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Relationship Between Protein Characteristics and Noodle Making Quality of Different Wheat Varieties

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Abstract

This study aims to determine structural changes that occurred in protein structures of noodles obtained from nine different wheat varieties (white and red bread and durum) during the preparation and cooking process. SDS-PAGE was used to evaluate the molecular weight of the proteins of these different wheat varieties and noodles, FT-IR was used to investigate the changes in chemical structure, and SEM was used better to understand the morphology, microscopic, and surface structures. High molecular weight protein bands in flours belonging to white bread varieties could not be detected in the noodle samples obtained from the same varieties. On the other hand, high molecular weight protein bands were obtained when noodles were prepared from flour samples of durum wheat. In FTIR evaluation, it was seen that the structure of noodles produced from white bread wheat did not deteriorate before and after cooking. In the noodle structures obtained from red bread wheat, protein loss was observed partially with the cooking process. No deterioration was observed in durum wheat before and after the cooking process. When all the results are evaluated together, it is thought that the most suitable variety for noodle production is the durum wheat variety. When the red and white bread varieties are

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assessed according to the determination of chemical structure, swelling ratio, morphology, microscopic and surface properties of the noodles during the preparation and cooking process, it is concluded that the white bread variety is more suitable for the production of noodles than the red bread variety.

Keywords: Wheat, Noodle, Protein, Swelling ratio.

Introduction

Wheat is the essential food grain in the human diet and responsible for the most significant portion of our calorie intake (FAO, 2017). It is considered a great source of energy, protein, and dietary fiber in human and animal nutrition. Today, it is reported that approximately 95% of the wheat grown in the world is hexaploid bread wheat, and the remaining 5% is tetraploid durum wheat (Yang et al., 2022). Wheat is used all over the world in different products with very different textural properties like bread, cookies, cakes, tortillas, noodles, and pasta. The main difference between the wheat flours of this wide variety of products is their gluten content and gluten composition. The gluten proteins determine the ability of wheat flour to be processed into different foods. The three-dimensional structure of wheat gluten proteins plays an essential role in the quality of wheat dough. Gluten (gluten and gliadin complexes) is a unique structure for imparting the adhesive and viscoelastic properties of the dough (Wang et al., 2017; Zhou et al., 2014). The rheological properties of dough correlate with the secondary structure of gluten proteins (Kaur et al., 2015). The gluten proteins consist of monomeric gliadins and polymeric glutenins. Glutenins and gliadins are recognized as the significant wheat storage proteins, constituting about 75–85% of the total grain proteins with a ratio of about 1:1 in bread wheat (Žilićet al., 2011).

Gluten consists of monomeric gliadins, which are mostly non-covalent and interact with intrachain disulfide bonds, and polymeric gluten composed of high and low molecular weight subunits (HMW and LMW, respectively) stabilized with hydrophobic and in-chain disulfide bonds. Gliadins act as plasticizers for gluten and increase the viscosity of the gluten network and reduce the high levels of flexibility provided by gluten (Pérez et al., 2008, Zhou et al., 2014). The gliadins can be divided into α, β-, γ- and ω-gliadins with a molecular weight of 30 to 80 kDa. The

molecular weights of ω-gliadins range from 46 to 74 kDa, while the molecular weights of α-, β- and γ-gliadins range from 30 to 45 kDa (Žilićet al., 2011). Glutenins, a type of polymeric protein, are categorized as high molecular weight (HMW) and low molecular weight (LMW) subunits in the range of 100 to 140 kDa and 30 to 55 kDa molecular weight (Mw), respectively (Katyal et al., 2016, Ram, 2012). While high molecular weight gluten constitutes the framework of the gluten structure, low molecular weight gluten plays an important role in the viscoelasticity and extensibility of the pulp (Wang et al., 2017). Wheat proteins are sensitive to dough making and undergo complex changes during mixing and subsequent processing. Knowing the changes in wheat protein behavior is very important to understand the mechanical properties of dough and control the final product quality (Li J et al., 2014). The rheological properties of gluten are needed not only for bread production but also in the production of different products such as noodles, pasta, pastries. Noodle, which has a traditional place in Turkish cuisine, is a product whose preparation process is simple, fast and easy to cook, with good sensory properties and long shelf life as well as its consumption, due to its variety, nutritional value and low cost. It has been stated that the protein amount and quality of the flour used in the production of noodles affect the texture of the noodles and therefore the noodle texture (Xiong et. al., 2021). In noodle making, the protein ratio of flour is usually around 10-12%. Hard (durum) wheat is preferred in noodle production because of its high protein content. However, the protein content of medium-hard bread wheat taken into culture today is quite high and has become close to hard wheat.

This study aimed to investigate the structural changes that occur in proteins during the preparation and cooking process of the noodles produced from flour and gluten samples obtained from bread (white and red) and durum wheat varieties. There is limited research on the importance of certain proteins to noodle quality compared to making bread. To determine whether bread wheat flour is suitable for making noodles, it is important to evaluate the protein properties in the noodle structure. In the study, the molecular weights of proteins in the flour, gluten and noodles produced from bread (white and red) and durum wheat were determined by SDS-

PAGE method. FTIR spectroscopy was used to measure changes in the secondary structures of the samples. The swelling rate of the noodles was also determined with the gravimetric method. In addition, SEM analysis was utilized to better understand the morphology and microscopic structures of the noodle samples.

Materials and methods

Materials

In this study, the used kinds of wheat were purchased from Sanlıurfa Wheat Exchange and were selected from registered wheat, which has first class quality characteristics according to the Turkish Standards Institution (TSE 2974) (TSE, 2001). Wheat samples determined as 3 red bread (Pandas, Sagittario Pehlivan), 3 white bread (Kaşifbey, Gökkan, Ceyhan-99) and 3 durum wheat (Zenit, Zühre, Svevo). All chemicals used in the analyses were analytical purity grade.

Flour milling

The wheat grains conditioned for 24 h at 14% moisture and milled in the Brabender Junior mill.

Noodle production

The noodle production model (Table 1) of Yalçın et al. (2005) was modified as determined by preliminary trials and the noodle ingredients were kneaded in the Kitchen Aid mixer for 8 minutes. The dough obtained after kneading was divided into 3 parts and rested for 30 minutes. The rested dough masses were first passed through a pre-thinning 3-4 times with the help of a roller. Some of the pre-thinned doughs were freeze-dried. The other part of the dough obtained was rested for 5 minutes at room conditions in order to prevent adhesion before the cutting process and dried. Noodle sizes (1 mm) were determined using Vernier caliper.

Chemical structure of dough (FTIR Spectrophotometric analysis)

The FTIR spectroscopy (Spectrum Two FTIR Spectrometer, Perkin Elmer) was used to reveal functional groups of the prepared materials in the range of 400–4000 cm^{-1}.

Scanning Electron Microscopy

The microscopic images of the prepared samples were acquired using SEM (LEVO-EVO 40, Cambridge). The samples were dried and coated with Au/Pd by sputter (BAL-TEC SCD 050, Liechtenstein) before the measurement.

Swelling Studies

The swelling studies were determined according to the method reported by Mehteroğlu et al. (2020). The gravimetric method, which is widely known, was used to determine the swelling rate of the noodles. Swelling measurements were carried out in the water and at room temperature. First, the dry weights of the noodles were weighed. Then the noodle samples were immersed in water. At certain intervals, the noodles were weighed again by removing excess water on the swollen noodle surface. The swelling of the noodles reached a maximum in about 1 h. The mean value of at least three measurements for each sample was taken, and the swelling percentage is calculated, by using Eq. (1).

$$\text{Swelling } \% = (W_s - W_d) / W_d \times 100 \quad (1)$$

W_s is the weight of noodle sample swollen in the water and W_d is the weight of the dry noodle sample.

SDS–PAGE Analysis

SDS-PAGE of proteins was tested according to the method of Li M et al., 2014 with some modifications. SDS–PAGE was performed using 12% separating gel (pH 8.8) and 5% stacking gel (pH 6.8). A 50 mg of each sample was stirred in 1 mL of extraction buffer (pH 6.8, 0.01 M Tris–HCl, including 10% (w/v) SDS, 5% (v/v) 2-mercaptoethanol (2-ME), 10% (v/v) glycerol, and 0.1% (w/v) bromophenol blue). The dispersions were heated for 5 min at 100°C. 10 µL of the sample was loaded into the instrument, and electrophoresis was performed at 100 V during the run. The gel was Coomassie brilliant blue R250 stain of 0.25% w/v and de-stained in 10% acetic acid.

Statistical Analysis

In this study, the numerical results were expressed as mean ± standard error. Data were analyzed using the Kruskal-Wallis test. Multiple comparisons were performed

with Dunn's test. The p-value lower than 0.05 was considered as statistically significant. IBM SPSS Statistic 25.0 for Windows package program was used for the analyzes.

Results and discussion

Flour yield

In order to increase the grinding efficiency, wheat samples were annealed to 14% by cold annealing. Annealing process took place in 3 stages. In the first stage, 2/3 of the water required annealing the wheat samples and 1/3 of the water in the second stage were added and kept at room temperature for 24 hours. Annealed wheat was milled in a roller mill and then milled by sieving number 8 (180 μ). The obtained flours were stored in closed containers in a dark environment in order not to change color at + 4°C.

Flour yields of flour obtained from red bread wheat varieties were determined as the highest value between 52-54%. Flour yields of white bread and durum wheat varieties were determined between 45-48% and 30-45%, respectively. Flour yields ranged between 45% and 54%, durum wheat varieties showed lower while bread wheat varieties showed higher flour yield. Red bread varieties had the highest values. According to wheat flour protein values, it is seen that the highest protein value belongs to the variety of Pehlivan and the lowest protein value belongs to Kaşifbey and Ceyhan-99 variety. Park and Baik (2004) reported that the effect of wheat flour protein quality and protein content on the texture properties of instant noodles was significant. The protein content of flour milled from different varieties ranged between 13.0 % and 15.6 %. Zühre (DW) and Zenit (DW) showed lower while Pehlivan (RBW) showed the highest protein content.

Chemical structure of flour and noodle

The chemical structure characterization of flour varieties of bread and durum wheat and the noodles obtained from flour were carried out using FTIR spectroscopy.

White bread varieties were selected as Ceyhan-99, Gökkan and Kaşifbey. Figure 1a, 1b and 1c represent the FTIR spectra of flour and dry/cooked noodle structures obtained from Ceyhan-99, Gökkan and Kaşifbey white bread wheat varieties,

respectively. In Figure 1a, in Ceyhan-99 white bread wheat flour structure, H bond stretching vibrations originated from OH groups suitable for the structure of the flours were observed in the range of 2990-3550 cm^{-1}, 3000-3600 cm^{-1} and 3100-3600 cm^{-1}. Aliphatic C-H stretching vibrations associated with carbohydrate structure were detected at 2800-2910 cm^{-1}, at 2800-2950 cm^{-1} and at 1448 cm^{-1}.
In addition, C-O-C vibrations originating from carbohydrate structures, and etheric units between saccharide units were seen as a clear band in Ceyhan-99 and Kaşifbey varieties at 1040 cm^{-1} and 1100 cm^{-}. Although the gluten structure obtained from Ceyhan-99 flour variety had a lower intensity protein structure than other gluten structures, carbonyl, amide 1 and amide 2 peaks belonging to classical protein structures were seen in FTIR spectrums. In the gluten structure of Gökkan variety in Figure 1b, it was seen that there are no etheric stretching vibrations at 1100 cm^{-1} originating from carbohydrate structures. In addition, C=O stretching vibrations belonging to the protein structure were very clear and apparent. It has been observed that amide 1 and amide 2 peaks were quite intensive. In the range of 3000-3600 cm^{-1}, H bond stretching vibrations were observed, one of which is peptide bond hydrogen and the other is originating from structural moisture. In the Kaşifbey variety in Figure 1c, the spectrum of the gluten showed the classical protein structure. In this structure, C=O stretching vibrations at 1660 cm^{-1}, amide 2 peaks at 1580 cm^{-1}, C-N stretching vibrations at 1448 cm^{-1} and H bonds of the gluten at 3100-3600 cm^{-1} were determined. In the noodle structure of Ceyhan-99 variety, protein ratio decreased compared to flour. This is understood from the decrease in the intensity of the peaks of C=O stretching vibrations (1680 cm^{-1}), amide 1 and amide 2 (1540-1650 cm^{-1}), and aliphatic C-H (approximately 2900 cm^{-1}). The general carbohydrate structure has been preserved during the noodle preparation process. It is observed that the ratio in flour structure is preserved when the OH group H bond peaks are proportioned with structural moisture strain vibration. In Gökkan variety, the intensity of the moisture peaks decreased due to the drying in the noodle structure. It was observed that the peaks in the range of 3000-3600 cm^{-1} of the dried noodle structure were considerably decreased. The spectrum of the

noodle structure produced from the Kaşifbey variety confirms the stable carbohydrate structure in noodle structure during preparation process.

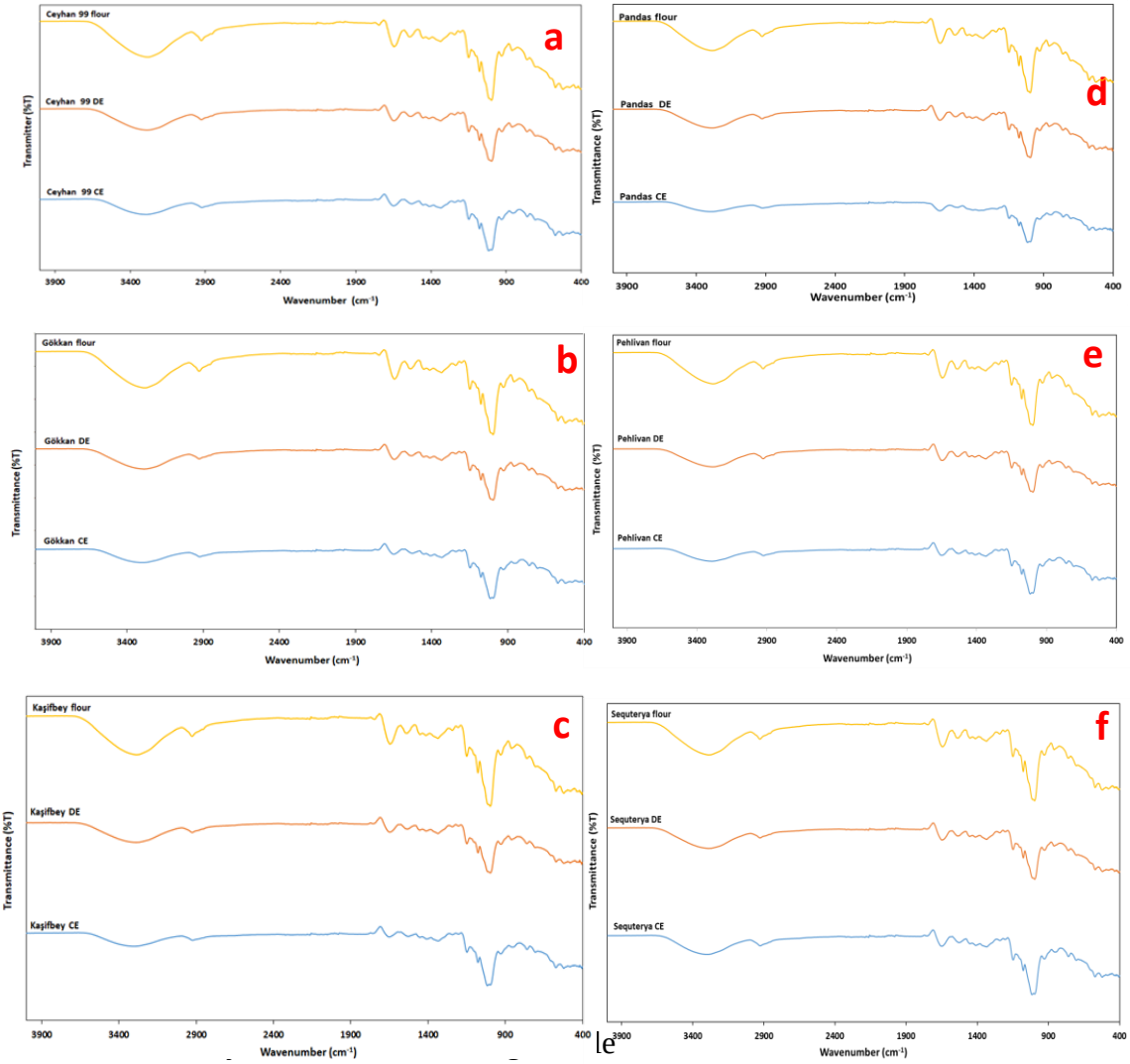

Figure 1. FTIR spectra of flour and dry/cooked noodle structure obtained from the white and red bread wheat varieties a) for Ceyhan- 99, b) for Gökkan, c) for Kasifbey, d) for Pandas, e) for Pehlivan and f) for Sagittario.

In general, the structural stability of the noodles obtained from white bread varieties was also preserved during cooking. This is understood from the stability of all structural peaks before and after cooking.

Pandas, Pehlivan and Sagittario varieties were evaluated in red bread wheat varieties. Figure 1d, 1e and 1f. show the FTIR spectra of flour and dry/cooked noodle structures obtained from Pandas, Pehlivan and Sagittario red bread wheat varieties, respectively. It is seen that Pandas flour variety contains H bonds

originating from moisture at 3000-3600 cm^{-1} in Figure 1d. Aliphatic C-H peaks of proteins in flour structure were seen in the range of 2850-2950 cm^{-1}. C=O stretching vibration at 1680 cm^{-1}, amide peak at 1560 cm^{-1} and C-N stretching peak at 1444 cm^{-1} attributed to protein peaks and all of these peaks were also seen in gluten. In the noodle structure, protein loss was determined partially by cooking. C-O-C stretching vibrations of the carbohydrate structure in the range of 1000-1100 cm^{-1} in the structure of flour, noodle and dried noodle of Pehlivan variety and C-O stretching vibrations at 1200 cm^{-1} were observed in Figure 1e. In addition, H bond peak belonging to OH groups originating from moisture was observed at 3000-3600 cm^{-1} in the structure of these three varieties. C=O, amide and C-N stretching vibrations of protein groups were observed at 1680 cm^{-1}, 1580 cm^{-1} and 1440 cm^{-1}, respectively. These peaks are compatible with the literature (Rai et al. 2013). After cooking, it has been determined that carbohydrates in the structure were preserved. But, proteins were partially degraded. In FTIR spectrum in Figure 1f, in the flour structure of Svevo variety, H bond peaks of OH groups in the range of 3600-3300 cm^{-1} were determined as a thick band. It has been thought that aliphatic C-H peaks in the range of 2950-2850 cm^{-1} were associated with glycoside units in the structure. In the related spectrum, carbonyl stretching vibrations belonging to amide groups in the protein structure, peptide bond C-N stretching vibrations, and C-O-C and C-O stretching vibrations from carbohydrates have been determined at 1600 cm^{-1}, 1490 cm^{-1} and about 1000 cm^{-1}, respectively. Since the gluten has a protein structure, the related spectrum looks like a typical protein FTIR spectrum. In this spectrum, C=O stretching vibrations of gluten proteins at approximately 1600 cm^{-1}, C-N stretching vibration at 1490 cm^{-1}, C-C stretching vibration at about 1500 cm^{-1}, C-H stretching vibrations of aliphatic methyl groups in the range of 2850-2950 cm^{-1} and a broad band of H bonds in the protein structure in the range of 3000-3600 cm^{-1} appeared. In uncooked noodles, the peaks appear similar to the flour structure. It was observed that the H bond peaks of OH groups, which were appeared only in the range of 3000-3600 cm^{-1} due to structural moisture loss during drying, decreased.

The cooked noodle structure, gave a similar FTIR spectrum as the dry noodle since it was dried after cooking. It is clearly seen that there is no structural deterioration during cooking due to the similarity in the spectra.

Durum wheat varieties were selected as Svevo, Zühre and Zenit. Figure 2g, h and ı represent the FTIR spectra of flour and dry/cooked noodle structures obtained from Svevo, Zühre and Zenit durum wheat varieties, respectively. In Figure 3a, in the flour spectrum of Svevo variety, H bond peaks belonging to OH groups in the range of 3600-3300 cm^{-1} were seen as a thick band. Aliphatic C-H peaks in the range of 2950-2850 cm^{-1} are attributed to the glycoside units in the structure. In Figure 2g spectrum, in the flour structure carbonyl stretching vibrations belonging to amide groups in protein structure at 1600 cm^{-1}, peptide bond C-N stretching vibration at 1490 cm^{-1}, were seen. C-O-C and C-O stretching vibrations associated with carbohydrates at 1000 cm^{-1} were also visible. In the gluten structure, C=O stretching vibrations at approximately 1600 cm^{-1}, C-N stretching vibration at 1490 cm^{-1}, C-C stretching vibration at about 1500 cm^{-1}, C-H stretching vibrations of the aliphatic methyl groups in the range of 2850-2950 cm^{-1} and the broad band attributed to H bonds in protein structure in the range of 3000-3600 cm^{-1} standed out. As the structure exhibits protein properties, the C-O-C peak was seen differently. The peaks in the uncooked noodles appear to be similar to the flour structure. It has been observed that the H bond peaks of OH groups, which are seen only in the range of 3000-3600 cm^{-1} due to structural moisture loss during drying, decreased. In the cooked noodle structure, FTIR spectrum similar to dry noodles was observed since it was dried after cooking process. It is clearly understood that there was no structural deterioration during cooking due to the similarity in the spectra.

In Figure 2h, in the spectrum of the flour of the Zühre variety, hydrogen bond vibrations originating from the hydroxyl group of the glycoside units in the range of 3000-3600 cm^{-1}, aliphatic C-H stretching vibrations in the range of 2830-2950 cm^{-1}, $amide^{-1}$ peak at 1620 cm^{-1}, amide-2 peak at 1540 cm^{-1}, C-N stretching vibration at 1490 cm^{-1}, C-O-C etheric stretching vibrations at 1112 cm^{-1} confirm the general flour structure. In FTIR spectra of gluten structure, C=O stretching vibration of the protein groups at 1620 cm^{-1}, amide-2 peak and C-C stretching

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vibration at 1540 cm^{-1}, and C-N stretching vibration at 1444 cm^{-1} were seen. The stretching vibrations in the structure of the carbohydrate disappeared. The gluten structure was obtained pure and clean. FTIR spectra of dried and cooked noodle were similar to each other and there was no structural degradation in the noodles during cooking process

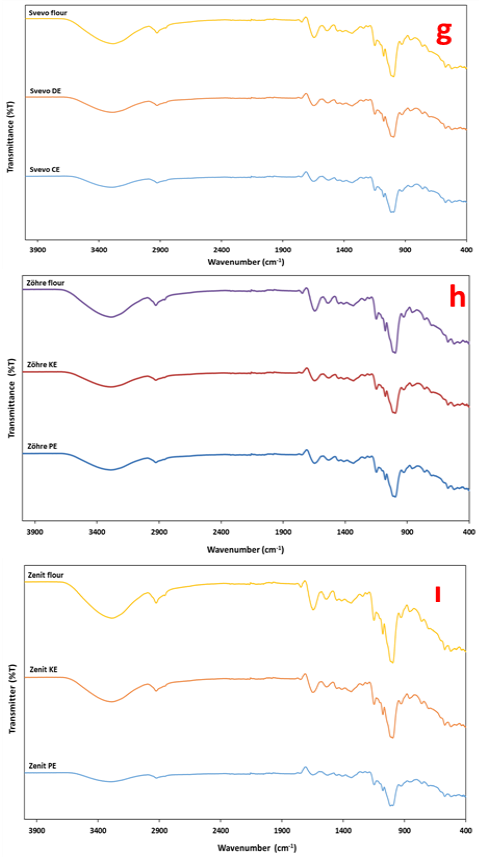

Figure 2. FTIR spectra of flour and dry/cooked noodle structure obtained from the durum wheat varieties g) for Svevo, h) for Zühre and ı) for Zenit.

. Basically the characteristic peak structure of the noodle originates from flour structures. In Figure 2ı, in the flour structure of Zenit variety, the etheric stretching vibrations in carbohydrate structure at 1000-1100 cm^{-1} were detected. This peak confirms the carbohydrate structures in dry and cooked noodles. In this spectra, C=O peak of the proteins in the flour structure at 1670 cm^{-1}, amide peak at 1560 cm^{-1} and C-N peak at 1440 cm^{-1} were observed. This protein structure was prominently detected in the gluten of Zenit variety. The dried noodles obtained from

the Zenit variety preserved the flour structure exactly. Therefore, it can be said that it is quite suitable for the production of noodles.

Morphology and Microscopic Properties of Noodles

The morphological structures of the noodles were investigated with SEM technique. SEM images of the noodle samples obtained from white bread wheat varieties were given in Figure 3 A, B, and C. In Figure 3A, the noodle structures obtained from Ceyhan-99 white bread wheat flour had a general spread pore size of approximately 10-20 µm. Figure 3B shows the noodle morphology produced from white wheat flour obtained from the Gökkan variety. Surface continuity was impaired. Cracked and large cavities standed out on the noodle surface. Unlike other flour varieties, regular pores spread over the general were not seen. There were laminar layers. In Figure 3C, this porous structure was preserved in the noodle structure obtained from Kaşifbey variety. However, the interface showed a more homogeneous structure. The distance between the pores has shortened. SEM images of the noodle samples obtained from red bread wheat varieties were given in Figure 3D, E, F. In Figure 3D, the noodle samples obtained from Pandas red bread wheat flour had a very porous and fractional structure. Pore sizes vary from approximately 20 µm to 1 µm. The noodle samples obtained from red bread wheat varieties had heterogeneous porosity. In Figure 3E, it was seen that the noodle samples obtained from Pehlivan red bread wheat flour have an ideal porosity structure.

The pore size distribution was quite stable, around 5µm. All porosity was visible throughout the entire image. The structure looked quite pure and clean and no foreign substance was observed. In Figure 3F, the noodles obtained from Sagittario red bread wheat flour showed a porous and locally smooth structure. Partial cracks were detected in noodles obtained from Sagittario red bread wheat flour. Furthermore, laminar (planar) fragments were visible in this noodle samples.

SEM images of the noodle samples obtained from durum wheat varieties are given in Figure 3 G, H, I. In Figure 3G, a deep porous and fractal structure was generally observed in the noodle samples obtained from Zenit durum wheat flour. A holistic SEM image was outstanding. There was a uniform distribution in certain regions and a heterogeneous distribution in certain regions.

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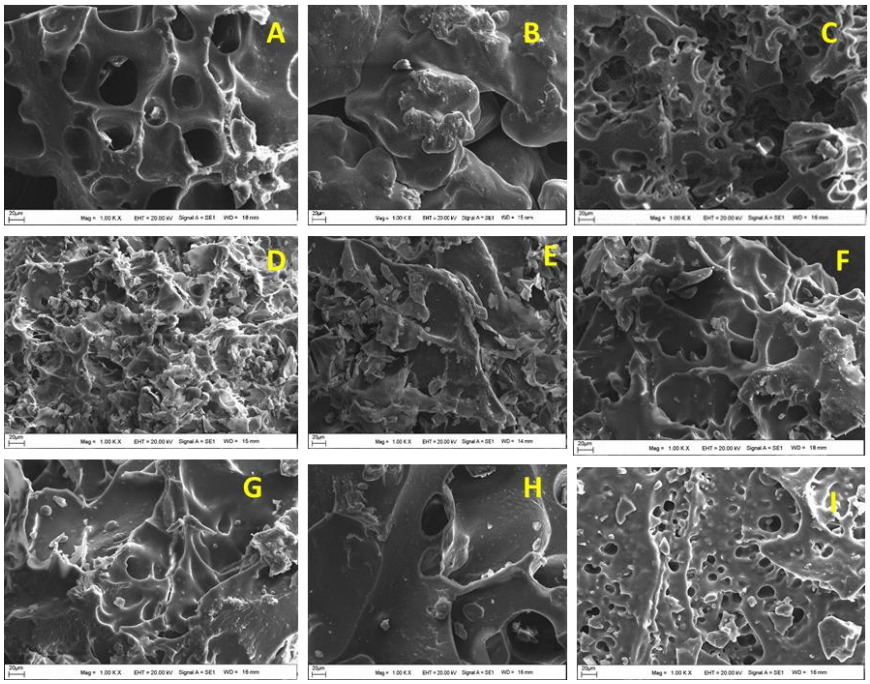

Figure 3. SEM images of (A) noodles obtained from Ceyhan-99 white bread wheat flour, (B) noodles obtained from Gökkan white bread wheat flour, (C) noodles obtained from Kaşifbey white bread wheat flour, (D) noodles obtained from Pandas red bread wheat flour, (E) noodles obtained from Pehlivan red bread wheat flour and (F) noodles obtained from Sagittario red bread wheat flour, (G) noodles obtained from Zenit durum wheat flour, (H) noodles obtained from Zühre durum wheat flour and (I) noodles obtained from Svevo durum wheat flour.

However, the structure looked homogeneous and clean. In Figure 4H, a very smooth, homogeneous and clean SEM image was obtained in the noodle samples obtained from Zühre durum wheat flour. Porosity was not detected. A fractal structure was dominant. In Figure 4I, there was a very common and spongy structure in noodle samples obtained from Svevo durum wheat flour. Although open porosity, pore sizes were not homogeneous. This porosity was around aproxmately 20 * 40 µm and 3 * 3 µm. The ideal noodle structure was determined in accordance with the literature (Li et. al., 2017).

Swelling Studies

Figure 4 indicates the swelling test results of different noodle samples in water. The swelling ratios of all of the samples increased with time. Zenit sample showed the highest swelling capacity and Pehlivan sample showed the lowest swelling capacity. All samples showed the highest swelling behavior in the first 5 min and

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then lower swelling in a period of one hour. The swelling values of each sample were measured every 5 min from the beginning and calculated as a percentage. Statistical analysis indicated that Pandas, Pehlivan, Zühre, Ceyhan 99 and Kaşifbey samples had a significant swelling (%) compared to the beginning at 55 and 60 min ($p < 0.05$). In the Svevo, Zenit and Gökkan samples, the swelling value (%) reached only at 60 min was significant compared to the beginning ($p < 0.05$). However, swelling value (%) in Sagittario sample did not show any significant difference at all times.

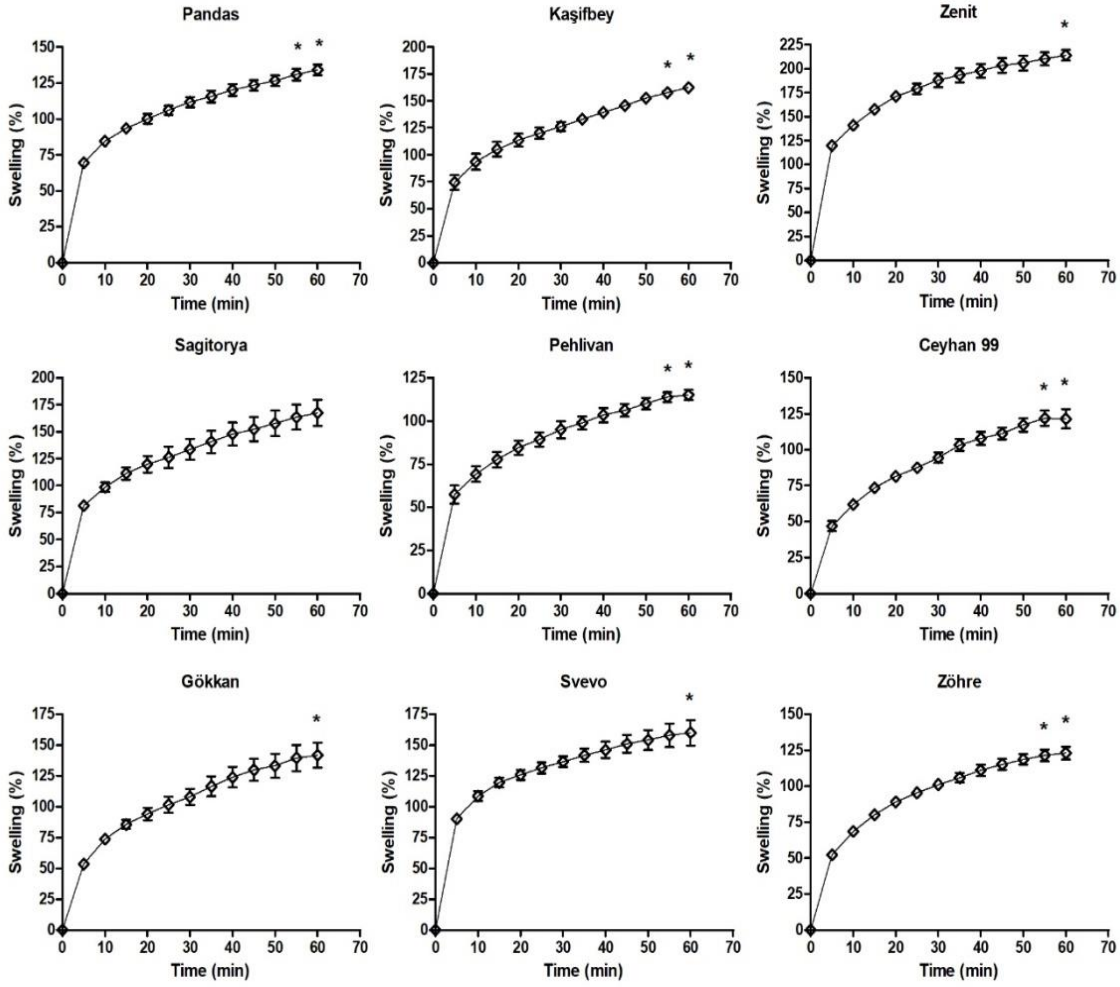

Figure 4. The results of the swelling test of different noodle samples. (The results are expressed as mean ± standard error. An asterisk (*) symbolizes the statistical significance between other times compared to the beginning ($p < 0.05$)

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SDS–PAGE

According to SDS-PAGE technique, protein profiles of bread and durum wheat flours and noodles obtained from these flours are shown in Figure 5 and Figure 6. It was determined that the molecular weights of the wheat flour proteins ranged from 29 to 117.8 kDa. The protein molecular weights of noodles prepared from the same flour were found to be between 32.41 and 118.57 kDa. The low molecular weight (24-66 kDa) wide protein bands detected in the first 3 flour samples of white bread varieties, when the same flour became noodles, turned into more thin protein bands with low molecular weight (32 kDa, 35 kDa, 38 kDa) (Fig. 5A). It has been observed that the low molecular weight protein bands detected in samples 4, 5 and 6 of the red bread varieties contain lower molecular weight bands when they converted into noodles (Fig. 5B).

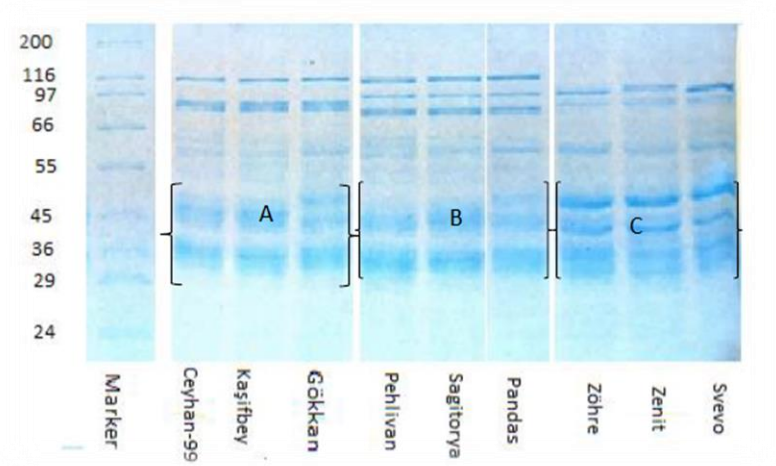

Figure 5. Electrophoresis image of wheat flours.

It has been found that protein bands of flours obtained from durum wheat varieties have low molecular weight (in the range of 32.12 kDa - 98 kDa). It is seen that the proteins detected in durum wheat flour samples are in the structure of gliadin and its derivatives. It was determined that the number of low molecular weight protein bands detected in flour samples of durum varieties decreased quantitatively when noodles were obtained from the same flour samples (Fig. 5C). These changes can reflect the decomposition of high molecular weight proteins due to the heat effect of cooking, which suggests the polymerization of gluten. This is consistent with a

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study reporting that the density of gluten bands is significantly reduced as a result of heat application and that the internal structures of gluten are more easily affected by high-temperature gliadins. (Luo et. al., 2016).

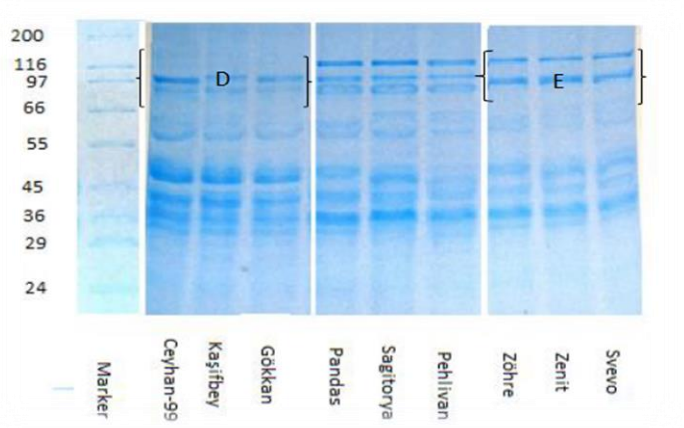

Figure 6. Electrophoresis image of wheat noodles.

The band density with a molecular weight of 45-55 kDa was found to be less in white bread varieties, while the band thickness was more intense, and less in red bread and durum varieties. High molecular weight (118 kDa) protein bands present in flours of white bread variety could not be detected in the noodle samples prepared from the same varieties (Fig. 6 D) In contrast, when flour samples of durum wheat were converted into noodles, high molecular weight (119-103 kDa) protein bands were obtained. (Fig. 6 E). The high molecular weight (118 kDa) band detected in white and red bread flours could not be detected in durum wheat varieties.

Conclusion

In this study, structural, morphological and chemical properties of noodles obtained from 9 different wheat varieties (white and red bread and durum) during preparation and cooking process were determined with different instrumental techniques. In the noodles obtained from wheat flours of durum and white bread varieties, no structural degradation was detected during cooking process. However, in the structure of noodles obtained from red bread wheat varieties, protein loss was partially determined by cooking. It has been observed that the surface continuity deteriorates and there are cracks and large cavities on the surface of the noodles obtained from bread wheat flour. There are laminar layers. A quite extended and

spongy structure was seen in the noodle samples obtained from durum wheat flour. SDS-PAGE technique was used to analyze protein model changes in different wheat flours and dried noodles obtained from these flours. With the same loading amount, the density of the protein bands of durum wheat flour decreased significantly with the increasing dehydration temperature during the preparation process of noodle and high molecular weight (119-103 k Da) protein bands were obtained. Low molecular weight (24-66 kDa) wide protein bands detected in flour samples of bread varieties, turned into more fine protein bands with low molecular weight when the same flours became noodles. Structural and molecular changes have been detected with increasing dehydration temperature. At the end of the study, when all the results are evaluated together, it is thought that the most suitable wheat variety for noodle production is durum wheat. When the red and white bread wheat varieties are evaluated within themselves, it is concluded that white bread wheat is more suitable than red bread wheat for noodle production. This study provided information on flour's protein structure during processing, as well as providing reference information for evaluating noodle quality.

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