Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.86021

Evaluation of cookery methods in reduction of pesticide residues and quality attributes of okra fruit (*Abelmoschus esculentus* L.)

Bushra ISHFAQ[1], Aysha SAMEEN[1*], Imran PASHA[1], Muhammad SHAHID[2], Muhammad ABRAR[3]

Abstract

The objective of the current investigation was to evaluate the okra before cooking (fresh) and after cooking to determine the best cooking method by using compositional analysis, colour, texture, sensory evaluation and pesticide residues reduction. The cooking methods used were steam blanching, simmering, baking and sautéing. Cooking treatments resulted in a momentous increase ($p < 0.05$) in crude fibre and fat content during sautéing and total carbohydrate in baking in comparison to control. The CIE lab coordinates (L* and b*) significantly decreased while a* increased in all cooking treatments except in baking. The texture analysis revealed a significant ($p < 0.05$) reduction in shear force N (Newton) due to contact of the heating medium in moist cooking i.e. steam blanching and simmering. Sautéing and steam blanching scored better and showed acceptance of the consumers except simmering that exhibited lower acceptability ($p < 0.01$). Moreover, among the analyzed pesticide residues**,** minimum reduction occurred in cypermethrin (8.57-37.14-%), while the chlorpyrifos was completely removed in case of baking and sautéing. Among all cooking treatments, only sautéing resulted in maximum pesticide residues reduction. The study revealed that the sautéing cooking treatment was best to preserve the vegetable nutrients compounds, maximum pesticide residues reduction and maybe among preferred cooking treatments.

Keywords: cooking; colour; Okra; pesticide residues; sautéing; texture.

Practical Application: Okra (*Abelmoschus esculentus* L.) can be cooked for various culinary preparation by four different cooking methods; steam blanching, simmering, baking and sautéing. However, limited data is available on the effect of these cooking methods on the nutritional composition, pesticide residues reduction and sensory attributes. The purpose of this investigation is to propose to consumers the best cooking method in terms of nutritional contents, pesticide residues reduction and sensory attributes.

1 Introduction

Okra belongs to the family Malvaceae, having the botanical name *Abelmoschus esculentus L.* Moench, *and in local terms, it is named as* "*Bhindi*". This medicinal and aromatic vegetable is characterized by Food and Drug Administration (FDA) as "Herb of Unidentified Safety". In ancient times (4000 years ago), it was mostly grown in African regions but now a day, it is cultivated in temperate and warm regions like Asia, the USA, Iran and Greece and is called the most drought and heat tolerant species of vegetable at world level. World widely the area under cultivation for okra is 2.16 million hectares and production is estimated as 8.90 million tons. Pakistan ranked at 5th number with its 1.3% share in the World area under cultivation is 1.55 million hectares and the production of okra is 0.128 tonnes in Pakistan (Saleem et al., 2020). The immature okra pods comprising white, round seeds, largely consumed as a vegetable in a variety of ways and is a prominent constitute of diet in West Africa, Ethiopian and South Asian countries. However, the nutritional profile greatly depends on the fruit fraction, namely seeds, whole pods and seedless pods with low calories and a good source of nutrients vitamins, minerals dietary fibre and bioactive compounds, such as phenolics (Petropoulos et al., 2018; Xu et al., 2020). Its immature green pods are consumed as a vegetable and are also being employed in various culinary preparations such as soups, stews, boiled or fried, fresh or dried. Likewise, its water-soluble polysaccharide is offering a healthful choice and stable storage life to food commodities and is very often used in baked goods, potato chips and ice cream (Hu & Lai, 2017).

Cooking of vegetables is performed before consumption in order (i) to increase the palatability and edibility, (ii) to improve the texture, aroma, taste and appearance (iii) to achieve high acceptance among consumers (Castro et al., 2020). Cooking methods play an important role in determining the nutritional quality of any food and affect it both positively and negatively. Most vegetables are consumed in a cooked form, and several investigations demonstrated that the method of cooking can improve the nutrition quality of food by deactivation of antinutrients which are naturally present in the food or microorganisms/contaminants incorporated while post-harvest

Received 10 Aug., 2021
Accepted 27 Sep., 2021
[1] *National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan*
[2] *Department of Chemistry and Biochemistry, University of Agriculture, Faisalabad, Pakistan.*
[3] *Post Harvest Research Centre, Ayub Agricultural Research Institute, Faisalabad, Pakistan.*
*Corresponding author: ayshasameen@uaf.edu.pk

handling of the food (Dewangani et al., 2021). However, an adequate selection of the cookery method produces a product with great health-promoting contents and sensory attributes (Stanikowski et al., 2021).

Different cooking methods depending on their temperature like deep frying, shallow frying, stewing and roasting are used in Asian countries as well as in Pakistan, whilst boiled or semi-cooked vegetables are consumed in Western countries (Sultana et al., 2008). However, the cooking temperature and medium (water or oil) greatly influence the nutritional composition owing to the leaching of certain hydrosoluble nutrients into the water, while the use of oil may improve the phytochemical contents which ultimately enhance the antioxidant capacity. During the culinary process of vegetables the heat treatment breakdown the cell structure and enhance the bioavailability of bioactive components (Silva et al., 2019; Soares et al., 2017). Cooking treatments can be one of the ways, removing or decreasing the pesticide residue contents in the food commodities and ultimately minimizing hazards to human health (Jankowska et al., 2019).

While taking into consideration of aforementioned facts. The relationship between the cooking treatment and nutrient retention aid the individual consumers and food service industries in the selection of the most suitable cooking treatment for okra. The current study aimed to compare the changes in composition, colour parameters and consumer opinion via sensory analysis and pesticide residues reduction by using different cooking treatments (steam blanching, simmering, baking and sautéing).

2 Materials and methods

2.1 Plant material and chemicals

Okra variety namely Sabaz Pari was collected from Vegetable Research Institute, Ayub Agricultural Research Institute (AARI), Faisalabad. The tender pods were washed thoroughly with tap water and stored in a refrigerator at 4°C for cooking treatments and further investigation.

Extra virgin olive oil (EVOO) was purchased from Metro, PVT, Ltd, Faisalabad, Pakistan. Reagents and standards (HPLC and analytical grade) were attained from Merck (Merck KGaA, Darmstadt, Germany) and Sigma-Aldrich (Sigma-Aldrich Tokyo, Japan).

2.2 Cooking treatments

To investigate okra before cooking (fresh) and after cooking by steam blanching, simmering (moist heating), sautéing and baking (dry heating) for the chemical composition, colour, sensory attributes and pesticide residues reduction, the preliminary trials were conducted to assess the cooking conditions. To obtain a homogeneous sample, 3 batches of 2.5 kg were prepared by removing inedible parts with a sterilized sharp steel knife, cut into almost equal small slices, and then mixed well. Each batch was further divided into 5 equal parts (500 g each) and prepared according to the treatment plan (Table 1) and after cooking treatments, the samples were immediately cooled to stop the process of cooking. Assays before cooking and after cooking were carried out in triplicate.

2.3 Chemical composition

The chemical composition i.e. moisture contents, crude fat, crude protein, crude fibre, ash, and total carbohydrate of fresh and cooked okra prototypes was determined according to their corresponding protocols of Association of Official Analytical Chemists International (2016).

2.4 Colour analysis

The colour of both fresh and cooked okra was determined by using a colourimeter (CIELAB SPACE, Color Tech-PCM, USA). To measure the colour parameters, the sample was retained in a translucent petri dish and directly positioned in the pathway of the light to measure the L* value (lightness or darkness), a* value (+a redness or –a greenness) and b* value (+b yellowness or –b blueness) by following the protocol of (Little, 1975; Miglio et al., 2008). From, coordinates (L*, a*, and b*) its Browning index (BI) Equation 1 Chroma (C*) (Equation 2) and hue angle (h*) (Equation 3) were calculated by following the expression of (Dadalı et al., 2007; Hunter, 1975; Little, 1975).

$$BI = \frac{\left[100\left(x - 0.3\right)\right]}{0.17} \tag{1}$$

$$\text{Where, } x = \frac{\left(a + 1.75L\right)}{\left(5.645L* + a* - 3.012b*\right)} \; C* \left[a*^2 + b*^2\right]^{1/2} \tag{2}$$

$$h^o* = tan^{-1}\left(b*/a*\right) \tag{3}$$

2.5 Texture analysis

The texture of fresh and cooked okra was measured using a compressible probe of texture analyzer TA-XTPlus (stable microsystems Hamilton, Canada) attached to a software (Castro et al., 2020). A crosshead speed of 2 mm per second

Table 1. Treatment plan.

Treatments	Time (min.)	Description
Fresh okra	-	No heat treatment applied (control)
Steam blanching	8	In a traditional steam pot with 3 L capacity and equipped with a pore barrier at 100 °C
Simmering	8	Bring the water and sample to boiling then covered the pan and cooked on low flame for the recommended time
Baking	8	In the domestic oven at 180 °C
Sautéing	8	Fresh okra and EVOO @ 1:0.3 proportion at 80-100 °C

with a load cell of 50 kg was used to compress the fresh okra (control) and cooked samples. The more the distance travelled, the more the capacity to endure compression force without breakage. The parameter obtained from the curves was hardness; the maximum force (N) required to compress was noted in triplicate and means were calculated.

2.6 Sensory analysis

The okra samples were cooked by adopting the recipe of Aworh et al. (1980) and protocol of Faid & Al-Matrafi (2018) with no condiment added other than table salt. Cooked okra samples were evaluated by an 11-member panellist by using a nine-point hedonic scale (9 = "like extremely" and 1 = "dislike extremely") for colour, texture, firmness and overall acceptability. Sensory evaluation was done by a panel of judges' participants from students and staff members of NIFSAT, UAF. Each panellist was provided with 50g samples of cooked okra along with water for rinsing the mouth in between tastes.

2.7 Pesticide residues analysis

The extraction of pesticide residues from fresh and cooked okra was done by following the protocol of Baig et al. (2009) by homogenizing with a blender at high speed (2200 rpm) to obtain a representative sample. For ethyl acetate extraction, a well-homogenized sample (50 g) was taken in a 250 mL Erlenmeyer flask that was wrapped with aluminium foil, and then add 70 mL ethyl acetate, 10:2.5 (anhydrous sodium sulphate: 2.5 g sodium chloride) were added to it and shaken in GFL shaker (Germany) for 1 hour. In the end, the extract was filtered through Whatman (No.4) filter paper and transferred onto a glass column (anhydrous sodium sulfate and activated charcoal @1:4) for bleaching. The mixture was vacuum-filtered through Whatman no.6 filter paper, evaporate and concentrate with a rotary evaporator at 70 °C and made a volume of up to 10 mL and then filtered through a 0.45 µm filter, the collected elute was concentrated just to dry under a gentle stream of nitrogen gas. The dried extract was then re-dissolved in acetonitrile volume made up to 500 µL for analysis with HPLC. While using the isocratic mode for HPLC analyses, using a Shimadzu LC-10 AS pumps and a Supelco C_{18} analytical column (25 cm - 4.6 mm (i.d)). A mixture of water and acetonitrile (70:30) was used as mobile phase and the flow rate was kept at 1 mL/min. The absorbance was read with an SPD-10A UV detector operating at 246 nm.

2.8 Statistical analysis

The data obtained from each parameter was presented as means ± SD for three replications. Analysis of variance (ANOVA) under completely randomized design (CRD) was used to determine the level of significance through Origin 9.0 software and significant ranges beyond ANOVA were compared by Tukey's HSD test by following the principles outlined by Montgomery (2008).

3 Results and discussion

3.1 Effect of cooking treatments on compositional profiling

The cooking treatments affect significantly ($p < 0.05$) compositional profiling in comparison to fresh ones (Table 2). All cooking treatments resulted in a significant reduction of moisture content except simmering owing to direct contact of the sample with water which resulted in higher retention of moisture content. The crude protein content was high in fresh okra that was reduced after cooking treatments and might be due to thermal degradation. The crude fat content was high in sautéing which indicate the absorption of EVOO during cooking treatment in comparison to the fresh one. The decrease in crude fibre content during steam blanching and simmering was attributed due to the leaching of soluble solids which in turn result in the decrease of total dry matter. The ash content was decreased during steam blanching which might be due to the loss of minerals resulted in the loss of dry matter and trigger the decrease of ash content. The increase in dry matter in sautéing and baking contribute to an increase in ash content. A similar trend was also observed for carbohydrate contents.

Faid and Al-Matrafi (2018), demonstrated the significant variation in chemical composition as a result of the steaming of okra. During steaming the protein, fat and ash content significantly decreased ($p < 0.05$) while total carbohydrate contents increased. The decrease in protein content after cooking treatment might be attributed to metabolic and physiological activities within the cell and in the meantime due to proteolysis. The increase in fibre contents during cooking treatments might be due to the loss of lipid-soluble components of vegetables and disruption of cell structure while reduction might be due to conversion of fibre cellulose into carbohydrate.

Likewise, Ramírez-Anaya et al. (2015) also reported a significant increase ($p < 0.05$) in the fat content of tomato, potato, pumpkin and eggplant during sautéing and maintaining

Table 2. Effect of treatments on the chemical composition of okra.

Compositional analyses (%)	Before cooking	After cooking			
	Fresh okra	Steam blanching	Simmering	Baking	Sautéing
Moisture	89.20 ± 1.45[a]	84.59 ± 1.52[b]	92.03 ± 1.53[a]	78.22 ± 1.56[c]	83.98 ± 0.95[b]
Crude protein	1.67 ± 0.57[a]	0.9 ± 0.11[a]	1.35 ± 0.66[a]	0.78 ± 0.42[a]	0.95 ± 0.12[a]
Crude fat	0.37 ± 0.42[b]	0.13 ± 0.13[b]	0.11 ± 0.04[b]	0.15 ± 0.10[b]	5.14 ± 0.67[a]
Crude fiber	5.86 ± 0.02[b]	4.89 ± 0.02[b]	5.11 ± 0.01[b]	5.45 ± 0.01[b]	8.63 ± 0.01[a]
Ash	1.55 ± 0.36[a]	0.95 ± 0.10[a]	1.56 ± 0.39[a]	1.67 ± 0.33[a]	1.66 ± 0.33[a]
Total carbohydrate	7.20 ± 1.86[c]	13.42 ± 1.38[b]	4.93 ± 2.44[c]	19.17 ± 1.33[a]	8.25 ± 1.86[c]

Values denote mean ± standard deviation of 3 replications. Treatment that carrying the same letter in a row were not significantly different ($p < 0.05$).

the moisture content similar to those of raw vegetables. The effect of domestic cooking methods on eggplant conducted by Arkoub-Djermoune et al. (2016) reported the significant variation ($p < 0.05$) between moisture and ash content before and after cooking by baking and in tomato (Arkoub-Djermoune et al., 2019). The moisture content increased in wet cooking and decreased in a dry cooking method such as baking. However, the ash represents the total amount of minerals present in foodstuff and great variation occurred during dry and wet cooking. A similar trend was also reported by Uthumporn et al. (2016) in the cooking of eggplant, Tian et al. (2016) in potato and Malik & Kajla (2020) in mixed vegetable curry.

3.2 Effect of cooking treatments on colour parameters

The colour tonality varied significantly based on treatments as presented in Figure 1, L*, a*, b*, C*, and BI showed a significant effect ($p < 0.05$) except h° ($p > 0.05$). The brightness (L* value) varied in the following order fresh > sautéing > simmering > steam blanching > baking. In this vista, the b* value is also considerably affected by treatments and showed a noteworthy increase in yellowness in the case of steam blanching. Similarly, the negative a* value explicated the greenish hue and the dry cooking i.e., baking showed a marked loss in greenness whilst, on contrary, in moist cooking the products became greener. Likewise, h° is more indicative of colour than a single colour attribute e.g., L* owing to its consideration for both a* and b* value and showed a momentous increase with cooking treatment in comparison to fresh okra and increment with moist cooking and decrement with dry cooking. The higher value is an indicator of lesser yellowness in okra prototypes. On contrary, BI showed a steady decline and did not show an expressive increase in cooked prototypes.

Colour is amongst the important quality characteristic that affects the acceptance of food commodities by the consumer. It is evident from the results that cooking significantly affects the colour of okra prototypes. The colour parameters differ significantly depending on the duration and method of cooking (Stanikowski et al., 2021). The current study outcomes are supported by Arlai et al. (2012) and enumerated the effect of cooking on physical and chemical attributes of okra and narrated that moist cooking induced a significant decrease in brightness (L*) and increased a* and b* value, while a* and b* values were significantly decreased ($p \leq 0.05$) by dry cooking methods. As a result of heating, the chlorophyll pigment (dark green colour) is converted to pheophytin (brown-green colour) by the substitution of Mg^{+2} by H^{+} in the centre of the porphyrin ring of the pigment. Similarly, Faid & Al-Matrafi (2018) noticed that boiling, steaming and blanching of okra results in a greater variation in colour parameters due to leaching and degradation of chlorophyll into blanched water. Silva et al. (2019) also reported that CIE lab coordinates (L*and b*) significantly decreased while a* increased after cooking treatments in pumpkin. Consequently,

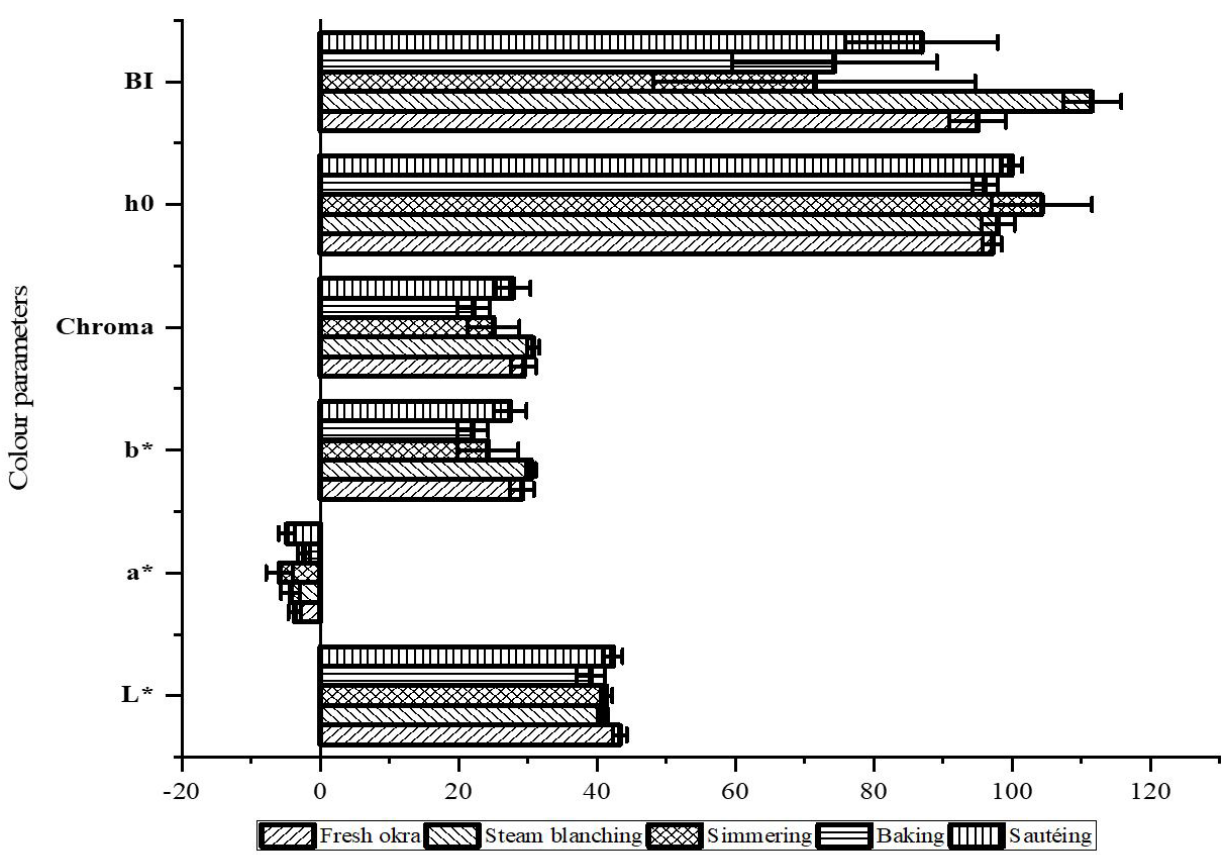

Figure 1. Effect of cooking treatments on color of okra prototypes.

cooking induces an alteration in the colour of green vegetables due to the degradation of chlorophyll and which in turn is also greatly affected by variety, maturity, and growing conditions (Koç et al., 2017). However, it is difficult to compare the colour parameters owing to greater variation in these vegetables.

3.3 Effect of cooking treatments on texture

A noteworthy variation in texture attributes was noted after cooking in comparison to the control sample (fresh okra) (Figure 2). Maximum shear force N (Newton) was gained before cooking and the lowest was taken after cooking. The significant difference ($p<0.05$) in the texture of steam blanching, sautéing and baking may also be associated with the absence of direct contact with heating medium (hot water) as in simmering which ultimately reduced the force many folds required to shred the vegetable by softening. Similar, findings were also reported by Stanikowski et al. (2021) and demonstrated that hardness differs significantly depending on the duration and method of cooking.

3.4 Effect of cooking treatments on sensory evaluation

Sensory attributes of cooked okra prototypes demonstrated significant ($p < 0.01$) differences in colour, texture, firmness and overall acceptability scores (Figure 3). The colour of cooked okra pods vary among all cooking treatments and the highest panellist ratings were scored by steam blanching and sautéing. This might be due to steam blanching and sautéing increase in colour efficiency. Whilst the baking was the method of lowest acceptance in colour which, can be associated with chlorophyll degradation in green vegetables and the formation of pheophytin. Poor rating in texture was noticed in simmering which might be due to exposure to water and accumulation of mucilage from inner cells to the outer layer of okra which seemed to displease most tasters. Similarly, the firmness score showed that sautéing and steam blanching attained maximum rating by the panellist. Therefore, based on positive results the rating for overall acceptability depicted that maximum score was assigned to sautéing treatments at initiation that gave a good colour and texture which causes a good feeling in the tasters. Consequently, the method for lowest acceptance was simmering which can be associated with longer exposure to moisture during cooking treatment which results in greater loss of texture and firmness.

In this regard, Faid & Al-Matrafi (2018) demonstrated the consumer preferences for blanched and steamed okra pods. It was noticed that the colour of blanched okra was most acceptable. In this context, he demonstrated that in overall acceptability steam-blanched okra was rated slightly better than un-blanched okra.

3.5 Effect of cooking on pesticide residues reduction

A noteworthy reduction ($p < 0.05$) among pesticide residues of the okra prototype was observed before and after cooking

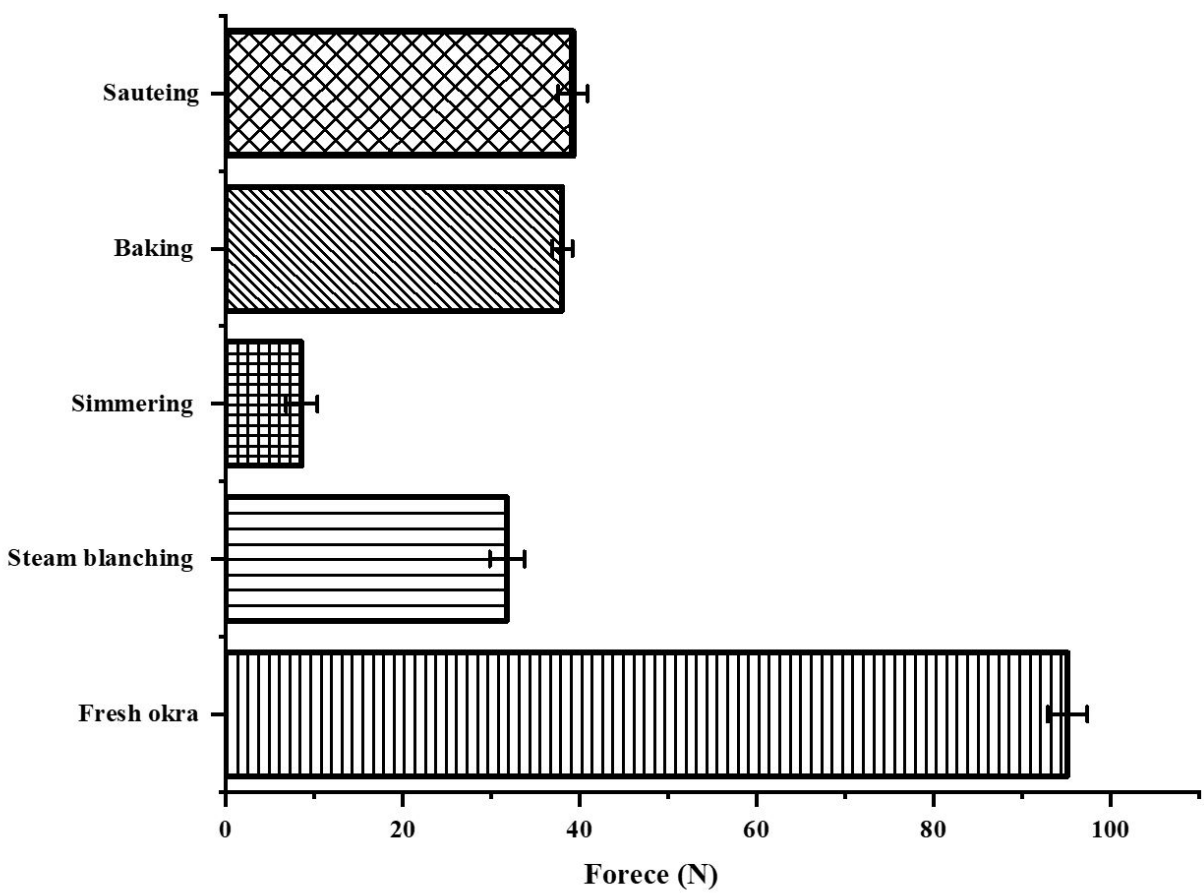

Figure 2. Effect of cooking treatments on texture of okra prototype.

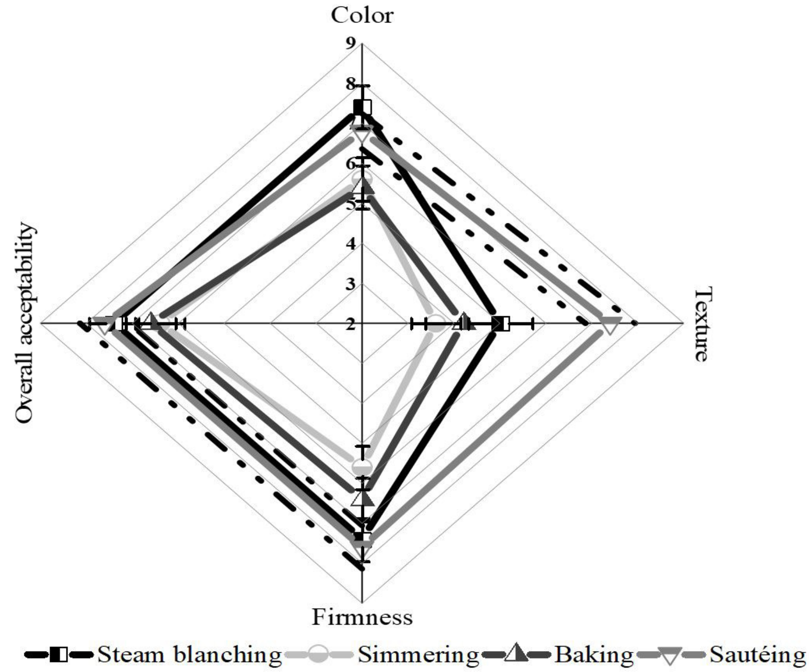

Figure 3. Effect of cooking treatments on sensory attributes of okra prototypes.

(Figure 4). It is obvious from the findings that the maximum content of λ-cyhalothrin was estimated in fresh okra as 0.28 ± 0.03 mg kg^{-1} and reduced to 0.09 ± 0.02 mg kg^{-1} in sautéing which might be attributed to higher lipid solubility of λ-cyhalothrin in EVOO. The maximum residual limits (MRLs) for all pesticide residues have been aforementioned in European Union pesticides database (European Food Safety Authority, 2019). It is also manifest that all samples of λ-cyhalothrin falls below the MRLs. Likewise, the profenofos residues limits exceeding MRLs 0.01 mg kg^{-1} in all samples except sautéing. The per cent reduction of profenofos ranged from 11.11-100% (Figure 5). The highest reduction of imidacloprid was observed in sautéing (50%) and the lowest was demonstrated in steam blanching (12.5%) which might be owing to not having direct contact with water. While outcomes of chlorpyrifos residues portrayed that the contents were exceeded MRLs in all samples except the baking and sautéing. The chlorpyrifos was completely removed in the case of baking and sautéing okra prototypes. Higher acetamiprid residues were exhibited by fresh okra (0.18 ± 0.02 mg kg^{-1}) whilst lowest values were recorded for sautéing. All prototypes exhibited acetamiprid residues below MRLs and maximum reduction was noticed in sautéing (55.55%). Overall minimum reduction of pesticide residues occurs in cypermethrin among all studied pesticides of okra prototypes (8.57-37.14-%). that maximum reduction of pesticide residues occurs in sautéing and baking because of thermal degradation, evaporation and volatilization of pesticide residues, whilst in simmering the residues might be concentrated and deposited on the surface of okra prototypes and minimum in steam blanching due to no contact of fruit with water and decrease the wash off effect which help in residue dislodging.

Vegetables are mostly consumed in the form of fresh or after processing and occupy an elevated level of pesticide residues than other plant-based food groups like cereal-based foodstuffs, so the use of highly toxic chemicals on these vegetables is not enviable (Amir et al., 2015; Latif et al., 2019). Various heat treatments are widely used for food preparation and preservation such as boiling, blanching, simmering, frying, roasting, steaming, baking, drying, pasteurization and sterilization and results in a significant reduction of pesticide residues through thermal degradation, evaporation and co-distillation, thus each process has a cumulative effect on the reduction of pesticides residues (Đorđević & Đurović-Pejčev, 2016).

A similar trend of pesticide residues reduction was observed by Sheikh et al. (2012) the medium of cooking (moist or dry) played a crucial role in pesticide residues reduction and demonstrated the significant reduction ($p < 0.05$) by the moist medium of cooking in okra and the values were within MRLs. Likewise, Lozowicka & Jankowska (2016) observed the effect of moist cooking for 5 minutes in broccoli and tomatoes for the reduction of residues. Faid & Al-Matrafi (2018) also reported that moist cooking resulted in a significant reduction of acetamiprid residues in okra than steaming. In another study, Huan et al. (2015) evaluated the effect of cooking method and medium in the pesticide residues reduction of cowpea and demonstrated 100% reduction of λ-cyhalothrin, s-fenvalerate, pyridaben, bifenthrin and α-cypermethrin. The difference in their outcomes and the present results might be ascribed to the nature of food commodity, nature and duration of application of pesticide, processing method and duration of processing. A similar trend was also noted by Hanafi et al. (2016) in okra fruit by different processing procedures and mentioned that acetamiprid was reduced after cooking treatment to 90% while during steaming wash off effect could not occur owing to this factor that water is not in contact with fruit. Precious investigations revealed that processing might increases the volatilization, thermal disintegration and degradation of chemical residues by elevating the temperature and consequently in a further reduction of pesticide residues (Kim et al., 2015). Recently, Liu et al. (2020) evaluated the effect of classic household processing on six different pesticides widely used in shiitake culturing and outcomes are in support of present research. During frying and stir-frying the pesticides might defuse into the oil and concentrated into the oil and were effective in reduction.

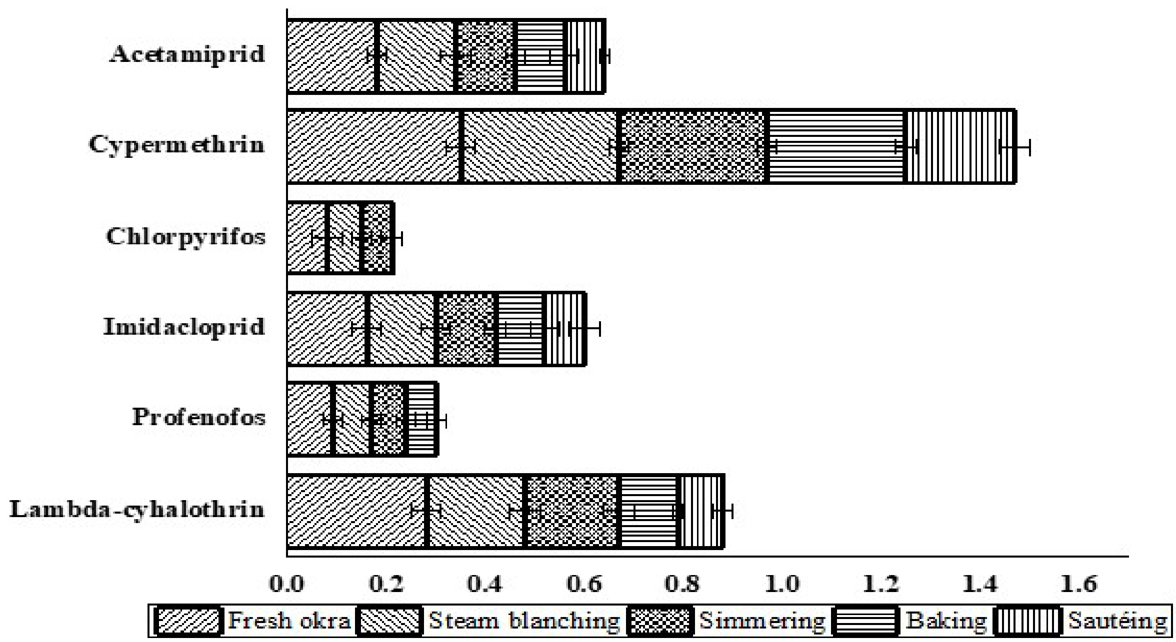

Figure 4. Effect of cooking treatments on pesticide residues of okra prototypes.

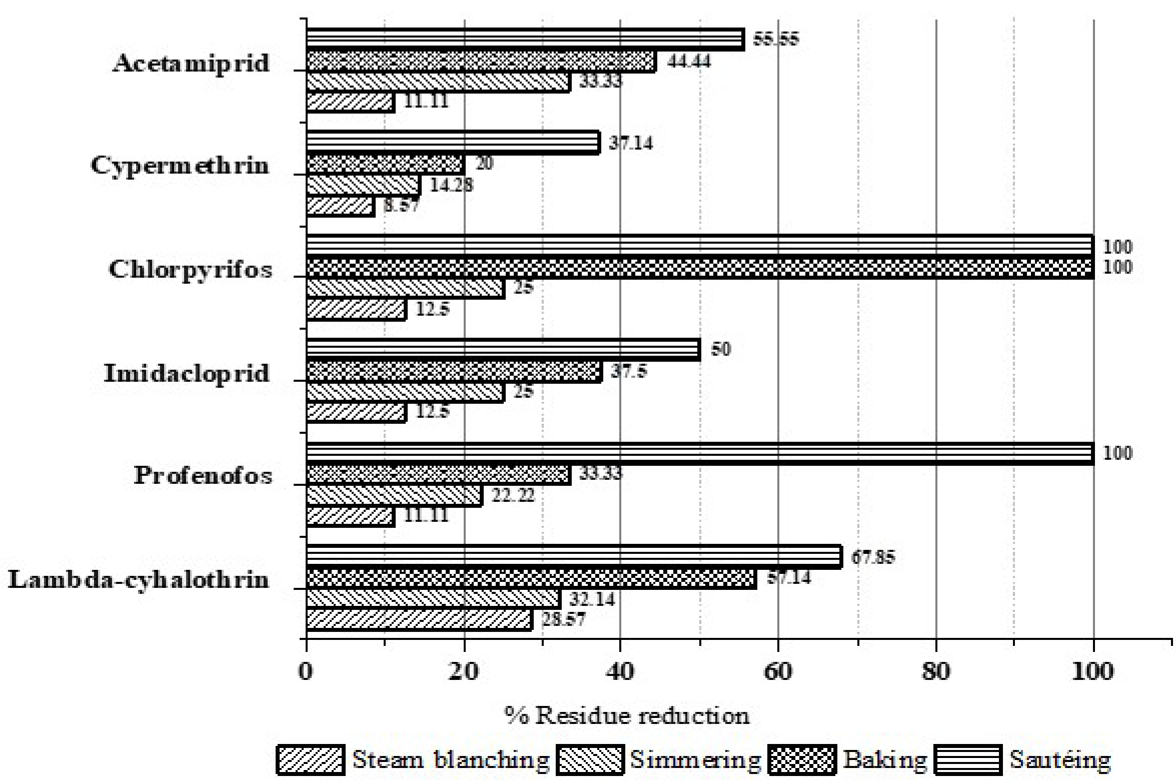

Figure 5. Effect of cooking treatments in pesticide residues reduction with respect to fresh okra.

4 Conclusion

From the current study, it is explicated that studied vegetable compositional profiling, pesticide residues and sensory attributes were significantly affected with cooking treatment. The cooking treatments employed in the current study, among them sautéing treatment showed beneficial effects on pesticide residues reduction, compositional profiling and the most acceptable method in sensory evaluation. It could be concluded that sautéing is preferred among studied cooking treatments. This investigation will serve as a database conferring information regarding the effects of cooking treatments on okra the other cooking methods and time, temperature combinations can be studied in future.

Conflict of interest

The authors declare that they have no conflict of interest.

Acknowledgements

The authors wish to thank Higher Education Commission for funding under the project "Indigenous 5000 Fellowship Program" and National Institute of Food Science and Technology, University of Agriculture, Faisalabad-Pakistan for providing the facilities to carry out the research work.

References

Amir, M., Anjum, F. M., Randhawa, M. A., & Sarwar, M. (2015). Multiple Pesticide Residues. *The Professional Medical Journal*, 22(05), 596-602. http://dx.doi.org/10.29309/TPMJ/2015.22.05.1273.

Arkoub-Djermoune, L., Bellili, S., Khenouce, L., Benmeziane, F., Madani, K., & Boulekbache-Makhlouf, L. (2019). Effect of domestic cooking on physicochemical parameters, phytochemicals and antioxidant properties of Algerian tomato (*Solanum Lycopersicum* L. Var. Marmande). *Journal of Food Technology Research*, 6(1), 1-17. http://dx.doi.org/10.18488/journal.58.2019.61.1.17.

Arkoub-Djermoune, L., Boulekbache-Makhlouf, L., Zeghichi-Hamri, S., Bellili, S., Boukhalfa, F., & Madani, K. (2016). Influence of the thermal processing on the physico-chemical properties and the antioxidant activity of a solanaceae vegetable: eggplant. *Journal of Food Quality*, 39(3), 181-191. http://dx.doi.org/10.1111/jfq.12192.

Arlai, A., Nakkong, R., Samjamin, N., & Sitthipaisarnkun, B. (2012). The effects of heating on physical and chemical constitutes of organic and conventional okra. *Procedia Engineering*, 32, 38-44. http://dx.doi.org/10.1016/j.proeng.2012.01.1234.

Association of Official Analytical Chemists International – AOAC. (2016). Official Methods of Analysis of Association of Official Analytical Chemists International (20th ed.). Rockville: AOAC International.

Aworh, O., Olorunda, A., & Akibo, O. (1980). Quality attributes of frozen okra as influenced by processing and storage. *International Journal of Food Science & Technology*, 15(4), 429-433. http://dx.doi.org/10.1111/j.1365-2621.1980.tb00959.x.

Baig, S. A., Akhtera, N. A., Ashfaq, M., & Asi, M. R. (2009). Determination of the organophosphorus pesticide in vegetables by high-performance liquid chromatography. *American-Eurasian Journal of Agricultural & Environmental Sciences*, 6(5), 513-519.

Castro, N. T., & Lacerda, L., Alencar, E. R., & Botelho, R. B. A. (2020). Is there a best technique to cook vegetables?–A study about physical and sensory aspects to stimulate their consumption. *International Journal of Gastronomy and Food Science*, 21, 100218.

Dadalı, G., Kılıç Apar, D., & Özbek, B. (2007). Color change kinetics of okra undergoing microwave drying. *Drying Technology*, 25(5), 925-936. http://dx.doi.org/10.1080/07373930701372296.

Dewangani, H. G. N., Jayawardena, B. M., Chandrasekara, N. V., & Wijayagunaratne, H. D. S. P. (2021). Effect of common culinary methods practiced in sri lanka on the nutrient composition of commonly consumed vegetables and other foods. *International Journal of Food Science*, 2021, 5537683. http://dx.doi.org/10.1155/2021/5537683. PMid:34336992.

Đorđević, T., & Đurović-Pejčev, R. (2016). Food processing as a means for pesticide residue dissipation. *Pesticidi i Fitomedicina*, 31(3-4), 89-105. http://dx.doi.org/10.2298/PIF1604089D.

European Food Safety Authority – EFSA. (2019). *EU Pesticides data base*. Retrieved from https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/mrls/?event=search.pr

Faid, S. M., & Al-Matrafi, M. M. (2018). Evaluation of okra pods quality (*Abelmoschus esculentus* l.) after reduction of pesticides. *Journal of Biochemical Technology*, 9(4), 81.

Hanafi, A., Elsheshetawy, H. E., & Faied, S. F. (2016). Reduction of pesticides residues on okra fruits by different processing treatments. *Journal für Verbraucherschutz und Lebensmittelsicherheit*, 11(4), 337-343. http://dx.doi.org/10.1007/s00003-016-1054-0.

Hu, S., & Lai, H. (2017). Developing low-fat banana bread by using okra gum as a fat replacer. *Journal of Culinary Science & Technology*, 15(1), 36-42. http://dx.doi.org/10.1080/15428052.2016.1188192.

Huan, Z., Xu, Z., Jiang, W., Chen, Z., & Luo, J. (2015). Effect of Chinese traditional cooking on eight pesticides residue during cowpea processing. *Food Chemistry*, 170, 118-122. http://dx.doi.org/10.1016/j.foodchem.2014.08.052. PMid:25306325.

Hunter, R. (1975). Scales for the measurements of color difference. In R. S. Hunter, & R. W. Harold (Eds.), *The measurement of appearance* (pp. 133-140) New York: John Willy and Sons.

Jankowska, M., Łozowicka, B., & Kaczyński, P. (2019). Comprehensive toxicological study over 160 processing factors of pesticides in selected fruit and vegetables after water, mechanical and thermal processing treatments and their application to human health risk assessment. *The Science of the Total Environment*, 652, 1156-1167. http://dx.doi.org/10.1016/j.scitotenv.2018.10.324. PMid:30586803.

Kim, S., Abd El-Aty, A., Rahman, M. M., Choi, J., Lee, Y., Ko, A., Choi, O., Jung, H. N., Hacımüftüoğlu, A., & Shim, J. (2015). The effect of household processing on the decline pattern of dimethomorph in pepper fruits and leaves. *Food Control*, 50, 118-124. http://dx.doi.org/10.1016/j.foodcont.2014.08.023.

Koç, M., Baysan, U., Devseren, E., Okut, D., Atak, Z., Karataş, H., & Kaymak-Ertekin, F. (2017). Effects of different cooking methods on the chemical and physical properties of carrots and green peas. *Innovative Food Science & Emerging Technologies*, 42, 109-119. http://dx.doi.org/10.1016/j.ifset.2017.06.010.

Latif, M., Abbas, M., Hafeez, F., & Hussain, D. (2019). Regulatory efficacy of novel insecticides against major pests of vegetables in Faisalabad, Pakistan. *Pakistan Journal of Agricultural Research*, 32(1), 41-45. http://dx.doi.org/10.17582/journal.pjar/2019/32.1.41.45

Little, A. C. (1975). Off on a tangent. *Journal of Food Science*, 40(2), 410-411. http://dx.doi.org/10.1111/j.1365-2621.1975.tb02213.x.

Liu, T., Peng, J., Pan, L., Zhou, D., Sun, K., Tu, S., & Tu, K. (2020). Effects of shiitakes household processing on the residues of six pesticides. *Journal of Food Processing and Preservation*, 44(4), e14395. http://dx.doi.org/10.1111/jfpp.14395.

Lozowicka, B., & Jankowska, M. (2016). Comparison of the effects of water and thermal processing on pesticide removal in selected fruit and vegetables. *Journal of Elementology*, 21(1). http://dx.doi.org/10.5601/jelem.2015.20.2.917.

Malik, T., & Kajla, P. (2020). Comparative nutritional and microbiological quality of ready to cook mixed vegetable curry. *Journal of Food Science and Technology*, 57(6), 2099 -2106. http://dx.doi.org/10.1007/s13197-020-04245-4. PMid:32431336.

Miglio, C., Chiavaro, E., Visconti, A., Fogliano, V., & Pellegrini, N. (2008). Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables. *Journal of Agricultural and Food Chemistry*, 56(1), 139-147. http://dx.doi.org/10.1021/jf072304b. PMid:18069785.

Montgomery, D. C. (2008). *Design and analysis of experiments* (7th ed.). New York: John Wiley and Sons.

Petropoulos, S., Fernandes, Â., Barros, L., & Ferreira, I. C. (2018). Chemical composition, nutritional value and antioxidant properties of Mediterranean okra genotypes in relation to harvest stage. *Food Chemistry*, 242, 466-474. http://dx.doi.org/10.1016/j.foodchem.2017.09.082. PMid:29037716.

Ramírez-Anaya, J. P., Samaniego-Sánchez, C., Castañeda-Saucedo, M. C., Villalón-Mir, M., & Serrana, H. L.-G. (2015). Phenols and the antioxidant capacity of Mediterranean vegetables prepared with extra virgin olive oil using different domestic cooking techniques. *Food Chemistry*, 188, 430-438. http://dx.doi.org/10.1016/j.foodchem.2015.04.124. PMid:26041214.

Saleem, H., Khan, A. R., Jilani, T. A., & Jilani, M. S. (2020). Knowledge based system for diagnosis and management of okra diseases. *International Journal Of Engineering and Information Systems*, 4(8), 255-268.

Sheikh, S. A., Nizamani, S. M., Jamali, A. A., Panhwar, A. A., Channa, M. J., & Mirani, B. N. (2012). Removal of pesticide residues from okra vegetable through traditional processing. *Journal of Basic and Applied Sciences*, 8(1), 79-84. http://dx.doi.org/10.6000/1927-5129.2012.08.01.23.

Silva, M. F. G., Sousa, P. H. M., Figueiredo, R. W., Gouveia, S. T., & Lima, J. S. S. (2019). Cooking effects on bioactive compounds and sensory acceptability in pumpkin (Cucurbita moschata cv. Leite) 1. *Ciência Agronômica*, 50(3), 394-401. http://dx.doi.org/10.5935/1806-6690.20190047.

Soares, A., Carrascosa, C., & Raposo, A. (2017). Influence of different cooking methods on the concentration of glucosinolates and vitamin C in broccoli. *Food and Bioprocess Technology*, 10(8), 1387-1411. http://dx.doi.org/10.1007/s11947-017-1930-3.

Stanikowski, P., Michalak-Majewska, M., Jabłońska-Ryś, E., Gustaw, W., & Gruszecki, R. (2021). Influence of sous-vide thermal treatment, boiling, and steaming on the colour, texture and content of bioactive compounds in root vegetables. *Ukrainian Food Journal*, 10(1), 77-89. http://dx.doi.org/10.24263/2304-974X-2021-10-1-7.

Sultana, B., Anwar, F., & Iqbal, S. (2008). Effect of different cooking methods on the antioxidant activity of some vegetables from Pakistan. *International Journal of Food Science & Technology*, 43(3), 560-567. http://dx.doi.org/10.1111/j.1365-2621.2006.01504.x.

Tian, J., Chen, J., Lv, F., Chen, S., Chen, J., Liu, D., & Ye, X. (2016). Domestic cooking methods affect the phytochemical composition and antioxidant activity of purple-fleshed potatoes. *Food Chemistry*, 197(Pt B), 1264-1270. http://dx.doi.org/10.1016/j.foodchem.2015.11.049. PMid:26675866.

Uthumporn, U., Laila, D. L., Rabeta, M. S., Aida, H., & Ruri, A. S. (2016). Effects of different cooking methods on the physico-chemical and quality attributes of eggplants. *International Journal on Advanced Science. Engineering and Information Technology*, 6(4), 460-464.

Xu, K., Guo, M., Roman, L., Pico, J., & Martinez, M. M. (2020). Okra seed and seedless pod: comparative study of their phenolics and carbohydrate fractions and their impact on bread-making. *Food Chemistry*, 317, 126387. http://dx.doi.org/10.1016/j.foodchem.2020.126387. PMid:32086121.