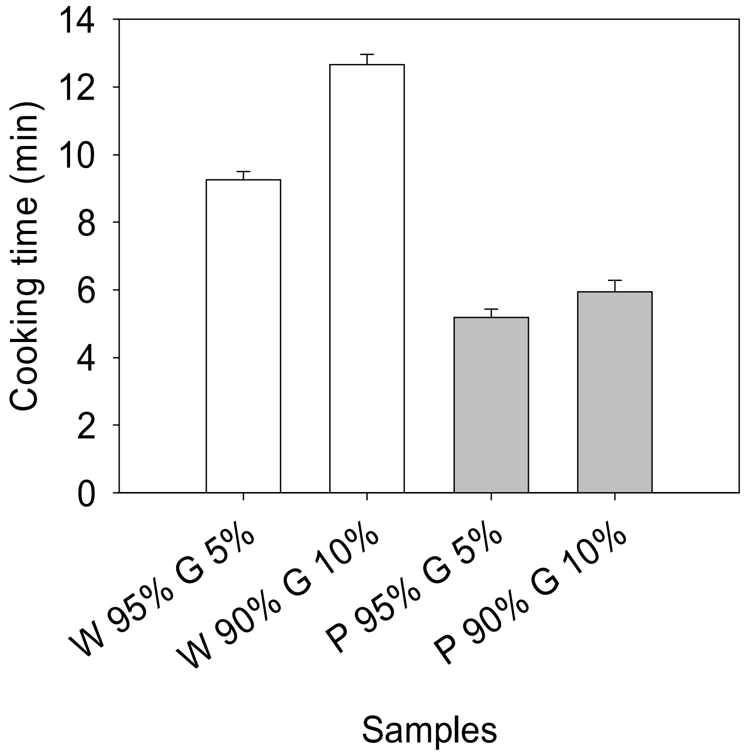
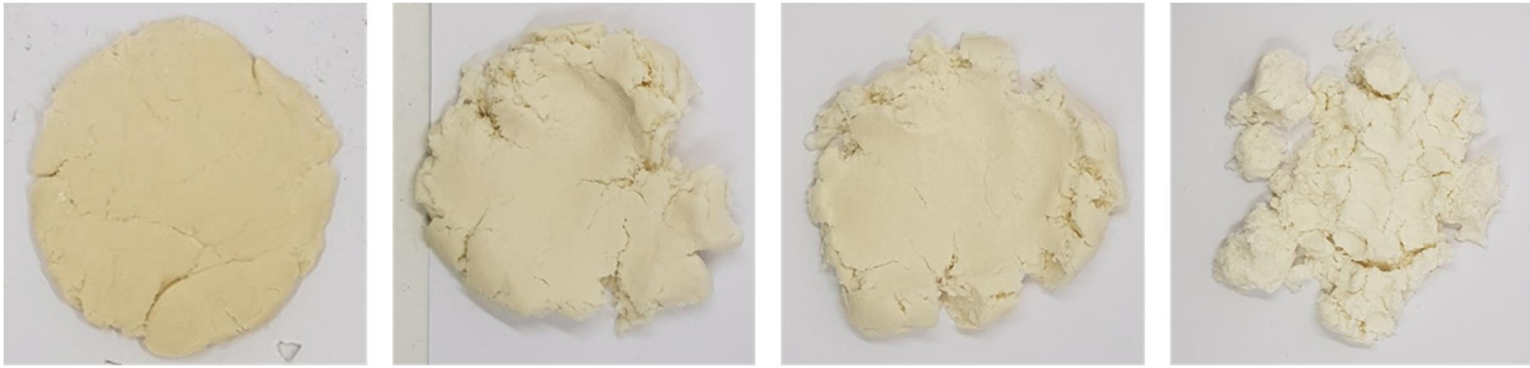


Figure 15. Cooking time of wheat and potato starch noodles in different gluten contents: (W) wheat starch, (P) potato starch, (G) gluten.



A B C D

Figure 16. Appearances of potato doughs in different gluten contents: (A) 10%, (B) 7.5%, (C) 5%, (D) 2.5%.

3.2.1. Potato dough appearance

Figure 17 is a photo of dough with various heat resting processes added. In the control sample (A) without the resting process, you can see that the dough does not smoothen and is fragile. In the sample of 65°C at 30 min (B), the dough was hardened and the noodle making was impossible. The samples rested at 45°C and 25°C were smooth and the doughs became noodles well. However, when the resting time became longer (E: 90 min, H: 6 hrs), the dough was slightly broken. The 4°C resting samples had no change from the control group.

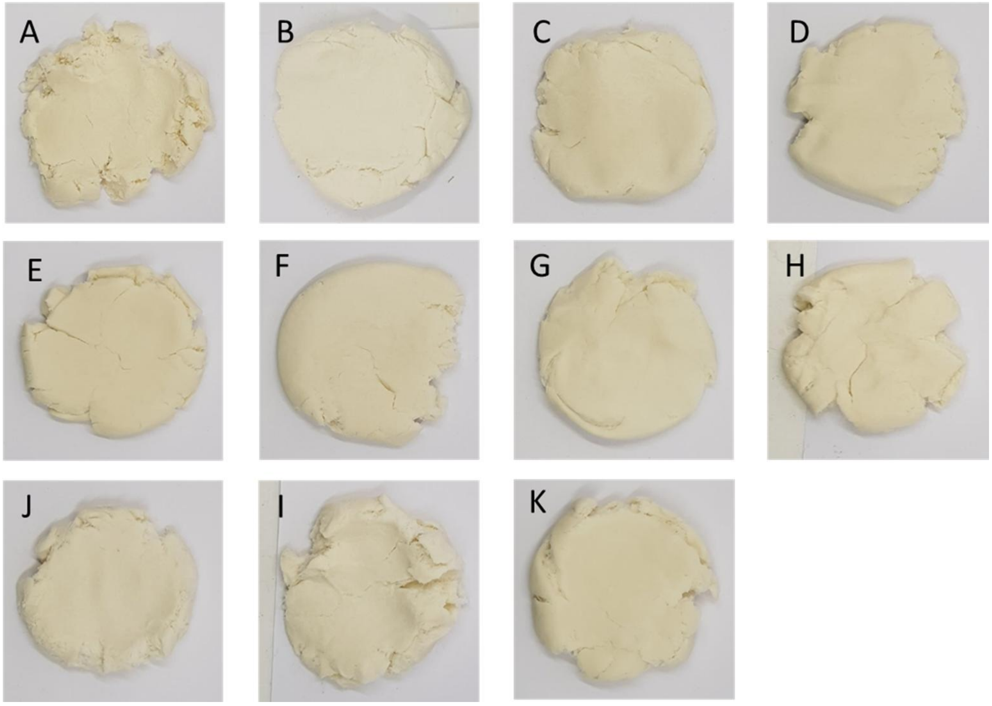


Figure 17. The dough appearance in different resting process: (A) control. (B) 65°C 30 min. (C) 45°C 30 min. (D) 45°C 60 min. (E) 45°C 90 min. (F) 25°C 2 hrs. (G) 25°C 4 hrs. (H) 25°C 6 hrs. (I) 4°C 1 day. (J) 4°C 2 days. (K) 4°C 3 days.

3.2.2. Rheological properties of potato dough

The rheological spectra of all the dough samples tested in this study displayed higher storage modulus (G') values than loss modulus (G'') throughout whole frequency range. Only the 1 Hz results are shown for more clear comparison. Compared with other resting temperatures, both G' and G'' increased dynamically at 45°C. Tan δ, which is the ratio of G'' to G', were lower than 1 in all samples (Figure 20). Resting at 45 and 25°C induced significant decrease in the tan δ. Protein is supposed to be one of the main contributors of rheological property change. The rate of change of the G' at 45°C differs by more than 10 times from that at 25°C, because the protein network is formed much faster at 45°C (Figure 21).

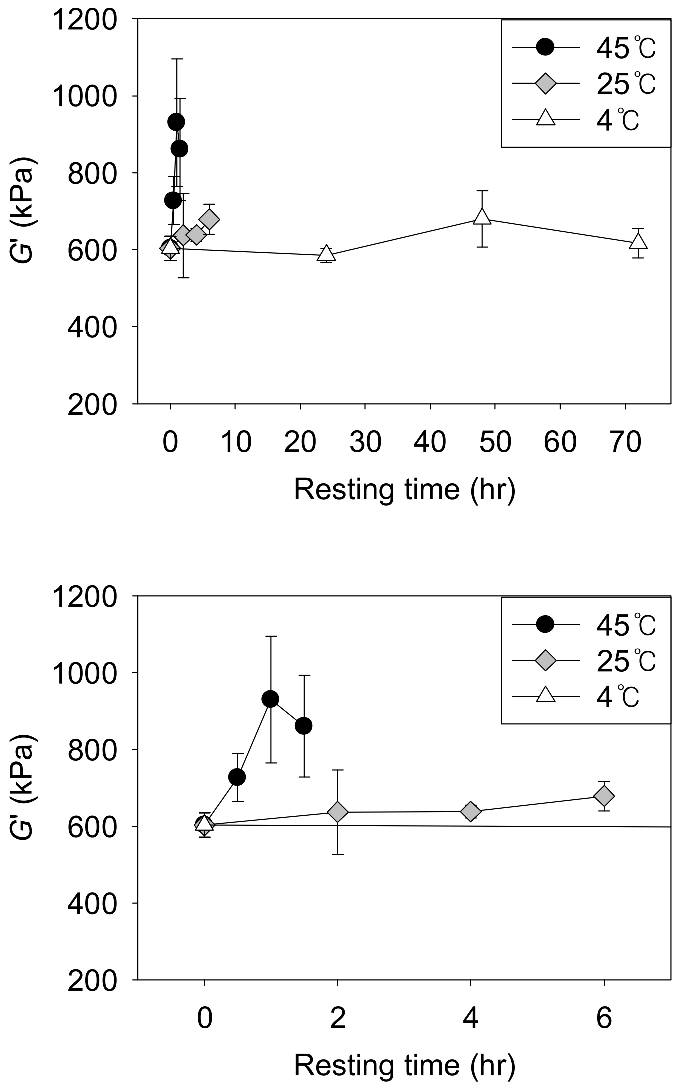


Figure 18. The storage modulus of potato doughs in 5% gluten contents at different resting temperatures.

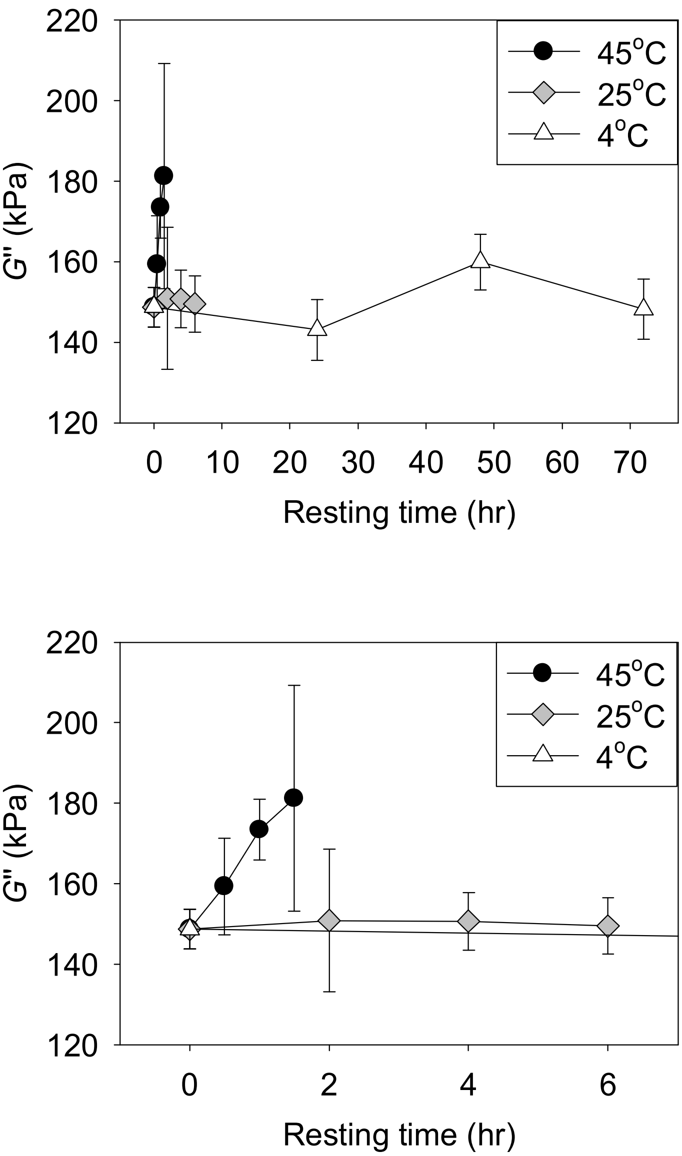


Figure 19. the loss modulus of potato doughs in 5% gluten contents at different resting temperatures.

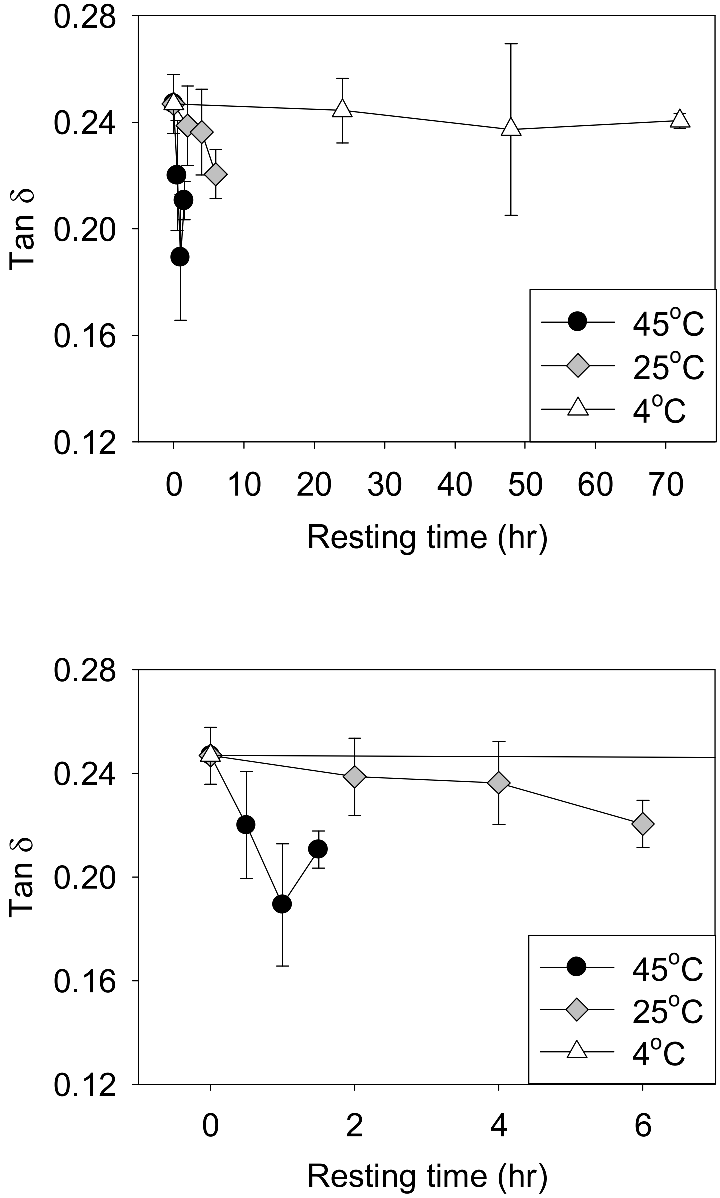


Figure 20. The tan δ of potato doughs in 5% gluten contents at different resting temperatures.

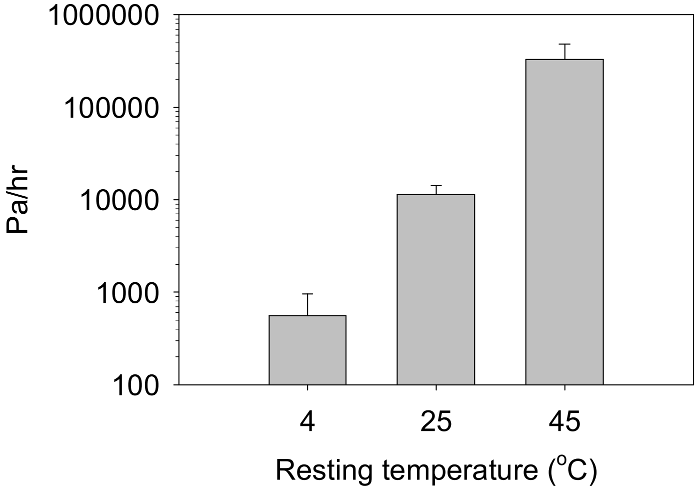
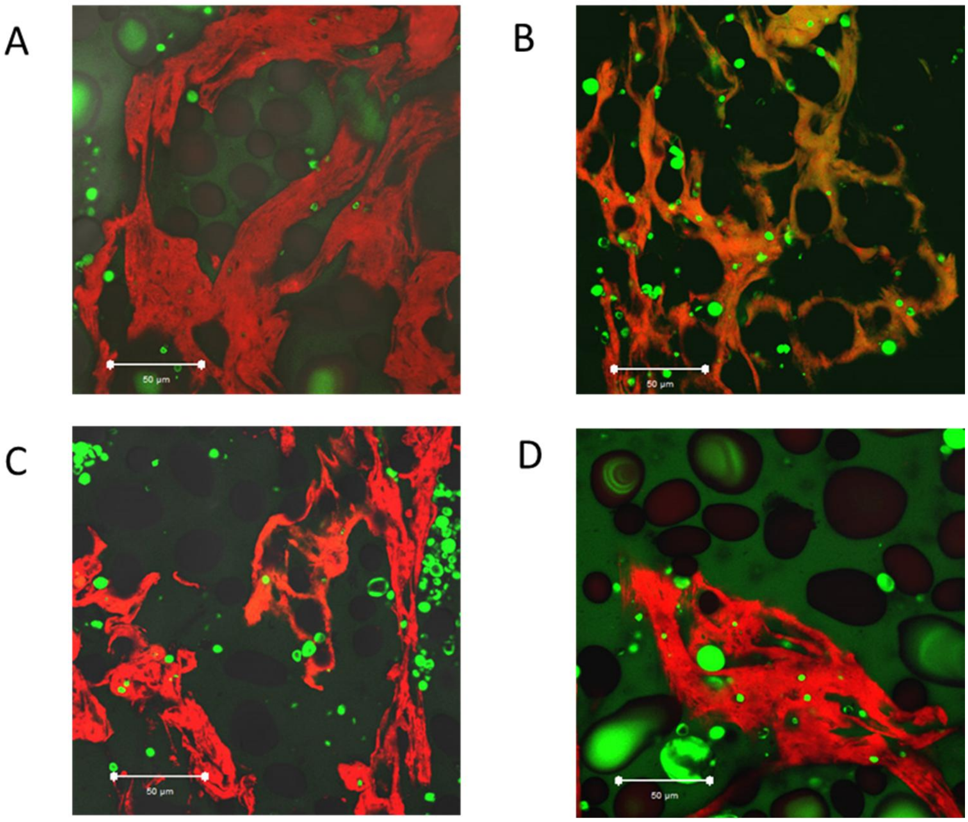


Figure 21. The increase rate of storage modulus at different resting temperatures.

3.2.3. Internal protein structures of potato dough during resting

The CLSM images were compared with the highest G's resting time at each temperature (Figure 22). The degree of protein distribution was calculated using the Image J program. After extracting the red color from each image, divide the image into small square areas and determine the percentage of red color in each area. The lower their standard deviation, the better the distribution. Thus, the distribution at 45°C was the best, so the protein network is the best condition to form, as well as the increased results of G'.

In the size-exclusion-HPLC results, the first peak is a S-S networked protein. Thus, the ratios of the first peak area to the total peak area show how much the proteins are networked. The degree of protein network was no difference as resting temperature (Figure 23). However, considering the difference in CLSM image, it can be predicted that protein network consists of a hydrophobic bond rather than a S-S bond.


A
B
C
D
50 μm
50 μm
50 μm
50 μm

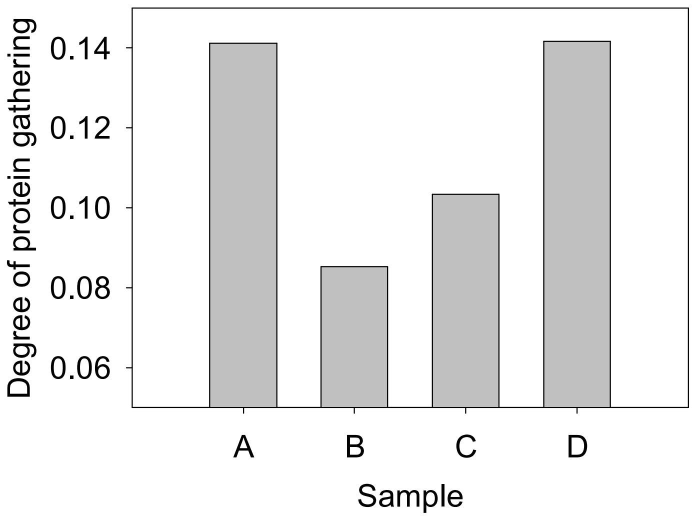

Degree of protein gathering
0.06
0.08
0.10
0.12
0.14
A
B
C
D
Sample

Figure 22. The internal structure and distribution of potato doughs in different resting condition: (A) no resting. (B) 45°C 60 min. (C) 25°C 4 hours. (D) 4°C 3 days.

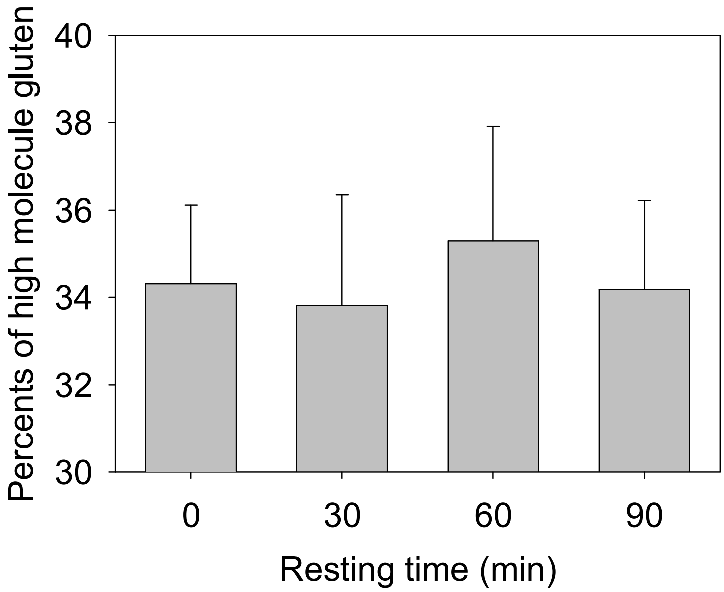


Figure 23. Percent of high molecule gluten in potato doughs at 45°C resting.

3.2.4. Cooking and texture properties of instant air-dried potato noodle

The long cooking time was a disadvantage to use air-dried noodles as cup noodles. In this experiment, the air-dried noodles made from potato starch reduced cooking time in hot water by more than two minutes compared to conventional wheat noodle (figure 24).

The water absorption was decreased in the rested dough sample. The sample rested at 45°C in 60 min was the lowest because well-formed protein networks limited the swelling of the starch and reduced water absorption (figure 25). The cooking loss was generally high in samples rested at 4°C, the highest sample was rested for 3 days. Because in 4°C resting the protein network is hardly formed the starch particles easily fall off during cooking.

The hardness and adhesiveness were generally increased when the dough was rested (figure 26). The sample rested at 45°C for 60 min was the highest because the protein network is the most favorable condition. When a protein network is formed, a suitable amount of starch granule is pushed out of the noodles, which has the effect of increasing adhesiveness.

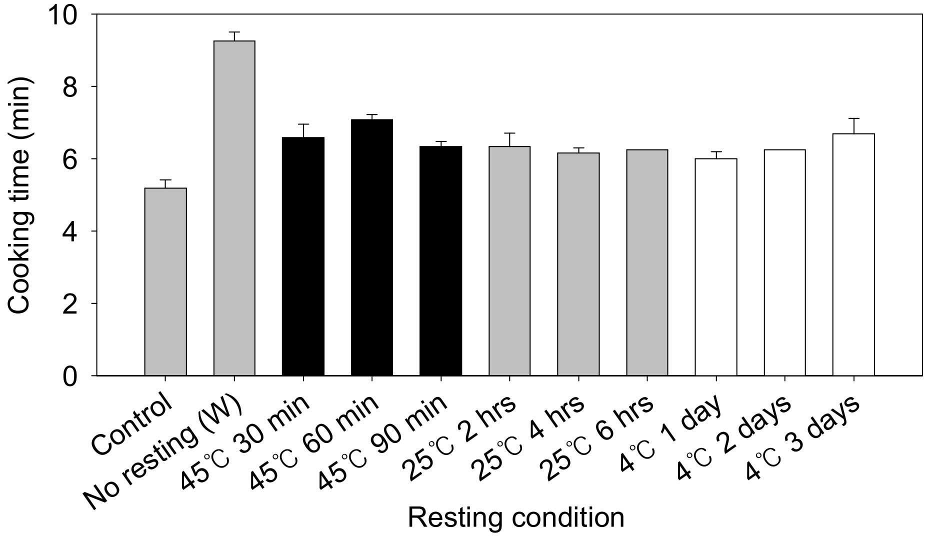


Figure 24. The cooking times of instant air-dried potato noodles.

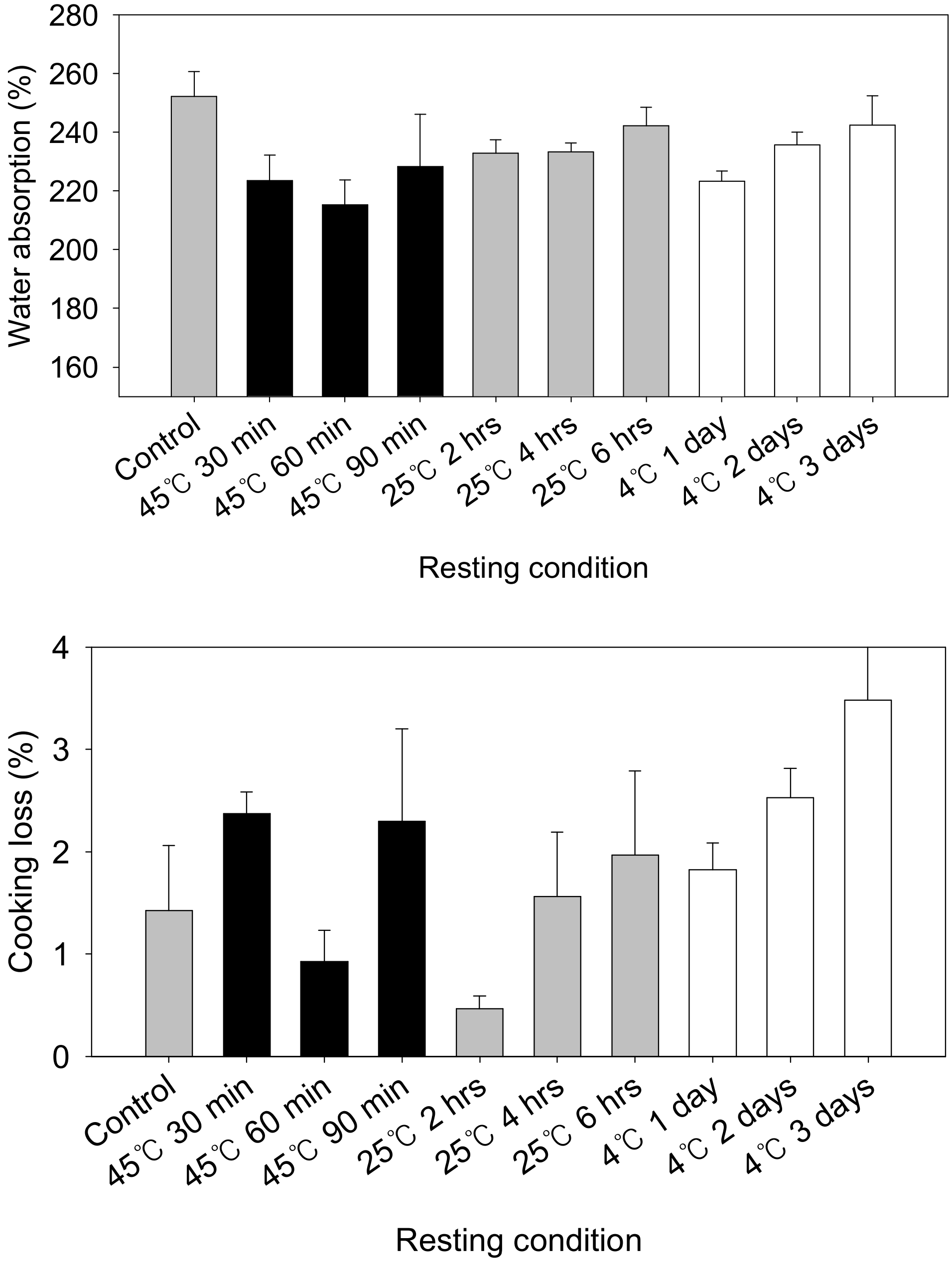
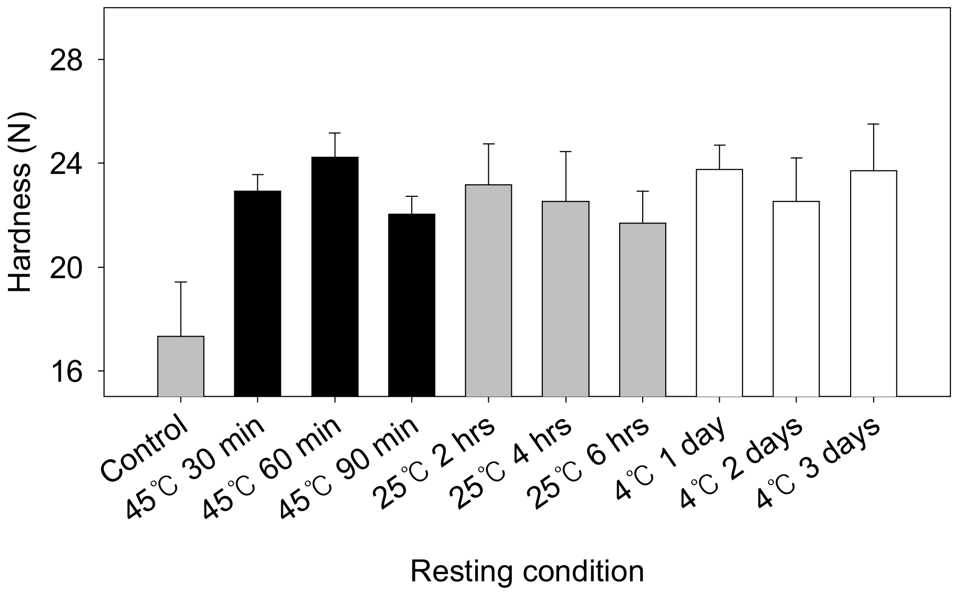
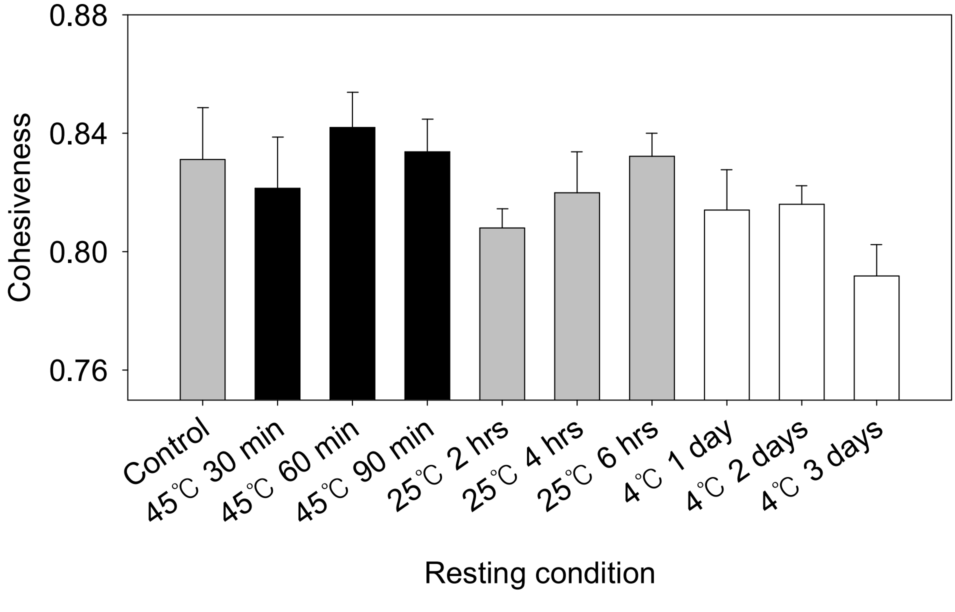
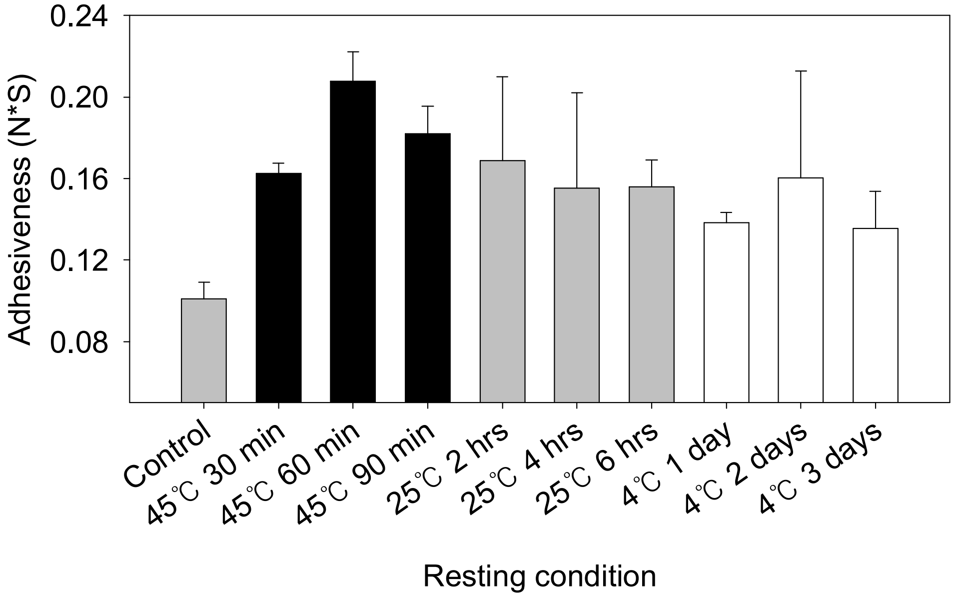
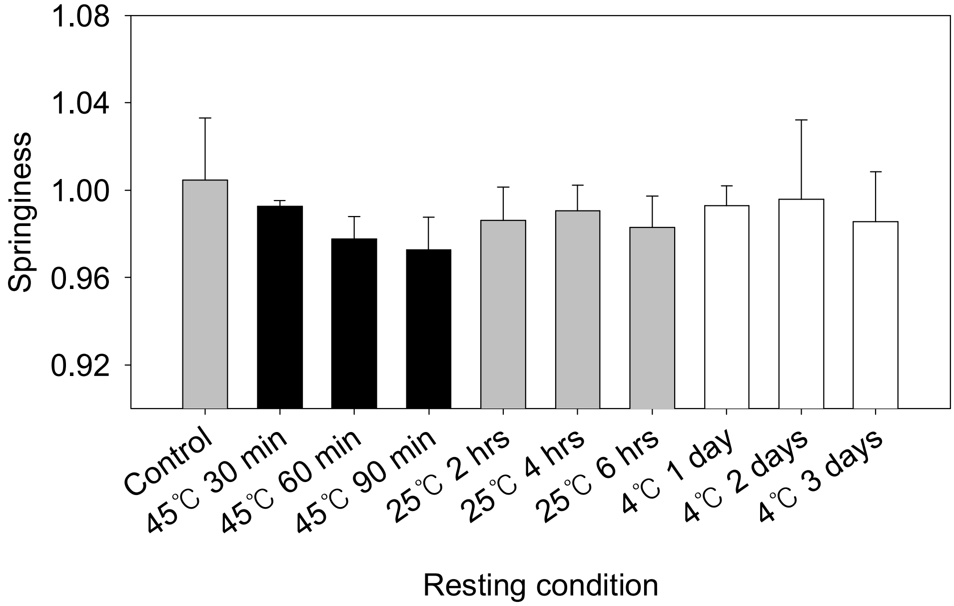


Figure 25. The cooking properties of instant air-dried potato noodles.


Hardness (N)
28
24
20
16
Control
45℃ 30 min
45℃ 60 min
45℃ 90 min
25℃ 2 hrs
25℃ 4 hrs
25℃ 6 hrs
4℃ 1 day
4℃ 2 days
4℃ 3 days
Resting condition


Cohesiveness
0.88
0.84
0.80
0.76
Control
45℃ 30 min
45℃ 60 min
45℃ 90 min
25℃ 2 hrs
25℃ 4 hrs
25℃ 6 hrs
4℃ 1 day
4℃ 2 days
4℃ 3 days
Resting condition


0.24
0.20
0.16
0.12
0.08
Adhesiveness (N*S)
Control
45℃ 30 min
45℃ 60 min
45℃ 90 min
25℃ 2 hrs
25℃ 4 hrs
25℃ 6 hrs
4℃ 1 day
4℃ 2 days
4℃ 3 days
Resting condition


1.08
1.04
1.00
0.96
0.92
Springiness
Control
45℃ 30 min
45℃ 60 min
45℃ 90 min
25℃ 2 hrs
25℃ 4 hrs
25℃ 6 hrs
4℃ 1 day
4℃ 2 days
4℃ 3 days
Resting condition

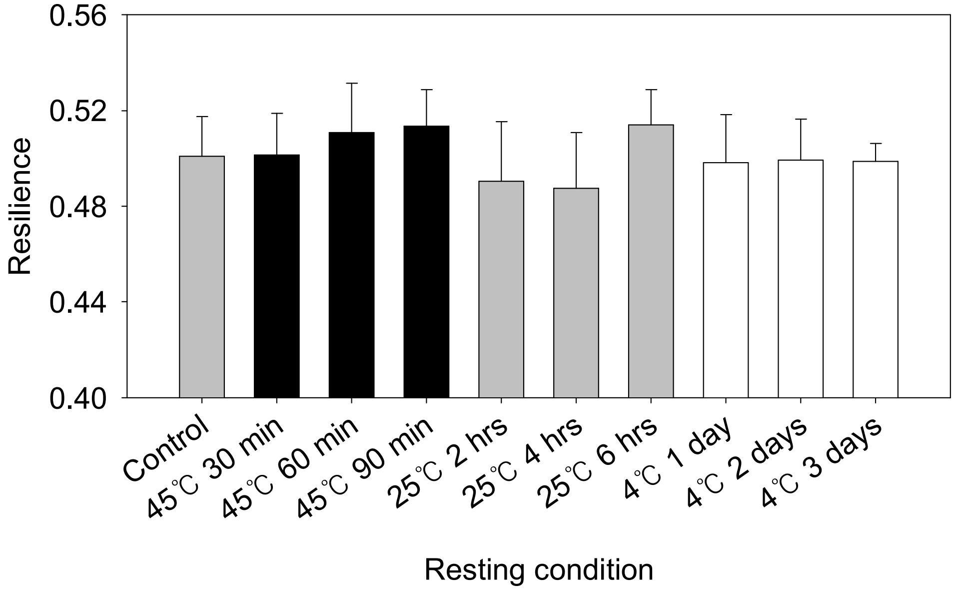


Figure 26. The texture index of cooked instant air-dried potato noodles.

IV. CONCLUSIONS

The steaming process affected gelatinize starch particles and reduced the cooking loss. It also has an effect of increasing hardness, cohesiveness, springiness, and resilience in texture characteristics but decreasing adhesiveness because of the well-formed protein network. Because the boiling process is stronger than the steaming process, the starch particles were more washed out. The adhesiveness is dramatically decreased in the boiling process, so this characteristic is suitable for the stir-fried noodles.

The dough resting process does not have a significant effect on the texture properties due to the weak heat treatment, but it forms the protein network and could make the potato noodles with low gluten content. The protein network represented by G' is maked ten times faster at 45°C resting than control. The protein network in CLSM images was much better distributed at 45°C. The degree of protein network was no difference as resting temperature. However, considering the difference in CLSM image, it can be predicted that protein network consists of a hydrophobic bond rather than a S-S bond. In addition, the rehydration time of instant air-dried potato noodles rested at 45°C was decreased by 30% compared to instant air-dried flour noodles.

In a further study, the deep discussion would be possible if there is a test that the changes in starch particles during heat treatment and other types of proteins.

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국 문 초 록

인스턴트 건면은 지방 함량이 적어 점점 소비량이 늘고 있지만 연구는 많이 진행되어 있지 않다. 따라서, 기초적으로 가열 공정에 따라 면의 특성이 어떻게 부여되는지 살펴보았다. 증숙 공정이 가해지거나 증숙과 함께 또 다른 열처리 공정이 추가되면 다공성의 내부 구조가 형성이 되며 조리 중 손실이 감소하였다. 과열 수증기를 이용한 증숙은 불규칙한 내부 구조를 형성하였고, 조리 중 손실을 증가시켰다. 우동에서는 증숙 공정에 열탕 공정이 추가되면 면의 점착성이 낮아져 볶음면에 적합한 특징을 지니게 된다.

한편 인스턴트 건면은 건조과정중에 발생하는 단단한 구조 때문에 재수화에 어려움을 겪는다. 감자 전분은 호화 능력이 매우 뛰어나 이 단점을 극복할 것으로 기대되지만, 높은 호화 능력은 면 내부구조에 손상을 가해 면 형성이 힘들게 된다. 이 문제를 해결하기 위해 감자 전분 반죽의 숙성 과정에 온도를 변화시켜 (4°C, 25°C 및 45°C) 전분의 팽윤이 덜 일어나면서 면 내부 단백질 구조의 형성이 잘 일어날 것으로 기대하였다. 결과적으로, 25°C 및

45°C에서 숙성한 반죽은 면 형성이 잘 되었다. 단백질 네트워크의 형성 속도는 25°C에 비해 45°C에서 10배 더 빠르며, 잘 분포된 구조를 나타냈다. 이렇게 제작한 인스턴트 감자 건면의 재 수화 시간은 밀 건면에 비해 30% 감소하였다. 우리의 결과는 인스턴트 건면의 단점을 극복해 컵라면 제작에 적용 가능하며, 면의 글루텐 함량을 줄여 면을 만들 시 도움이 될 것이다.

주요어: 인스턴트 건면, 열처리 공정, 단백질 네트워크, 증숙, 열탕, 숙성, 조리 특성, 텍스쳐 특성

학번 : 2017-23001