Effects of Various Citrus Fiber Coatings on the Color, Texture, and Sensory Properties of Chicken Nuggets

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Abstract

Wastes from the fruit juice industry are sources rich in functional compounds like dietary fiber. The present study aimed to investigate the suitability of dietary fibers derived from the orange, lemon, and grapefruit juice production wastes in the production of chicken nuggets as a coating material. In the control group, nugget samples were coated with breadcrumbs. Obtained chicken nuggets were analyzed for color, texture, pH, and sensory properties. The results indicated that the use of dietary fiber from different sources had a statistically significant effect on the pH and L^*, a^*, and b^* values of the product before and after cooking at the level of $p < 0.01$. Particularly, the use of lemon and grapefruit fiber decreased the pH value of the samples significantly, whereas the usage of grapefruit fiber increased the a^* value of both raw and cooked samples significantly. The results of the sensory analysis of the cooked samples revealed that except for salinity and juiciness, all sensory parameters were influenced significantly ($p < 0.05$) by the use of dietary fiber, and the grapefruit-coated samples had a more bitter taste compared to the other groups. In terms of overall acceptability scores, the lowest mean value was determined in the samples coated with grapefruit fiber. All texture parameters except adhesiveness and springiness were influenced by the use of different dietary fibers in cooked samples ($p < 0.05$).

Keywords: Nugget, Orange fiber, Grapefruit fiber, Lemon fiber.

1. Introduction

Chicken meat is an important source of protein that can be purchased at a lower price. Due to its structure, it is appropriate for further processing techniques and can be used to produce a wide variety of processed meat products from chicken ham to emulsified sausage. One popular food obtained by processing chicken meat is nuggets (Talu and Kayaardı, 2012). For the production of a quality industrial nugget, 80-85% chicken breast meat and 5-10% chicken skin are used. For production at low cost, the ratio of chicken skin in the base formulation can be increased and the production can also include mechanically separated chicken meat. Depending on the recipe, a certain amount of salt, spices, phosphate and ice water can be included in this mixture. The shaped nuggets are dusted with a fine layer of flour for a better adhesion of the batter and following the battering process, the outer surface of the battered nuggets are coated with crumbs for enhanced texture and flavor (Feiner, 2006). By changing the ingredients in the nugget recipe, the product formulation can be modified and the nugget formulation can be made more functional (Khatun et al., 2022).

Fruits and vegetables naturally have many beneficial functional compounds for human health. Dietary fiber, which is among these functional compounds, positively affects consumer health and is used for improving product's technological features. In terms of its general chemical composition, chicken meat is an important source of protein and essential amino acids. Unlike plant-based products, however, due to its structure, chicken meat does not contain dietary fiber and to eliminate the deficiency, plant-based dietary fibers can be added to processed chicken products for functional purposes (Talukder, 2015).

Citrus wastes are an important source of dietary fiber. There have been many studies conducted on the

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use of fibers derived from these wastes in the formulations of highly processed products (Nieto et al., 2021). Among the processed meat products in which citrus fibers are used successfully in formulations are dry-fermented sausage (Yalınkılıç et al., 2015; 2016), non-fermented dry-cured sausage (Sayas-Barbera et al., 2012), emulsified sausage (Viuda-Martos et al., 2010), chicken patty (Abdel-Naeem et al., 2022), and chicken meatball (Kılınççeker and Yılmaz, 2019). The effects of dietary fiber sources including wheat bran (Pathera et al., 2017), green pea (Binti Mohd Zaini, 2021), and dragon fruit peel (Madane et al., 2020) were investigated in studies on the quality parameters of chicken nuggets. On the other hand, the effects of orange fiber (Golge et al., 2018) and orange albedo (Ammar, 2017) were investigated in studies on the effects of citrus fibers on nugget production. Nevertheless, there is no study that investigates the effect of using citrus fibers like lemon and grapefruit, as well as orange fiber, as coating material in nugget production on the color, texture and sensory features of the product. Therefore, this study aims to investigate the effect of heat-treated dietary fibers derived from orange, lemon, and grapefruit juice production wastes on the textural, color, and sensory features of chicken nuggets.

2. Material and Methods

2.1. Materials

All of the materials (skinned chicken breast meat, sunflower oil, spices, and salt) that were used in the study were purchased from a national gross market chain (Iğdır/Türkiye). The oranges, lemons, and grapefruits used in the production of dietary fiber were also obtained from the same market chain.

2.2. Production of dietary fibers

For dietary fiber production, the flavedo layer of lemon, orange, and grapefruit fruits was first peeled with a knife and then the juice extraction process was performed with the assistance of a juicer (Sinbo SJ-3143, Istanbul, Turkey). Following this process, the residual pulp was processed based on the method described by Fernandez-Gines et al. (2003), which resulted in the production of cooked-dried dietary fibers. Within this scope, fibers of lemon, orange and grapefruit were produced from fruit juice wastes. In total three different groups of dietary fibers were produced in the laboratory environment.

2.3. Nugget production

For the production of nuggets, chicken breast meat was used. After purchasing, the skinned chicken breast meat was brought to the meat technology laboratory under cold chain and stored in refrigerator at 2°C until use. The chicken breast meat was ground in a meat grinder (Beko Km 5024M, Istanbul, Turkey) using a 3 mm plate and the ground chicken meat was then mixed by adding 2% NaCl, 0.3% black pepper, and 0.5% garlic powder. Following the mixing process, the nugget dough was allowed to rest at 2°C for 2 hours and then proceeded to the molding process. In the molding process, manual nugget molds (Artvinli Machine, Bursa, Turkey) with a 70 mm diameter were used and the nugget dough weight was standardized as 40g. The molded nugget mixtures were coated with flour and milk-egg mixture in order, and at the last step, they were coated with breadcrumbs in the control group and lemon fiber, orange fiber and grapefruit fiber individually in the experimental groups. After the coating process, the nuggets were rested at 2°C for 1 hour and then deep-fried in sunflower oil at 175°C for 3.5 minutes. As a result, four different groups of nuggets were produced. The group coated with breadcrumbs served as the control group, while the nuggets coated with lemon fiber, orange fiber, and grapefruit fiber constituted the other groups.

2.4. Analyses

2.4.1. Color Analysis

The color measurements (L*: lightness, a*: redness, and b*: yellowness) of the raw nugget samples were determined using a colorimeter (Chroma Meter CR-400, Japan) with illuminant D65, 2° observer. Following the calibration of colorimeter, raw nugget samples were measured prior to cooking, and cooked nugget samples were measured 15 min after cooking process. The color values of the samples were measured on the outer surfaces of the nuggets. The color measurement was carried out at three replicates with five samples in each group.

2.4.2. Texture profile analysis

Cooked nugget samples were cooled to room temperature for 10 min after cooking, and the samples were analyzed with the use of a texture profile analyzer (Stable Macro System - TA.XT2I) for hardness, adhesiveness, chewiness, springiness, resilience, gumminess, and cohesiveness parameters. Five parallel measurements were taken from each sample in each replicate. The running conditions were as follows; probe: 36 mm dia aluminium radiused aacc, pre-test speed: 1.00 mm/sec, test speed: 5.00 mm/sec, post-

test speed: 5.00 mm/sec, distance: 10mm, time: 5 sec, trigger force: 5.00 g, load cell: 5 kg

2.4.3. Sensory analysis

After cooking, samples were evaluated by 23 semi-trained panelists in terms of appearance, texture, odor, bitterness, saltiness, juiciness, and overall assessment parameters using a nine-point hedonic scale. The total number of semi-trained panelists who participated in three different sensory sessions was 69.

2.4.4. pH

Ten g of samples in 100 mL of distilled water were homogenized using an Ultra-Turrax (IKA Werk T 25, Germany) homogenizer, and the pH value of the samples was measured with a calibrated pH-meter (ATI ORION 420, MA 02129, USA). The pH measurement was carried out at three replicates with two samples in each group.

2.4.5. Statistical analysis

The use of dietary fiber in the study was evaluated as a factor. The experiments were performed with three replicates. The results obtained for each parameter were analyzed with one-way ANOVA, and the differences among the groups were tested with Duncan's multiple comparison test at the $p < 0.05$ level. All statistical analyses were carried out using the IBM SPSS Statistics 25 software package.

3. Results and Discussion

3.1. Color Values

Table 1 presents the L*, a*, and b* values of raw nuggets. Application of cooked-dried citrus fibers as coating material in nugget production had a very significant ($p < 0.01$) impact on the color values of the product. In fact, a statistical difference at $p < 0.05$ level was detected between the experimental groups and the control group in the L* value, an indicator of brightness, depending on the use of dietary fiber in the production of nuggets. This situation is likely due to the color substances in citrus fibers. In a similar manner to our findings, it was determined that the use of orange fiber in dry fermented sausage (Yalınkılıç et al., 2012) and lemon fiber in low-fat chicken meatballs led to a significant increase in L* value (Chappalwar et al., 2021). Regarding a* values, which give information about redness and blueness values, it was found that the highest a* value was found in nuggets produced using grapefruit fiber. On the contrary, it was found that the a* values of the products coated with lemon fiber and orange fiber were lower than the control group ($p < 0.05$). Regarding the b* values of the nuggets without heat treatment, it was also determined that higher b* values were observed due to the use of citrus fiber and the highest b* value was detected in the products coated with grapefruit fiber, as in the a* value. The samples coated with grapefruit fiber had higher a* values, which is likely due to the fact that this dietary fiber source contained more lycopene and β-carotene than oranges and lemons (Xu et al., 2006).

The L*, a*, and b* values of deep fried nuggets are presented in Table 1. It can be observed that there were statistically significant differences ($p < 0.01$) between the groups with respect to the color parameters in the cooked nuggets as in the raw product. There was a decrease in the mean values of all groups after the heat treatment with respect to L* value, while there was an increase in the mean values of a* and b* parameters independently of the group. Caramelization reaction and Maillard reaction products during deep frying process probably lead to a decrease in L* value of chicken nuggets (Ngadi et al., 2007). In terms of L* value, no statistical difference was observed between the control group and the nuggets coated with lemon

Table 1. Color values of nuggets before and after cooking

Group	Color of uncooked product			Color of cooked product		
	L*	a*	b*	L*	a*	b*
Control	66.53±3.61[a]	3.84±1.01[c]	18.81±2.95[a]	55.67±2.89[b]	11.13±1.21[b]	37.74±1.84[a]
Lemon	74.27±2.64[c]	1.71±0.34[b]	20.61±1.10[b]	54.60±2.98[b]	12.33±1.39[c]	38.06±1.86[a]
Orange	74.98±2.71[c]	-1.36±0.34[a]	29.83±1.55[c]	63.17±1.12[c]	7.06±1.68[a]	46.54±1.16[c]
Grapefruit	69.84±1.50[b]	7.47±0.68[d]	32.19±0.84[d]	49.56±2.81[a]	17.78±1.72[d]	41.31±2.57[b]
Significance	**	**	**	**	**	**

a-d: Any two means in the same column having the same letters in the same section are not significantly different. **$p < 0.01$.

fiber (p >0.05), while the highest value was determined in the products coated with orange fiber (p < 0.05) and the lowest value was determined in the products coated with grapefruit fiber (p < 0.05). When the a* value averages of the samples were taken into consideration, as in the raw samples, the highest average a* value was detected in the products coated with grapefruit fiber. There was no difference (p > 0.05) in the mean b* values of the heat-treated products between the products coated with lemon fiber and the control group, whereas a statistically significant difference was observed in the mean b* values of the products coated with orange and grapefruit fiber (p < 0.05). In a similar manner to our study findings, the color values of cooked chicken meatballs with apple fiber, pea fiber, and lemon fiber exhibited variability depending on the type of fiber used (Kılınççeker and Yılmaz, 2019). Furthermore, in the study conducted by Ngadi et al. (2007), it was determined that deep-frying increased the a* and b* values of chicken nuggets significantly. Another study on chicken nuggets with different protein types deep-fried in oil found that deep-frying decreased the L* value and increased the a* value of the samples, although a similar tendency was not found for the b* value (Doğan et al., 2005).

3.2. pH value

Table 2 presents the pH values of the raw nugget samples. The pH values of the raw nugget samples ranged between 5.14 and 5.98 and there were significant (p < 0.01) differences in pH values due to the use of dietary fiber. While the lowest pH value was detected in the group with lemon fiber with 5.14, a statistically significant (p < 0.05) difference was detected between the group with grapefruit fiber and the control group. It is likely that the different pH values detected in raw nugget samples are associated with the acidic compounds in the fiber type used as coating material (Ünal et al., 2022). Indeed, it has been found that the use of lemon fiber in the production of low-fat chicken meatballs decreased the pH value of the product significantly, which is similar to our findings (Chappalwar et al., 2021). Moreover, dietary fiber use in meat products can either decrease or increase the pH value of the product based on the type and source of the dietary fiber used, or it can have little effect on the pH value of the product (Choi et al., 2011).

In all deep fried groups, significant increase was observed in the mean pH values (Table 2). The lowest pH value of 5.46 was observed in the nuggets coated with lemon fiber (p < 0.01) just like the raw nuggets. Presumably, the pH increase in the heat-treated products is related to changes in the proteins in the

Table 2. pH values of nugget samples coated with different citrus fibers before and after cooking

Group	Uncooked Product	Cooked Product
Control	5.98±0.05[c]	6.12±0.05[c]
Lemon	5.14±0.66[a]	5.46±0.95[a]
Orange	5.93±0.10[c]	6.10±0.06[c]
Grapefruit	5.40±0.72[b]	5.76±0.05[b]
Significance	**	**

a-d: Any two means in the same column having the same letters in the same section are not significantly different. **p < 0.01.

meat layer of the nugget. In fact, denaturation of meat proteins and degradation of free amino acids take place depending on the heat treatment during cooking, and as a result, nitrogenous compounds that lead to an increase in pH are produced (Sohn and Ho, 1995; Alugwu et al., 2022). Increase in pH was also observed in another study in nugget samples, produced by the use of orange fiber, after cooking and this situation was interpreted by the alkaline compounds that emerged in the meat mixture during the heat treatment (Ammar, 2017).

3.3. Sensory analysis

Table 3 presents the results of the sensory analysis of the deep fried nuggets. According to the scores of the samples presented to the panelists, except for salinity and juiciness parameters (p > 0.05), all parameters were significantly (p < 0.01) effected by the use of dietary fiber as coating material. In case of using dietary fibers from different sources, there may be significant differences in the sensory scores of nugget samples (Ammar, 2017; Chappalwar et al., 2021; Khatun et al., 2022). While appearance score was the highest in the samples coated with grapefruit fiber, the control group was the next highest. For texture parameter, the highest mean values were determined in the control group and nuggets coated with orange fiber (p < 0.05). On the other hand, the lowest texture value was found in the samples coated with grapefruit fiber. For the odor parameter, similar to the texture value, the lowest mean value was found in the nuggets coated with grapefruit fiber (p < 0.05), while no statistical difference was noted between the mean values of the other three groups with respect to the odor parameter (p > 0.05). Panelists who consumed the heat-treated nuggets disliked the products coated with grapefruit fiber with respect to bitterness parameter and rated the products coated with this fiber with a

Table 3.   The results of sensory analysis of cooked nugget samples coated with different citrus fibers

Group	Appearance	Texture	Odor	Bitterness	Salinity	Juiciness	Overall Assessment
Control	5.98±1.66[ab]	6.36±1.64[b]	6.36±1.57[b]	2.02±1.27[a]	3.11±1.50[a]	4.64±1.97[a]	6.29±1.50[b]
Lemon	5.64±1.57[a]	6.00±1.70[ab]	6.22±1.86[b]	2.64±1.86[a]	3.02±1.40[a]	4.60±2.09[a]	6.11±1.60[b]
Orange	5.71±2.30[a]	6.60±1.47[b]	6.70±1.52[b]	1.88±1.08[a]	2.81±1.36[a]	4.40±2.13[a]	6.17±1.68[b]
Grapefruit	6.56±1.83[b]	5.51±1.82[a]	4.91±2.26[a]	5.84±2.74[b]	2.67±1.45[a]	3.89±2.22[a]	3.61±1.82[a]
Significance	*	*	*	*	NS	NS	*

a-d: Any two means in the same column having the same letters in the same section are not significantly different. *$p < 0.05$, **$p < 0.01$, NS: not significant.

high bitterness score ($p < 0.05$). Nevertheless, no statistical difference ($p > 0.05$) was found between the orange fiber and lemon fiber groups and the control group for bitterness values. Regarding the overall assessment parameter, it was understood that the use of grapefruit fiber in nugget production was at unacceptable levels ($p < 0.05$). Conversely, no statistical difference ($p > 0.05$) was found between the use of lemon fiber and orange fiber as coating material and the control group with respect to the overall assessment parameter. The fact that the nugget samples coated with nugget scored high on bitterness score is possibly due to the flavanone glicoside called naringin, which is found in grapefruit fiber and gives a bitter taste to the product. Because this compound imparts a bitter taste to grapefruit where it is present in high levels (Victor et al., 2018).

3.4. Texture Profile Analysis

Table 4 presents the results of texture profile analysis of the nuggets cooled at room temperature after deep fat frying. It was found that there were significant statistical differences ($p < 0.01$) between the mean values of hardness value. Whereas the lowest hardness value was determined in the control group where breadcrumbs were used as the outer coating material,

all groups prepared using citrus fiber showed higher mean values in comparison to the control group ($p < 0.01$). This was probably a result of the chemical composition of the dietary fibers used in the study. Because citrus fiber sources are rich in different carbohydrate compounds, dietary fiber coated nuggets may have been harder (Wang et al., 2015). However, on the other hand, this variation may have affected the water-holding capacity of dietary fiber and thus particularly affect product texture scores (Binti Mohd Zaini et al., 2021). No statistically significant difference ($p > 0.05$) was observed between the groups with respect to adhesiveness and springiness values. Cohesiveness and resilience values were the highest mean values and gumminess and chewiness parameters were the lowest mean values in the control group ($p < 0.05$). The nugget samples coated with lemon fiber, orange fiber, and grapefruit fiber exhibited higher gumminess and chewiness values. In studies where alternative dietary fibers were used to produce chicken nuggets, significant differences between the samples with respect to texture parameters were found similar to our findings, according to the type of dietary fiber used (Pathera et al., 2017; Chappalwar et al., 2021).

Table 4.   The results of texture profile analysis of cooked nuggets coated with different citrus fibers

Group	Hardness	Adhesiveness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
Control	23486.64±7206.97[a]	-1.46±1.09[a]	0.86±0.004[a]	0.73±0.05[b]	16891.44±4371.49[a]	14545.83±3603.90[a]	0.34±0.04[b]
Lemon	32019.94±9797.98[ab]	-2.72±2.77[a]	0.82±0.06[a]	0.66±0.04[a]	20774.77±5725.42[ab]	17021.78±5096.07[a]	0.29±0.02[a]
Orange	43741.87±5635.72[c]	2.68±2.01[a]	0.85±0.08[a]	0.63±0.02[a]	27505.79±2747.54[c]	23382.11±4261.97[b]	0.29±0.01[a]
Grapefruit	36188.91±5757.54[bc]	-4.80±2.42[a]	0.80±0.04[a]	0.66±0.03[a]	23901.35±2562.41[bc]	18981.36±2490.65[ab]	0.29±0.02[a]
Sig.	*	*	*	*	NS	NS	*

a-d: Any two means in the same column having the same letters in the same section are not significantly different. *$p < 0.05$, **$p < 0.01$, NS: not significant

4. Conclusions

The present study investigates the usability of dietary fiber derived from the wastes of orange, lemon, and grapefruit juice production as a coating material in chicken nugget production. It was found that it is possible to successfully use orange and lemon fiber as nugget coated material, except for grapefruit fiber, which adversely affects the sensory properties of the product. The use of orange and lemon fiber as a coating material in the production of nuggets is a favorable example of converting agricultural wastes in food production into high value products. Furthermore, the health beneficial phytochemicals within the dietary fiber are delivered to the consumer via chicken nuggets, which makes chicken nuggets more functional in terms of health.

Declaration of Competing Interest

The authors declare that they have no financial or non-financial competing interests.

Author's Contributions

B. Yalınkılıç (0000-0002-6195-7821): *Definition, Data Collection, Investigation Conceptualization, Writing, Methodology, Supervision, Editing.*
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References

Abdel-Naeem, H. H., Elshebrawy, H. A., Imre, K., Morar, A., Herman, V., Paşcalău, R., & Sallam, K. I. (2022). Antioxidant and antibacterial effect of fruit peel powders in chicken patties. Foods, 11(3), 301.

Alugwu, S. U., Okonkwo, T.M. & Ngadi, M.O. (2022). Effect of Cooking on Physicochemical and Microstructural Properties of Chicken Breast Meat. European Journal of Nutrition & Food Safety, 14(11), 43-62.

Ammar, M. S. (2017). Producing of high fiber chicken meat nuggets by using different fiber sources. Middle East Journal of Agriculture Research, 6(2), 415-423.

Binti Mohd Zaini, H., Mantihal, S., Ng, F. W. Y., & Pindi, W. (2021). The incorporation of green peas as the source of dietary fiber in developing functional chicken nuggets. Journal of Food Processing and Preservation, 45(5), e15412.

Chappalwar, A. M., Pathak, V., Goswami, M., Verma, A. K., & Rajkumar, V. (2021). Efficacy of lemon albedo as fat replacer for development of ultra-low-fat chicken patties. Journal of Food Processing and Preservation, 45(7), e15587.

Choi, Y. S., Kim, H. W., Song, D. H., Cho, J. H., Park, J. H., Kim, M. Y., ... & Kim, C. J. (2011). Quality characteristics and sensory properties of reduced-fat emulsion sausages with brown rice fiber. Food Science of Animal Resources, 31(4), 521-529.

Dogan, S. F., Sahin, S., & Sumnu, G. (2005). Effects of batters containing different protein types on the quality of deep-fat-fried chicken nuggets. European Food Research and Technology, 220, 502-508.

Feiner G., 2006. Typical patty and nugget products from around the World. In Meat products Handbook Practical Science and Technology, CRC Press, New York.

Fernandez-Gines, J.M., Fernandez-Lopez, J., Sayas-Barbera, E., Sendra, E., & Perez-Alvarez, J.A., 2003. Effect of storage conditions on quality characteristics of Bologna sausages made with citrus fiber. J. Food Sci. 68 (2), 710e715.

Golge, O., Kilincceker, O., & Koluman, A. (2018). Effects of different fibers on the quality of chicken meatballs. Journal of Food Safety and Food Quality, 69(6), 177-183.

Khatun, M. M., Hossain, M. A., Ali, M. A., Rahman, M. M., Azad, M. A. K., & Hashem, M. A. (2022). Formulation of value added chicken nuggets using carrot and ginger as a source of dietary fiber and natural antioxidant. SAARC J. Agric., 20(1), 185-196

Kilincceker, O., & Yilmaz, M. T. (2019). Physicochemical, technological and sensory properties of chicken meatballs processed with dietary fibers. Journal of the Hellenic Veterinary Medical Society, 70(2), 1525-1532.

Madane, P., Das, A. K., Nanda, P. K., Bandyopadhyay, S., Jagtap, P., Shewalkar, A., & Maity, B. (2020). Dragon fruit (Hylocereus undatus) peel as antioxidant dietary fibre on quality and lipid oxidation of chicken nuggets. Journal of food science and technology, 57(4), 1449-1461.

Ngadi, M., Li, Y., & Oluka, S. (2007). Quality changes in chicken nuggets fried in oils with different degrees of hydrogenatation. LWT-Food Science and Technology, 40(10), 1784-1791.

Nieto, G., Fernández-López, J., Pérez-Álvarez, J. A., Peñalver, R., Ros, G., & Viuda-Martos, M. (2021). Valorization of citrus co-products: Recovery of bioactive compounds and application in meat and meat products. Plants, 10(6), 1069.

Pathera, A. K., Riar, C. S., Yadav, S., Sharma, D. P., Yadav, Y. S., & Kumar, M. (2017). Optimization of dietary fiber enriched chicken nuggets for different cooking methods. Journal of Food Measurement and Characterization, 11, 1386-1397.

Sayas-Barberá, E., Viuda-Martos, M., Fernández-López, F., Pérez-Alvarez, J. A., & Sendra, E. (2012). Combined use of a probiotic culture and citrus fiber in a traditional sausage 'Longaniza de Pascua'. Food Control, 27(2), 343-350.

Sohn, M., & Ho, C. T. (1995). Ammonia generation during thermal degradation of amino acids. Journal of agricultural and food chemistry, 43(12), 3001-3003.

Talu, P., & Kayaardı, S. (2012). Tavuk etinin günümüzdeki önemi ve tavuk etinden üretilen bazı ürün çeşitleri. II. Et Ürünleri Çalıştayı 'İşlenmiş Kanatlı Eti Ürünleri', 6-7 Aralık 2012, Manisa.

Talukder, S. (2015). Effect of dietary fiber on properties and acceptance of meat products: a review. Critical reviews in food science and nutrition, 55(7), 1005-1011.

Unal, K., Alagöz, E., Çelik, İ., & Sarıçoban, C. (2022). Marination with citric acid, lemon, and grapefruit affects the sensory, textural, and microstructure characteristics of poultry meat. British Poultry Science, 63(1), 31-38.

Victor, M. M., David, J. M., Sakukuma, M. C., França, E. L., & Nunes, A. V. (2018). A simple and efficient process for the extraction of naringin from grapefruit peel waste. Green Processing and Synthesis, 7(6), 524-529.

Viuda-Martos, M., Ruiz-Navajas, Y., Fernández-López, J., & Pérez-Álvarez, J. A. (2010). Effect of added citrus fibre and spice essential oils on quality characteristics and shelf-life of mortadella. Meat science, 85(3), 568-576.

Wang, L., Xu, H., Yuan, F., Pan, Q., Fan, R., & Gao, Y. (2015). Physicochemical characterization of five types of citrus dietary fibers. Biocatalysis and agricultural biotechnology, 4(2), 250-258.

Xu, J., Tao, N., Liu, Q., & Deng, X. (2006). Presence of diverse ratios of lycopene/β-carotene in five pink or red-fleshed citrus cultivars. Scientia Horticulturae, 108(2), 181-184.

Yalınkılıç, B., Kaban, G., & Kaya, M. (2012). The effects of different levels of orange fiber and fat on microbiological, physical, chemical and sensorial properties of sucuk. Food microbiology, 29(2), 255-259.

Yalınkılıç, B., Kaban, G., Ertekİn, Ö., & Kaya, M. (2015). Determination of volatile compounds of sucuk with different orange fiber and fat levels. Kafkas Universitesi Veteriner Fakultesi Dergisi, 21(2): 233-239.

Yalınkılıç, B., Şişik-Oğraş, Ş., Kaban, G., Karaoğlu, M., & Kaya, M. (2016). Textural properties of fat-Reduced sucuk with orange fiber. Kafkas Universitesi Veteriner Fakultesi Dergisi, 22(3), 431-435.