Effect of Ohmic Heating on the Physical Properties of Fried Carrot Cubes

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***Abstract*—In the present study, the effect of ohmic heating on some physical and quality properties of carrot cubes was evaluated. Carrot cubes (1 cm^3) were pre-treated at two different voltage levels (95 V and 150 V) for 10 seconds. Then, carrot cubes were fried in sunflower oil for 60 seconds at 180 ℃. Moisture content (%, db), oil content (%, db), textural properties (firmness; g-force and hardness; g-force) and colour parameters (L*, a*, b* and total colour change; ΔE) of the samples were determined. According to the results, the moisture content of carrot samples varied in the range of 67.98±0.82-88.72±0.03 and the lowest corresponding value belonged to the carrot sample treated at 150 V. Similarly, the highest oil content (7.15±0.90) was measured for that same cube sample, as well. Any significant difference in hardness value was not observed among all fried samples (p>0.05). For colour parameters, the highest *L** (61.04±1.03) and *a** (31.22±1.52) were measured at the surface of raw carrot cubes and highest *b**(44.35±0.82) was found for the sample treated at 95 F. The lowest *L** (51.49±1.03) was measured on the surface of the samples subjected to the ohmic heating at 150 V. The lowest values corresponding to *a** (18.95±1.43) and *b**(38.10±1.45) were for the samples fried without ohmic treatment. The total colour change (Δ*E*) was in between 15.68±1.62 to 16.32±2.26 for all fried samples.**

***Index Terms*—carrot, ohmic heating, frying, physical properties, quality**

I. Introduction

One of the oldest and most popular cooking methods is frying, and deep-fat-frying is one of the techniques used for this cooking method. It is very popular for consumers because of their desirable flavor, colour and crispy texture [1]. Deep-fat frying is widely used in an industrial as well as institutional preparation of foods to obtain unique flavors, colours, and textures in processed foods.

In this method of food cooking, an edible fat/oil is heated above the boiling point of water (generally between 150-180 ℃) and the material is immersed in that hot oil for a certain time to fry so food material is partially or totally dried at the end of frying. During frying, oil migrates into the food, which accompanies water movement, but in the opposite direction [2], [3]. Frying time, food surface area, the initial moisture content of the food, types of breading or battering materials, and frying oil are the significant factors affecting the rate of oil and moisture transport during frying [4].

Carrot (*Daucus carota*) is one of the popular root vegetables grown throughout the world and is one of the world's most traded vegetable as both fresh and processed [2]. It is widely produced and consumed in Turkey and around the world (569.533 ton per year in Turkey, 2017) [5]. The carrot varieties have different colours, but the most common skin color is the orange. Carrot is a good source of vitamins and minerals especially β-carotene, provitamin A. Apart from its vitamin activity, carotenoids have strong antioxidant properties that may reduce the incidence of cardiovascular disease and certain types of cancer. Moreover, biologically active compounds found in carrot are necessary for bone growth and tooth development, gene expression, embryonic development, immune function and for normal vision. High intakes of dietary carotene have been investigated as a treatment to inhibit lipid oxidation and to prevent certain types of cancer in humans [3].

Carrots are processed, cooked and used in a wide variety of food products, such as fried carrot, chips, carrot juice, soup mixes, and also in oil and other skin care products. There are different cooking techniques for carrot such as deep frying, blanching, vacuum frying, etc, and these different techniques have different effects on the carrots. Congcong Xu *et al.* [6] studied the effects of the blanching pre-treatment on texture attributes and cell structure of carrots, and they said that blanching at 60 ℃ for 40 min improved the textural attributes by increasing elasticity strength. In another study, Fan *et al.* [3] studied the effect of vacuum frying on carrot chips. This study showed that the breaking force of carrot chips decreased with an increase in frying temperature and vacuum degree. However the statistical analysis indicated that there was no significant difference in the breaking force as a function of temperature.

Ohmic heating has been used for many years and has been expected to be one of the promising food processing technologies. Ohmic heating, also known as resistive heating, joule heating or electro-heating technique, is a heating process based on the passage of an electrical current through a material, which acts as a resistance against the electrical current [7]-[13]. The main advantages of this system are the rapid uniform heating, no residual heat transfer after the shutting-off of the current, and the high energy conversion efficiency, high

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maintenance of the colour and nutritional value of food, shorter processing times, and higher yields [8], [14]. Also, it has been used for different purposes instead of cooking, such as blanching, evaporation, dehydration, fermentation, sterilization, pasteurization, and heating of foods to serving temperature [9]-[12]. For example, Lima *et al.* [15] evaluated the effect of ohmic heating frequency on apple juice yield and hot-air drying rate, and they reported that ohmic heating increases the yield of apple juice when it is used as a pre-treatment. Wang *et al.* [13] determined the extraction rates of ohmically treated apple tissue with respect to the non-treated sample and measured the effect of frequency on extraction yield. Lima & Sastry [15] investigated the effects of voltage gradient, temperature, and holding time on the polyphenol oxidase activity for grape juice. Kumari *et al.* [16] studied the effects of the ohmic heating application on oil recovery from sesame seeds and its quality and the ability to increase the oil recovery. On the other hand, studies about the effect of ohmic heating pre-treatment on oil uptake behavior of vegetables during frying are fairly limited. Salengke *et al*. reported a study about ohmic heating as pre-treatment for potato slices before frying to investigate its effect on oil absorption. In that study, samples were placed directly in between two metal sandwiches as electrodes in a liquid medium. The results indicated that oil uptake during frying and subsequent cooling of potato slices was decreased as a result of ohmic pre-treatment using directing sandwiching in liquid medium [17]. However, any study investigating the effect of ohmic heating pre-treatment on the oil absorption behavior and quality parameters of carrot has been reported in the available literature.

Thus, in the present study, the effect of ohmic heating pre-treatment on (1) oil and moisture content of carrots before and after frying and (2) colour and textural properties of carrot cubes were investigated.

II. Material and Methods

A. Preparing the Samples

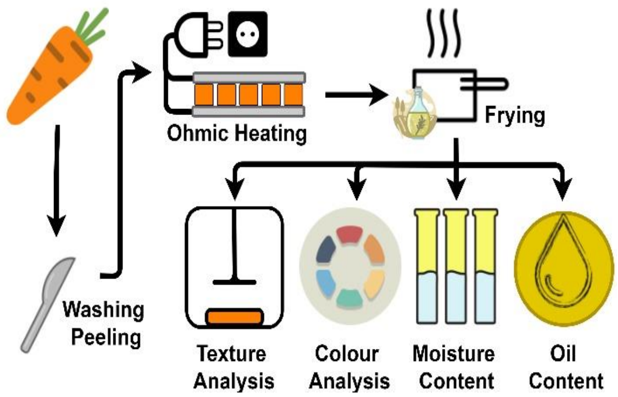

Figure 1. Graphical presentation of the study

Carrots (*Daucus carota L.*) used in the study were obtained from the local market in Isparta, Turkey and they were stored in a refrigerator at 4 ℃ until processes. Prior to ohmic heating, special care was given in order to select similar samples in colour and size and the ones having any physical damage and microbiological spoilage were removed. Then, carrots were washed using tap water and cut into cubes (1 cm^3). Carrot cubes (15 cubes) were placed between two electrodes (stainless steel) and heating for 10 seconds at two different voltages (95 and 150 V). Following, pretreated and control (no pre-treatment) samples were immediately fried using an electric fryer (Arnica universal ZG 27A, China) at 180 ˚C for 60 seconds using sunflower oil as a heating medium. A graphical summary of the study is presented in Fig. 1.

B. Analyses

The moisture content of the samples was determined using a bench top moisture analyzer (KERN DBS 60-3, Kern & Sohn GmbH, Balingen-Frommern, Germany) and the results were given in db%.

Total lipid content (%, db) was determined according to the chloroform-methanol extraction method suggested by Bligh and Dyer [18] with some modifications presented by Lee, Trevino [19]. Briefly, 10 g of sample was mixed and homogenized with 30 ml of extraction solvent (chloroform: methanol, 2:1) for 2 min and the mixture was filtrated through a Whatman no.1 filter paper. This step was repeated 3 times and all the filtrates were combined. The resulting solution was transferred into a separation funnel, 20 ml of 0.5% NaCl solution was added over and the mixture was left for overnight at room temperature. Following, the total volume of chloroform layer was recorded and 10 ml of this phase was transferred to a pre-weighed aluminum plate and completely evaporated on a hot plate by preventing from overheating. After 15 min of cooling stage, the weight of dish was recorded and fat content was calculated as follows:

$$Total\ lipid\ content(\%) = \frac{w_L}{w_S} \times \frac{v_C}{5\ ml} \times 100 \qquad (1)$$

where w_L and w_S were the weight of extracted lipid and sample, and v_C was the previously recorded total volume of chloroform.

Color parameters (L*, a*, b* and total colour change. ΔE) of carrot samples were measured using a colorimeter (NH310, 3nh, Shenzhen 3nh Tech. Co., Ltd, Nanshan District, Shenzhen, China) and the total color change (ΔE) was calculated as follows:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2} \qquad (2)$$

Firmness (F, g-force) and hardness (H, g-force) of sample were determined using a texture analyzer (TA.XTPlus; Stable Micro Systems Co. Ltd, Godalming, UK). In order to measure these parameters, a Perspex blade (A/LKB) for firmness and a 50mm Cyl. Aluminum (P/50) for hardness were used. Probe movement speed was set as 1×10^{-3} m s^{-1} for both firmness and hardness, and the strain was adjusted to 20% and 70%, respectively.

C. Statistical Analysis

All the results were compared by using Minitab Statistical Software (version 16.2.3.0) (Minitab Inc., State

College, PA, USA). Tukey pairwise comparison test was conducted to determine the significance of mean values during comparison at level of $p \leq 0.05$. The results were presented as "mean ± standard error of means".

III. Results and Discussion

In the present study, the effect of ohmic heating pre-treatment on some quality properties of fried carrots cubes was investigated. Moisture and oil contents were presented in Table I. It is clear that frying and electrical heating caused a decrement in moisture content of the samples. In deep fat frying, two simultaneous mass transfer phenomena, namely moisture and oil transfer, take place in opposite directions within the materials, and at the same time heat is transferred from the oil to the food, which forces the evaporation of water from the food and oil is absorbed in it [14]. In ohmic pre-treatment, electrical heating influences the mass transfer properties and makes changes in the texture which leads to the release of part of the water from inside of the plant tissues, also high temperature as a result of high voltage, leads to the partial evaporation of water from sample inside [20]. Among the samples, the cube treated at 150F had the lowest moisture content (67.98±0.82) due to the effect of frying and the pre-treatment of ohmic heating, both of which lead to the loss of moisture. Similar changes were observed for the samples pretreated at 95 F, but moisture loss (70.82±0.69) was less than former one most probably because of the lower voltage level used in ohmic heating compared to 150F treatment. So, higher the voltage leads to less the moisture content. On the other hand, the lowest oil content (5.07±0.32) was found for FC sample, and the highest one (7.15±0.90) was for sample heated at 150F, see Table I. During frying, heat is transferred from the oil to the food, water is evaporated from the food and oil is absorbed by the material. During this mass transfer cycle, the inner moisture content plays a critical role, as it is converted to steam, creating a pressure gradient as the surface dries out and causing oil to adhere to the product's surface at the damaged areas [20]. Thus, briefly, it means that the higher initial moisture content of samples results in higher inner pressure decelerating oil absorption. From that point of view, since sample treated at 150F has the least moisture content, it was thought that this sample absorbed more oil during frying. Moreover, ohmic heating leads damages and alterations in cell and tissue structure which help the penetration of oil inside the sample during the frying. Low voltage causes less damage, as a result, less moisture loss. This explains why these fried samples heated at 95 V gradient of ohmic heating absorbed less oil than that treated at 150F.

Textural properties (firmness and hardness, g-force) of the processed and raw carrot samples were given in Table II. The frying and pre-treatment processes were found to be significantly effective on textural properties of the carrot cubes ($p \leq 0.05$), and textural properties of all samples irrespective of the application of pretreatment (directly fried and treated by ohmic heating and then fried cubes) significantly decreased compared to fresh carrot cube samples. Based on the above results, in both fried and non-fried carrots, firmness and hardness decreased with the increase of used voltage level. This may be attributed to the deteriorative impacts of electrical current on the plant tissue. Ohmic treatment leads to the breakdown and the rupture of large cells which accelerates the softening [21]. On the other hand, applied high temperature levels as a result of frying and ohmic heating lead to the decreases in firmness and hardness of plant tissues due to potenital structural modifications which are associated with different phenomena induced by these thermal processes such as changing of inner chemical structure of the cell walls by the hydrolytic degradation reactions, protein insolubilization and the breakdown of the interlamellar layer of cell walls [22]. According to the results, RC samples had the highest firmness and hardness, followed by 95B and 95F which had shown lower strength against deformation than RC samples due to ohmic heating at 95 V as a pre-treatment. The lowest strength against deformation belonged to the samples labelled as 150B and 150F due to the high voltage (150 V) use as a pre-treatment. For the samples treated at the processes defined as 95F and 150F, the low textural values were attributed to the two successive thermal treatments (frying and ohmic heating). The deteriorative changes such as cell membrane disruption, turgidity loss, and cell wall matrix dissociation at the micro-and ultra-structure levels could be the underlying reasons [6]. So, the higher the voltage the lower the strength against deformation.

TABLE I. Effect of Different Voltage as Pre-Treatment on Oil and Moisture Content for Carrot Samples

Sample	Moisture content (% db)	Oil content (% db)
RC	88.72±0.03^{a}	-
FC	73.26±0.21^{b}	5.07±0.32^{a}
95B	87.54±0.33^{a}	-
95F	70.82±0.69^{b}	5.82±0.15^{a}
150B	85.47±0.40^{a}	-
150F	67.98±0.82^{c}	7.15±0.90^{a}

- RC: Raw carrot, FC: Fried carrots (no pre-treatment), 95B: Pre-treated carrots at 95 V, 95F: Fried pre-treated carrots at 95 V, 150B: Pre-treated carrots at 150 V, 150F: Fried pre-treated carrots at 150 V.
- $^{a-c}$ means in the same column with different superscripts are significantly different ($p \leq 0.05$).

TABLE II. Effect of Different Voltage as Pre-Treatment on Textural Properties (Hardness and Firmness) of Carrot Samples

Sample	Firmness (g-force)	Hardness (g-force)
RC	1720.82±76.29^{a}	6207.90±136.13^{a}
FC	492.42±130.22^{c}	429.78±58.92^{c}
95B	1481.76±69.39^{a}	4021.17±463.44^{b}
95F	1112.32±62.90^{b}	577.22±90.50^{c}
150B	736.28±46.23^{c}	927.15±56.06^{c}
150F	416.68±93.59^{c}	231.03±46.79^{c}

- RC: Raw carrot, FC: Fried carrots (no pre-treatment), 95B: Pre-treated carrots at 95 V, 95F: Fried pre-treated carrots at 95 V, 150B: Pre-treated carrots at 150 V, 150F: Fried pre-treated carrots at 150 V.
- $^{a-c}$ means in the same column with different superscripts are significantly different ($p \leq 0.05$).

TABLE III. EFFECT OF DIFFERENT VOLTAGE AS PRE-TREATMENT ON TEXTURAL PROPERTIES (HARDNESS AND FIRMNESS) OF CARROT SAMPLES

Sample	L*	a*	b*	ΔE
RC	61.04 ± 1.03^{a}	31.22 ± 1.52^{a}	42.71 ± 0.81^{a}	-
FC	53.66 ± 0.61^{bc}	18.95 ± 1.43^{c}	38.10 ± 1.45^{a}	16.32 ± 2.26^{a}
95B	56.99 ± 1.80^{abc}	28.45 ± 2.35^{ab}	39.10 ± 1.47^{a}	13.51 ± 2.19^{a}
95F	59.53 ± 0.77^{ab}	25.27 ± 1.22^{abc}	44.35 ± 0.82^{a}	8.918 ± 1.11^{a}
150B	58.57 ± 2.6^{ab}	22.69 ± 1.95^{bc}	40.60 ± 2.94^{a}	15.36 ± 3.29^{a}
150F	51.49 ± 1.03^{c}	20.83 ± 1.37^{c}	38.38 ± 1.75^{a}	15.68 ± 1.62^{a}

- RC: Raw carrot, FC: Fried carrots (no pre-treatment), 95B: Pre-treated carrots at 95 V, 95F: Fried pre-treated carrots at 95 V, 150B: Pre-treated carrots at 150 V, 150F: Fried pre-treated carrots at 150 V.
- $^{a\text{-}c}$ means in the same column with different superscripts are significantly different ($p \leq 0.05$).

The effect of ohmic heating on color properties (L*, a*, b*, ΔE) of samples can be seen from Table III. There were significant differences between color values for raw carrot and pretreated (especially at 150 V) fried samples ($p \leq 0.05$). All color properties were reduced under the thermal stress, and this reduction may be related to the α- and β-carotene decreases and/or their isomerization during thermal treatments [23]. Moreover, a study by Sulaeman *et al.* [24] indicated that there was a high negative correlation between the color parameter and the carotene content of thermally treated carrots especially for deep fried carrot samples. L* (lightness) values (which is a critical colour parameter of fried foods, is usually used as a quality control determinant and so adequately determining its value is of most importance [25]) were between 51.49±1.0 for samples treated as defined at 150F and 61.04±1.03 for RC. The lowest L* was found for the treatment at 150F due to more severe pre-treatment which decreased the lightness of the surface of the sample. This phenomenon most probably arose from that the only fried samples (no pre-treatment) were exposed to high temperatures less than others, as in others that exposure to additional heat due to the ohmic pre-treatment causing further colour loss. Heating and dehydration lead to the drying of the surface that resulted in a decrease in the lightness (L*) value, also the reduction in lightness may be attributed to intense browning reaction due to the exposure the food material to high temperature levels and to carotene content as noted above. Another colour parameter is the a* value, which represents the degree of redness of the surface colour was in between 18.95±1.43 for FC and 31.22±1.52 for RC. A similar result for the *b** value which indicates the yellowness of surface colour was observed and it was between 38.10±1.45 for FC and 42.71±0.81 for RC. The a* value and b* value were low for samples treated at FC which underwent one time thermal treatment (only frying) meaning FC samples had more familiar visual characteristics compared to the other pretreated samples, but for the samples fried after pre-treated with ohmic heating (95F and 150 F), a* and b* values increased due to the ohmic heating giving darker red and yellow colours [14].

IV. CONCLUSION

In the present study, the effects of ohmic heating on some quality characteristics (moisture, oil content, texture, and colour) of both pre-treated and pre-treated\fried carrot samples were evaluated. Two voltages were used as pre-treatments (95 and 150 V) for 10 seconds. Deep-fat frying was carried at 180°C using sunflower oil for 60 seconds. Using high voltage and then frying for 60 seconds it was found to be effective on decreasing the hardness, firmness and decreasing of *L** value as it was found with 150F samples. The undesirable result of increased voltages was increased oil absorption during frying and also decreasing in moisture content. For colour values, there were differences between the *L** and *a** for the 150 V fried and 95 V fried samples, with fewer differences in non-fried samples.

REFERENCES

[1] G. Boskou, F. N. Salta, A. Chiou, E. Troullidou, and N. K. Andrikopoulos, "decadienal in deep-fried and pan-fried potato content of trans,trans-2,4-oes," *Eur. J. Lipid Sci. Technol.*, vol. 108, no. 2, pp. 109–115, 2006.

[2] E. Karacabey, M. S. Turan, Ş. G. Özçelik, C. Baltacıoğlu, and E. Küçüköner, "Optimisation of pre-drying and deep-fat-frying conditions for production of low-fat fried carrot slices," *J. Sci. Food Agric.*, vol. 96, no. 13, pp. 4603–4612, 2016.

[3] L. P. Fan, M. Zhang, and A. S. Mujumdar, "Vacuum frying of carrot chips," *Dry. Technol.*, vol. 23, no. 3, pp. 645–656, 2005.

[4] T. D. Capar and H. Yalcin, "Effects of pre-drying on the quality of frying oil and potato slices," *Qual. Assur. Saf. Crop. Foods*, vol. 9, no. 3, pp. 255–264, 2017.

[5] Tarimorman.gov.tr. (2018). [Online]. Available: https://www.tarimorman.gov.tr/sgb/Belgeler/SagMenuVeriler/BUGEM.pdf

[6] C. Xu, C. Yu, and Y. Li, "Effect of blanching pretreatment on carrot texture attribute, rheological behavior, and cell structure during the cooking process," *LWT - Food Sci. Technol.*, vol. 62, no. 1, pp. 48–54, 2015.

[7] T. Gally, O. Rouaud, V. Jury, and A. Le-Bail, "Bread baking using ohmic heating technology; a comprehensive study based on experiments and modeling," *J. Food Eng.*, vol. 190, pp. 176–184, 2016.

[8] I. Sengum, G. Turp, F. Icier, P. Kendirci, and G. Kor, "Effects of ohmic heating for pre-cooking of meatballs on some quality and safety attributes," *LWT - Food Science and Technology*, vol. 55, no. 1, pp. 232-239, 2014.

[9] F. Icier and C. Ilicali, "Temperature-dependent electrical conductivities of fruit purees during ohmic heating," *Food Res. Int.*, vol. 38, no. 10, pp. 1135–1142, 2005.

[10] M. Sakr and S. Liu, "A comprehensive review on applications of ohmic heating (OH)," *Renew. Sustain. Energy Rev.*, vol. 39, pp. 262–269, 2014.

[11] I. Castro, J. A. Teixeira, S. Salengke, S. K. Sastry, and A. A. Vicente, "Ohmic heating of strawberry products: Electrical conductivity measurements and ascorbic acid degradation kinetics," *Innov. Food Sci. Emerg. Technol.*, vol. 5, no. 1, pp. 27–36, 2004.

[12] S. Leizerson and E. Shimoni, "Effect of ultrahigh-temperature continuous ohmic heating treatment on fresh orange juice," *J. Agric. Food Chem.*, vol. 53, no. 9, pp. 3519–3524, 2005.

[13] W. C. Wang and S. K. Sastry, "Effects of moderate electrothermal treatments on juice yield from cellular tissue," *Innov. Food Sci. Emerg. Technol.*, vol. 3, no. 4, pp. 371–377, 2002.
[14] S. D. Bhale, "Effect of ohmic heating on color, rehydration and textural characteristics of fresh carrot cubes," LSU Master's theses, Dept. Bio & Agri Eng., Louisiana State University 3918, 2004.
[15] M. Lima and S. K. Sastry, "Effects of ohmic heating frequency on hot-air drying rate and juice yield," *J. Food Eng.*, vol. 41, no. 2, pp. 115–119, 1999.
[16] K. Kumari, V. D. Mudgal, G. Viswasrao, and H. Srivastava, "Studies on the effect of ohmic heating on oil recovery and quality of sesame seeds," *J. Food Sci. Technol.*, vol. 53, no. 4, pp. 2009–2016, 2016.
[17] S. Salengke and S. K. Sastry, "Potato slices during frying and subsequent cooling," vol. 30, no. 2007, pp. 1–12, 2005.
[18] B. Dyer, "A rapid method of total lipid extraction and purification," *Canadian Journal of Biochemistry and Physiology*, vol. 37, no. 8, pp. 911-917, 1959.
[19] L. CM, B. Trevino, and M. Chaiyawat, "A simple and rapid solvent extraction method for determining total lipids in fish tissue," *Journal of AOAC International*, vol. 79, no. 2, pp. 487-492, 1996.
[20] P. H. Y. Fu and P. H. Y. Fu, "Relationship between oil uptake and water content during deep-fat frying of potato particulates under isothermal temperature," 2014.
[21] D. F. Olivera, V. O. Salvadori, and F. Marra, "Ohmic treatment of fresh foods: Effect on textural properties," *Int. Food Res. J.*, vol. 20, no. 4, pp. 1617–1621, 2013.
[22] V. I. F. Ogliano and N. I. P. Ellegrini, "Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables," pp. 139–147, 2008.
[23] N. I. Lebovka, I. Praporscic, and E. Vorobiev, "Effect of moderate thermal and pulsed electric field treatments on textural properties of carrots, potatoes, and apples," *Innov. Food Sci. Emerg. Technol.*, vol. 5, no. 1, pp. 9–16, 2004.
[24] J. A. Sulaeman, *et al.*, "C : Food chemistry and toxicology effect of moisture content of carrot slices on the fat content, carotenoid content, and sensory characteristics of deep-fried carrot chips," vol. 69, no. 6, 2004.
[25] M. Mariscal and P. Bouchon, "Comparison between atmospheric and vacuum frying of apple slices," *Food Chem.*, vol. 107, no. 4, pp. 1561–1569, 2008.

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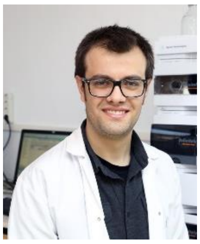

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