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Research Article

Production of Vegetable Based Gluten-Free Snack Food Containing Olive Oil and Tahini

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ABSTRACT

In this study, production of a gluten-free snack food was aimed by using different plant materials. For this purpose, based on the results of preliminary studies, various spices (turmeric, spice mix and blue poppy), chickpea flour, aquafaba and tahini/olive oil in addition to Jerusalem artichoke (JA) (*Helianthus tuberosus* L.) and carrot (*Daucus carota*) as tuber plants were used according to the most preferred recipe. The analyses of total polyphenol (TP) and flavonoid (TF), antioxidant capacity (AC) and bioaccessibility of TP were made to determine the functionality of the enriched snacks. The products were also evaluated by sensorial based on the parameters of colour, odour, taste, hardness, crispness and general acceptability. According to the results, depending on the oil source used, the significant difference ($p<0.05$) in TP and TF contents, TP bioaccessibilities and AC values at the end of gastric and intestinal digestion stages was detected. The AC value (621.96 mmol AAE/100g DM), TF (1.26 mg RE/g DM) and TP (0.95 mg GAE/g DM) amounts of the snack with tahini were determined more than the one with olive oil. However, TP bioaccessibility of snack with olive oil was higher compared to that with tahini. While snack with tahini was preferred in terms of crispness by the panelists, the product containing olive oil was more preferred in terms of other sensorial properties. Consequently, this study revealed that both snacks are beneficial regarding functionality and sensory properties.

1. Introduction

Snack foods are one of the most popular products liked by the majority of consumers. However, the most common grain-based ones, such as starch-rich wheat, corn and rice, are not sufficiently rich in bioactive compounds [1]. For this reason, today, there is an increasing demand for health-promoting and easily accessible functional snacks with enhanced nutritional value [2]. In recent years, various ingredients such as fruits, vegetables, whole grains and proteins have been incorporated into the formulations used for snack food production [3]. Jerusalem artichoke (JA) and carrot, which are rich in bioactive compounds, have high potential as an ingredient to improve the nutritional quality of these products. While JA is a good source of inulin as a dietary fiber and phenolic compounds [1, 4], carrot is very rich in β-carotene and dietary fibers [5]. There have been limited attempts to use these two plants in snack food production. Takeuchi & Nagashima [6] dried JA tubers to produce chips. In the study of Peksa et al. [1], corn snack was enriched with JA flour. Carrot was dried [5, 7–9] or deep-fried [10] to produce carrot chips.

Many snacks on the market contain wheat, so gluten, considered the backbone of the food industries due to its viscoelastic property. However, gluten can have adverse effects to the consumer. This has led to the growing adoption of a gluten-free diets and therefore an increased demand for gluten-free foods [11, 12]. In recent years, legumes with high protein content have been preferred instead of wheat in gluten-free diets [13]. Chickpea flour, one of these legumes,

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contains high amounts of important nutrients such as proteins, dietary fibers, carotenoids, polyphenols and minerals [14–16], and is a potential ingredient used in some products owing to its high water and oil absorption capacity [17].

It also has a lower glycemic index than wheat flour, which is important for diabetics and people with insulin resistance [16, 18]. There are numerous studies in which chickpea was used in various gluten-free products such as bread, cookie, biscuit and pasta [15, 19, 20]. Additionally, aquafaba, obtained by cooking of legumes such as chickpea, is a viscous liquid widely used in many products such as yoghurt [21], tomato powder [22] and confectionery [23] as an alternative to egg white for creating stable edible foams and emulsions with functional properties. To the best of our knowledge, there is no study on use of JA, carrot, chickpea and aquafaba together as ingredients in functional snack production. The aim of this study was to produce a gluten-free and functional snack food and to evaluate it based on some quality parameters (TP, bioaccessibility of polyphenols, TF, AC and sensorial properties). Additionally, the effects of olive oil and tahini, both rich in polyphenols and used as an oil sources, on these parameters were investigated.

2. Materials and Methods

2.1. Raw materials

JA tuber, carrot, chickpea flour, aquafaba, olive oil and tahini (as oil sources) and various spices (turmeric, a spice mix called cajun and blue poppy) were used to make the gluten-free snack. All ingredients were purchased from a local market, except for the chickpea flour and aquafaba, which were obtained by processing chickpeas in the laboratory.

2.2. Processing of the gluten-free snack food

Formulation studies were carried out to develop a JA and carrot-based snack, taking into account literature data [3, 5, 9, 24], preliminary trials and sensory properties. The most suitable recipe obtained is presented in Table 1. The prepared snack dough mixture, based on this recipe, was divided into two portions. Olive oil was added to one portion and tahini to the other, as oil sources, to provide crispness to the snack. The spices listed in Table 1 were used to aromatize the snack.

Table 1. Gluten-free snack food formulation

Ingredient	Amount (%)
JA	15.0
Carrot	15.0
Aquafaba	46.0
Chickpea flour	23.0
Turmeric	0.2
Spice mix (cajun)	0.2
Blue poppy	0.3
Tahini / olive oil	0.3

To obtain the juice of boiled chickpeas, known as aquafaba, the chickpea seeds were cooked in water (1:5 chickpea/water ratio) for 30 min in boiling water at 98°C, then left to stand for 12 h before being drained [25]. Then, the juice known as aquafaba was taken into a separate container to be used as an emulsifier in the formulation. The remaining cooked chickpeas were used to obtain flour according to the method of Hong et al. [26] with some modifications. Briefly, they were dried in an oven at 50°C until their moisture content reached 10% for safe storage, then ground into a powder using a laboratory grinder and then sieved.

The baked product was prepared by following the general procedure reported in the literature, with some modifications [27, 28]. Firstly, JA and carrot were washed and the unusable parts were removed. After peeling, they were grated and mixed with chickpea flour. Then, aquafaba, spices, olive oil/tahini were added. The produced dough was kneaded thoroughly, sheeted to 3 mm thickness using a roller, cut into pieces measuring 7.5 × 5 cm and baked at 180°C for 15 min on wax paper in a convection oven (Inoksan FKE 006, Bursa, Turkey). The baked snacks were allowed to cool at the room temperature for 30 min and stored in polyethylene bags until analysis.

2.3. Polyphenol extraction

The snacks were ground and sieved to obtain 150-300 μm particle size. The ground samples were extracted in falcon tubes using an 80%

aqueous methanol solution at a sample/liquid ratio of 1/10 on a mechanical shaker for two hours at room temperature [29]. After 2h, the mixture was centrifuged for about 15 min at 10.000 rpm and then filtered through Whatman No.1 filter paper. The obtained extract was stored at -18°C in falcon tubes until TP, TF, AC and in-vitro digestion analyses. Methanol was chosen because it is commonly used for polyphenol extraction [30]. Each extraction process was performed in thriplicate.

2.4.Determination of TP, TP Bioaccessibility, AC and TF

Folin-Ciocalteu reagent was used for TP analysis according to ISO 14502-1:2005 method [31]. The results were determined on the basis of gallic acid (5-50 µg/mL) standard curve (R^2=0.9968) and expressed as mg gallic acid equivalents (GAE) per gram of dry matter (DM). The bioaccessibility of polyphenols was assessed using the method of Minekus et al. [32], under simulated gastric and intestinal conditions. The method was briefly applied as follows.

Gastric phase

10 mL of extract was mixed with 7.5 mL of gastric fluid, 1.6 mL of stock pepsin solution, 5 mL of 0.3 M $CaCl_2$, 0.2 mL of 1M HCl (to adjust the pH to 3), and 0.695 µL of water. The mixture was incubated for 2 h at 37°C in a shaking water bath (Memmert WNB 22), then centrifuged at 12.000 rpm for 10 min (Sigma 3K30) and filtered from Whatman no:1.

Intestinal phase

10 mL o gastric fraction, 5.5 mL of intestinal fluid, 2.5 mL of pancreatin solution, 1.25 mL of 160 mM bile, 20 µL of 0.3 M $CaCl_2$, 0.075 mL of 1 M NaOH (to adjust pH to 7), and 0.655 mL of water were mixed. The mixture was incubated at 37°C in a shaking water bath for 2 h.

For both stages, the mixtures were centrifuged at 12.000 rpm for 10 min (Sigma 3K30) and filtered from Whatman no:1. The blank was prepared under the same conditions using the same chemicals, except for the extract. After each stage, the amount of TP was determined by spectrophotometer and the bioaccessibility (%) of TP was calculated as follows (Equation 1);

$$Bioaccessibility\ (\%) = (C_{digested}/C_{undigested}) \times 100 \quad (1)$$

$C_{digested}$: Concentration of the compound after the gastric or intestinal digestion (mg)
$C_{undigested}$: Concentration of the compound in the undigested sample (mg)

The percentage inhibition of 2,2,diphenyl-1-picryl-hydrazyl (DPPH) radical was calculated for the determination of AC [33]. A standard curve of reference antioxidant ascorbic acid (0-150 µg/mL) was assayed under identical conditions for its affinity to scavenge DPPH (R^2=0.9975) and the results were converted to ascorbic acid equivalent (AAE). TF of undigested samples was analyzed spectrophotometrically [34] and assessed based on the regression equation of rutin (0-1500 ppm) standard curve (R^2 = 0.9997). Since flavonoids are also members of polyphenols, their bioaccessibility analysis was not required.

2.5. Sensory evaluation

The sensory analysis was conducted by 10 trained panel members from the Department of Food Engineering at Bursa Uludag University. Samples were placed on white plates, identified with random three-digit numbers and evaluated based on colour, odour, taste, hardness, crispness and overall acceptability. Sensory assessment was performed using a five-point hedonic scale ranging from “dislike extremely” (1) to “like extremely” (5) [35]. The panel members were asked to rate their preference for the above properties of the snacks.

2.6. Statistical analysis

The statistical evaluation was performed using SPSS software (SPSS statistics 23, IBM.2015). Data were analyzed using analysis of variance (ANOVA) and compared by post hoc multiple comparison test.

3. Results and discussion

TP, AC and TP bioaccessibility values of JA and carrot-based gluten-free snacks are given in Table 2. The initial (undigested stage) TP (0.95

mg GAE/g DM) value of the snack with tahini was found to be higher than that of the sanack with olive oil (0.56 mg GAE/g DM). However, contrary to this result, Borchani et al. [36] reported that the TP content of tahini (16.82 mg caffeic acid/kg oil) was lower than that of olive oil (52.33 mg caffeic acid/kg oil). The TP values determined in this study were in agreement with those reported by Doğan [37] (48.80-125.07 mg GAE/100g sample for chips produced using mushroom powder and wheat flour) and Erdoğan [38] (559.32 mg GAE/kg for chips produced with red beet, olive oil and thyme). Additionally, Takeuchi & Nagashima [6] stated TP content of the chips produced from JA as 0.38-0.61 mg GAE/g DM, which was partially consistent with the TP values determined in this study. However, it was reported that TP values were 4.76-14.74 mg GAE/g DM in chips obtained from persimmon [39] and 1.74-5.52 mg GAE/g DM in red and purple potato chips [40], which were higher than those determined in this study. This difference can be attributed to variations in raw materials and processing methods.

As in TP content, the initial AC (621.96 mmol AAE/100g DM) value of the snack with tahini was found to be higher than AC (353.06 mmol AAE/100g DM) value of that with olive oil, which may be due to its higher TP content. This is because a strong relationship between TP and AC, reported in many previous studies [41–43]. A comparison of the AC values of the snacks in this study with those reported in the literature was not feasible due to differences in standard compounds used and antioxidant methods applied in those studies. Additionally, the results were expressed in different units.

The snacks with tahini and olive oil both showed a similar trend in terms of TP value after digestion. TP value of both snacks decreased significantly ($p<0.05$) at the end of the gastric stage compared to the initial one, but no significant change was observed in the intestinal stage compared to gastric one ($p>0.05$). However, both snacks showed different trends in terms of TP bioaccessibility. TP bioaccessibility of the snack with olive oil after digestion was higher than that of the snack with tahini (Table 2). While it decreased significantly ($p<0.05$) after the gastric stage, no change was observed after the intestinal stage. TP bioaccessibility of the snack with tahini showed a tendency to decrease significantly ($p<0.05$) after both stages. This may be attributed to the different types of phenolic compounds found in tahini and olive oil and the low stability of polyphenols during intestinal digestion due to the alkaline environment [44].

Y. Chen et al. [45] reported that the dominant phenolic compound in tahini is sesamin, which has a strong antioxidant capacity but is lost after gastrointestinal digestion. The decrease in TP after digestion has also been reported by previous researches. The TP content of noodle [46, 47] and enriched noodle with peanut skin extract [46] showed a significant decrease after digestion. Similarly, TP values of four different apple cultivars [48] and ten different walnut cultivars [42] decreased compared to their initial values after in vitro digestion. On the other hand, contrary to these findings, Wang et al. [49] stated that TP of grape pomace remained the same after the gastric digestion compared to the initial value, but decreased after the intestinal stage. Also, TP contents of undigested pomegranate products and wastes showed different trends after digestion, depending on the material and the solvent used in extraction [44]. This discrepancy in the results is thought to be due to differencies in the materials studied and digestion conditions.

While the initial AC value was higher in the snack with tahini than that with olive oil, higher AC was detected in the snack with olive oil after digestion, similar to the trend observed in TP bioaccessibility. In previous studies [50, 51], it was reported that the bioaccessibility of olive oil phenolics which have lower antioxidant activity than those of tahini was quite high, which is consistent with the results of this study. On the other hand, it is thought that regardless of the type of snack, the spices used in the formulation may also contribute significantly to its AC. This is supported by numerous studies that have reported AC of many spices, particularly turmeric [52–54].

In terms of TF, when tahini was used instead of olive oil in the snack dough, a much higher TF was detected in the snack (Table 3), which was consistent with the TP and AC results of the

samples. When the TF content of the snacks was compared with their TP ones, it was observed that the TF values of both snacks were higher. However, contrary to this result, Elhussein et al. [55] found the TF (0.37 ppm) content of tahini to be lower than TP (1.24 ppm). This discrepancy could be explained by differences in the composition of the sesame used and the method of tahini production.

Table 2. TP (mg GAE/g DM), AC (mmol AAE/100g DM) and *in-vitro* TP bioaccessibility (%) of snacks

		Digestion stage		
	Snack type	Initial/Undigested	Gastric	Intestinal
TP	Snack with tahini	$0.95 \pm 0.03^{b*}$	0.21 ± 0.01^{a}	0.19 ± 0.00^{a}
	Snack with olive oil	0.56 ± 0.00^{b}	0.45 ± 0.01^{a}	0.43 ± 0.01^{a}
TP bioaccessibility	Snack with tahini	100.00 ± 0.00^{c}	21.72 ± 0.53^{b}	20.23 ± 0.18^{a}
	Snack with olive oil	100.00 ± 0.00^{b}	80.17 ± 2.54^{a}	76.03 ± 1.45^{a}
AC	Snack with tahini	621.96 ± 6.29^{c}	165.69 ± 2.35^{b}	108.96 ± 3.67^{a}
	Snack with olive oil	353.06 ± 14.96^{b}	322.38 ± 5.18^{b}	261.83 ± 1.96^{a}

** In each row values with different letters are significantly different ($p < 0.05$).*

Table 3. TF amount (mg RE/g DM) of snacks

Snack type	Snack with tahini	1.26±0.09
	Snack with olive oil	0.62±0.05

Sensory analysis was conducted on the snacks based on six different parameters using a hedonic scale and the results were evaluated using a spider web (radar) model (Fig. 1). The parameters were selected from key quality attributes commonly used in snack product evaluation. The results revealed that the snack with olive oil had higher hedonic ratings than the snack with tahini in terms of colour, taste, odour, hardness and overall acceptability. However, in terms of crispness only, it was observed that the snack with tahini was rated slightly higher. As a result, both snacks can be recommended as alternative functional snack foods to those currently available on the market.

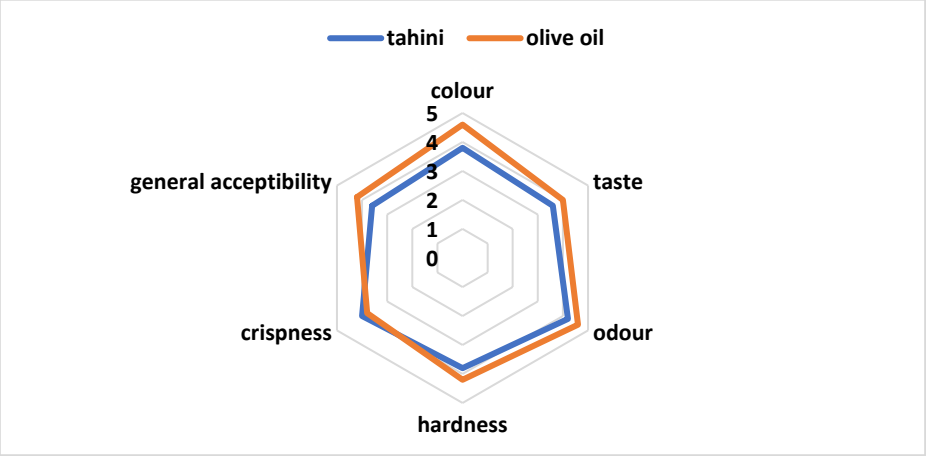

Figure 1. Sensory properties of snacks

4. Conclusion

The aim of this study was to develop a new recipe for gluten-free snack chips and evaluate them with respect to quality parameters. Chickpea flour, aquafaba, Jerusalem artichoke (JA), carrot and tahini/olive oil were used in certain proportions to produce the snack chips. The experimental results showed that the product with tahini had higher TP and TF contents and AC compared to the one with olive oil. On the other hand, after in vitro digestion, it was revealed that both snacks exhibited a similar trend in terms of TP content. However, in terms of TP bioaccessibility, it was determined that the polyphenols of snack with olive oil had higher bioaccessibility and also their AC was higher than that of snack with tahini. According to the sensory analysis results, both snacks were found to be acceptable, however, it is suggested that formulation studies may be continued to further improve their sensory and functional properties.

There are very limited studies on enriched healthy snacks and their bioaccessibility. Therefore, this research enables to fulfil the gap in the literature on gluten-free snacks. It is also believed that the data obtained will provide useful insights for both consumers and producers and this study will provide the basis for further research.

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Authors' Contribution
BK: Data curation, Resources, Project administration, Writing – review & editing Visualization. NTE: Supervision, Conceptualization, Methodology, Writing - original draft. HC: Investigation, Formal analysis, Validation.

The Declaration of Conflict of Interest/ Common Interest
No conflict of interest or common interest has been declared by authors.

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References

[1] A. Peksa, A. Kita, A. A. Carbonell-Barrachina, J. Miedzianka, J. Kolniak-Ostek, A. Tajner-Czopek, et al., "Sensory attributes and physicochemical features of corn snacks as affected by different flour types and extrusion conditions," LWT, vol. 72, pp. 26–36, 2016.

[2] R. Gormley, "Developing innovative food structures & functionalities through process & reformulation to satisfy consumer needs & expectations: Outcomes from the 32nd EFFoST international conference 2018, Nantes, France," Trends in Food Science & Technology, vol. 93, pp. 37–41, 2019.

[3] A. Kita, J. Nowak, A. Michalska-Ciechanowska, "The effect of the addition of fruit powders on the quality of snacks with *Jerusalem* artichoke during storage," Applied Sciences (Switzerland), vol. 10, 2020.

[4] Y. Mu, W. Gao, S. Lv, F. Li, Y. Lu, C. Zhao, "The antioxidant capacity and antioxidant system of *Jerusalem* artichoke (*Helianthus tuberosus* L.) tubers in relation to inulin during storage at different low temperatures," Industrial Crops and Products, vol. 161, 113229, 2021.

[5] J. Chen, C. Venkitasamy, Q. Shen, T. H. McHugh, R. Zhang, Z. Pan, "Development of healthy crispy carrot snacks using sequential infrared blanching and hot air drying method," LWT, vol. 97, pp. 469–475, 2018.

[6] J. Takeuchi, T. Nagashima, "Preparation of dried chips from Jerusalem artichoke (*Helianthus tuberosus*) tubers and analysis of their functional properties," Food Chemical, vol. 126, pp. 922–926, 2011.

[7] D. Konopacka, J. Cybulska, A. Zdunek, B. Dyki, A. Machlańska, K. Celejewska, "The combined effect of ultrasound and enzymatic treatment on the nanostructure, carotenoid retention and sensory properties of ready-to-eat carrot chips," LWT, vol. 85, pp. 427–433, 2017.

[8] M. N. Norazmir, K. Mastura, A. H. Syahrul Bariah, M. Naleena Devi, B. Siti Sabariah, "Development of whole grain carrot (*Daucus carota*) chips," Current Research in Nutrition and Food Science, vol. 2, pp. 26–32, 2014.

[9] J. Peng, J. Bi, J. Yi, K. Allaf, C. Besombes, X. Jin, et al., "Apple juice concentrate impregnation enhances nutritional and textural attributes of the instant controlled

pressure drop (DIC)-dried carrot chips," Journal of the Science of Food and Agriculture, vol. 99, pp. 6248–6257, 2019.

[10] A. Sulaeman, D. W. Giraud, L. Keeler, S. L. Taylor, J. A. Driskell, "Effect of moisture content of carrot slices on the fat content, carotenoid content, and sensory characteristics of deep-fried carrot chips," Journal of Food Science, vol. 69, pp. 450-455, 2004.

[11] J. A. Jamieson, L. Viana, M. M. English, "Folate content and chemical composition of commercially available gluten-free flour alternatives," Plant Foods for Human Nutrition, vol. 75, pp. 337–343, 2020.

[12] M. J. Christoph, N. Larson, K. C. Hootman, J. M. Miller, D. Neumark-Sztainer, "Who values gluten-free? Dietary intake, behaviors, and sociodemographic characteristics of young adults who value gluten-free food," Journal of the Academy of Nutrition and Dietetics, vol. 118, pp. 1389–1398, 2018.

[13] B. Carbas, N. Machado, D. Oppolzer, L. Ferreira, M. Queiroz, C. Brites, et al., "Nutrients, antinutrients, phenolic composition, and antioxidant activity of common bean cultivars and their potential for food applications," Antioxidants, vol. 9, p. 186, 2020.

[14] F. G. Santos, C. Fratelli, D. G. Muniz, V. D. Capriles, "Mixture design applied to the development of chickpea-based gluten-free bread with attractive technological, sensory, and nutritional quality," Journal of Food Science, vol. 83, pp. 188–197, 2018.

[15] S. Chillo, J. Laverse, P. M. Falcone, M. A. Del Nobile, "Quality of spaghetti in base amaranthus wholemeal flour added with quinoa, broad bean and chick pea," Journal of Food Engineering, vol. 84, pp. 101–107, 2008.

[16] K. Felisiak, S. Przybylska, G. Tokarczyk, M. Tabaszewska, J. Słupski, J. Wydurska, "Effect of chickpea (*Cicer arietinum* L.) flour incorporation on quality, antioxidant properties, and bioactive compounds of shortbread cookies," Foods, vol. 13, p. 2356, 2024.

[17] S. Kui Du, H. Jiang, X. Yu, J. lin Jane, "Physicochemical and functional properties of whole legume flour," LWT, vol. 55, pp. 308–313, 2014.

[18] L. Lu, C. He, B. Liu, Q. Wen, S. Xia, "Incorporation of chickpea flour into biscuits improves the physicochemical properties and in vitro starch digestibility," LWT, vol. 159, p. 113222, 2022.

[19] P. C. Flores-Silva, S. L. Rodriguez-Ambriz, L. A. Bello-Pérez, "Gluten-free snacks using plantain-chickpea and maize blend: Chemical composition, starch digestibility, and predicted glycemic index," Journal of Food Science, vol. 80, pp. 961–966, 2015.

[20] J. D. Hoyos-Leyva, E. Agama-Acevedo, L. A. Bello-Perez, E. J. Vernon-Carter, J. Alvarez-Ramirez, "Assessing the structural stability of gluten-free snacks with different dietary fiber contents from adsorption isotherms," LWT, vol. 73, pp. 576–583, 2016.

[21] V. Raikos, L. Juskaite, F. Vas, H. E. Hayes, "Physicochemical properties, texture, and probiotic survivability of oat-based yogurt using aquafaba as a gelling agent," Food Science and Nutrition, vol. 8, pp. 6426–6432, 2020.

[22] M. Kilicli, K. F. Erol, O. S. Toker, F. Tornuk, "Production of tomato powder from tomato puree with foam-mat drying using green pea aquafaba: Drying parameters and bioaccessibility of bioactive compounds," Journal of the Science of Food and Agriculture, vol. 103, pp. 3691-3700, 2022.

[23] D. Tufaro, C. Cappa, "Chickpea cooking water (Aquafaba): Technological properties and application in a model confectionery product," Food Hydrocolloids, vol. 136, p. 108231, 2023.

[24] C. Baltacıoğlu, A. Esin, "Crisp production from Jerusalem artichoke (*Helianthus tuberosus* L.) and investigation of quality parameters," Akademik Gıda, vol. 11, pp. 14-20, 2013.

[25] M. Aslan, N. Ertaş, "Possibility of using "chickpea aquafaba" as egg replacer in traditional cake formulation," Harran Tarım ve Gıda Bilimleri Dergisi, vol. 24, pp. 1–8, 2020.

[26] S. Hong, R. Xiao, G. Chen, Y Zhu, A. Garay, J. Yang, et al., "Effect of cooking conditions on chickpea flour functionality and its protein physicochemical properties," Journal of Food Science, vol. 89, pp. 6253-6267, 2024.

[27] C. Delgado-Andrade, R. Olías, M. C. Marín-Manzano, I. Seiquer, A. Clemente, "Chickpea seed flours improve the nutritional and the antioxidant profiles of traditional shortbread biscuits: Effects of in vitro gastrointestinal digestion," Antioxidants, vol. 13, p. 118, 2024.

[28] D. Chatziharalambous, C. Kaloteraki, P. Potsaki, O. Papagianni, K. Giannoutsos, D. I. Koukoumaki, et al., "Study of the total phenolic content, total antioxidant activity and in vitro digestibility of novel wheat crackers enriched with cereal, legume and agricultural by-product flours," Oxygen, vol. 3, pp. 256–273, 2023.

[29] N. Turkmen, F. Sari, Y. S. Velioglu, "The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables," Food Chemistry, vol. 93, pp. 713–718, 2005.

[30] I. Zardo, A. de Espíndola Sobczyk, L. D. F. Marczak, J. Sarkis, "Optimization of ultrasound assisted extraction of phenolic compounds from sunflower seed cake using response surface methodology," Waste and Biomass Valorization, vol. 10, pp. 33–44, 2019.

[31] ISO 14502-1:2005, "Determination of substances characteristic of green and black tea. Part 1: Content of total polyphenols in tea. Colorimetric method using Folin-Ciocalteu reagent," 8p.

[32] M. Minekus, M. Alminger, P. Alvito, S. Ballance, T. Bohn, C. Bourlieu, et al., "A standardised static in vitro digestion method suitable for food-an international consensus," Food and Function, vol. 5, pp. 1113–1124, 2014.

[33] N. Türkmen Erol, F. Sari, E. Çalikoğlu, Y. S. Velioğlu, "Green and roasted mate: Phenolic profile and antioxidant activity," Turkish Journal of Agriculture and Forestry, vol. 33, pp. 353–362, 2009.

[34] M. J. Rodrigues, V. Neves, A. Martins, A. P. Rauter, N. R. Neng, J. M. F. Nogueira, et al., "In vitro antioxidant and anti-inflammatory properties of *Limonium algarvense* flowers' infusions and decoctions: A comparison with green tea (*Camellia sinensis*)," Food Chemistry, vol. 200, pp. 322–329, 2016.

[35] B. Incedayi, N. Dogan, O. U. Copur, "Assessment of cactus pear leather (pestil) as a new snack food," Journal of Food Science and Technology, vol. 59, pp. 3158–3166, 2022.

[36] C. Borchani, S. Besbes, C. Blecker, H. Attia, "Chemical characteristics and oxidative stability of sesame seed, sesame paste, and olive oils," Journal of Agricultural Science and Technology, vol. 12, pp. 585–596, 2010.

[37] N. Doğan, "İstiridye mantarından (*Pleurotus ostreatus*) mantar tozu ve cips üretiminin optimizasyonu," PhD Thesis. Harran University, Şanlıurfa, Türkiye, 2016.

[38] S. Erdoğan, "Farklı baharat kullanılarak üretilen pancar cipslerinin kalite özelliklerinin belirlenmesi," MSc Thesis. T.C. Manisa Celal Bayar University, Manisa, Türkiye, 2019.

[39] R. R. Milczarek, A. M. Vilches, C. W. Olsen, A. P. Breksa, B. E. Mackey, M. T. Brandl, "Physical, microbial, and chemical quality of hot-air-dried persimmon (*Diospyros kaki*) chips during storage," Journal of Food Quality, vol. 2, pp. 1-15, 2020.

[40] A. Kita, A. Bakowska-Barczak, K. Hamouz, K. Kułakowska, G. Lisińska, "The effect of frying on anthocyanin stability and antioxidant activity of crisps from red- and purple-fleshed potatoes (*Solanum tuberosum* L.)," Journal of Food Composition and Analysis, vol. 32, pp. 169–175, 2013.

[41] M. Lutz, J. Hernández, C. Henríquez, "Phenolic content and antioxidant capacity in fresh and dry fruits and vegetables grown in Chile," CYTA - Journal of Food, vol. 13, pp. 541–547, 2015.

[42] F. Figueroa, J. Marhuenda, P. Zafrilla, A. Martínez-Cachá, J. Mulero, B. Cerdá, "Total phenolics content, bioavailability and antioxidant capacity of 10 different genotypes of walnut (*Juglans regia* L.)," Journal of Food and Nutrition Research, vol. 55, pp. 229–236, 2016.

[43] K. Ghafoor, F. Al Juhaimi, M. M. Özcan, N. Uslu, E. E. Babiker, I. A. Mohamed Ahmed, "Total phenolics, total carotenoids, individual phenolics and antioxidant activity of ginger (*Zingiber officinale*) rhizome as affected by drying methods," LWT, vol. 126, p. 109354, 2020.

[44] O. A. Fawole, U. L. Opara, "Stability of total phenolic concentration and antioxidant capacity of extracts from pomegranate co-products subjected to in vitro digestion," BMC Complementary and Alternative Medicine, vol. 16, pp. 1–10, 2016.

[45] Y. Chen, H. Lin, M. Lin, Y. Zheng, J. Chen, "Effect of roasting and in vitro digestion on phenolic profiles and antioxidant activity of water-soluble extracts from sesame," Food and Chemical Toxicology, vol. 139, 111239, 2020.

[46] B. İncedayı, N. Türkmen Erol, "Bioaccessibility of polyphenols from hazelnut skin and their use in noodle formulation," International Journal of Agricultural and Natural Sciences, vol. 15, pp. 32–41, 2022.

[47] N. T. Erol, B. Incedayi, F. Sari, O. U. Copur, "Optimization of polyphenol extraction from chestnut waste pretreated by ohmic heating using Box-Behnken design," Latin American Applied Research, vol. 52, pp. 173–179, 2022.

[48] J. Bouayed, H. Deußer, L. Hoffmann, T. Bohn, "Bioaccessible and dialysable polyphenols in selected apple varieties following in vitro digestion vs. their native patterns," Food Chemistry, vol. 131, pp. 1466–1472, 2012.

[49] S. Wang, M. Amigo-Benavent, R. Mateos, L. Bravo, B. Sarriá, "Effects of in vitro digestion and storage on the phenolic content and antioxidant capacity of a red grape pomace," International Journal of Food Sciences and Nutrition, vol. 68, pp. 188–200, 2017.

[50] S. Cicerale, X. A. Conlan, A. J. Sinclair, R. S. J. Keast, "Chemistry and health of olive oil phenolics," Critical Reviews in Food Science and Nutrition, vol. 49, pp. 218–236, 2009.

[51] K. L. Tuck, M. P. Freeman, P. J. Hayball, G. L. Stretch, I. Stupans, "The in vivo fate of hydroxytyrosol and tyrosol, antioxidant phenolic constituents of olive oil, after intravenous and oral dosing of labeled compounds to rats," Journal of Nutrition, vol. 131, pp. 1993–1996, 2001.

[52] E. M. Tanvir, M. S. Hossen, M. F. Hossain, R. Afroz, S. H. Gan, M. I. Khalil, et al., "Antioxidant properties of popular turmeric (*Curcuma longa*) varieties from Bangladesh," Journal of Food Quality, 2017.

[53] T. Van Hecke, P. L. Ho, S. Goethals, S. De Smet, “The potential of herbs and spices to reduce lipid oxidation during heating and gastrointestinal digestion of a beef product,” Food Research International, vol. 102, pp. 785–792, 2017.

[54] L. D. Do Nascimento, A. A. B. de Moraes, K. S. da Costa, J. M. P. Galúcio, P. S. Taube, C. M. L. Costa, et al., “Bioactive natural compounds and antioxidant activity of essential oils from spice plants: New findings and potential applications,” Biomolecules, vol. 10, pp. 1–37, 2020.

[55] E. Elhussein, M. Bilgin, S. Şahin, “Oxidative stability of sesame oil extracted from the seeds with different origins: Kinetic and thermodynamic studies under accelerated conditions,” Journal of Food Process Engineering, vol. 41, pp. 2–7, 2018.