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The effects of different cooking methods on the physicochemical properties of potatoes, carrots, and cultivated mushrooms

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Abstract

This study investigated the effects of different cooking techniques (hot-air baking and deep frying) on digestibility, thermal properties, and functional compounds of potatoes, carrots, and cultivated mushrooms. Color values (Hunter *L*, *a*, *b*, and ΔE), thermal properties (To and ΔH values), total phenolic content, antioxidant activity, estimated glycemic index (eGI), and sensory properties analyses were carried out on the obtained products. According to the results, a statistically significant ($p<0.05$) effect of different cooking techniques on the physicochemical and sensorial properties of cooked potato, carrot, and cultivated mushroom samples was found. The eGI values of the samples were ranged in 42.82-68.50 and had low (<55) glycemic indexes, with the exception of deep-fried carrot samples. With the cooking process, a decrease was observed in the antioxidant activity and total phenolic content of the samples. The sensory analysis results determined that the panelists gave higher scores to the deep-fried samples than the baked samples. In addition, the general acceptance scores of deep-fried products were higher. As a result, the baking process is recommended for the preservation of physicochemical properties of the samples, although deep frying provided higher scores for sensorial properties.

Keywords: Cooking, Thermal properties, Glycemic index, Functional properties, Vegetables

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INTRODUCTION

Heat treatment is one of the methods commonly used in the food industry and is generally preferred to extend the shelf life of food or to produce a new product. With the heat treatment, several complex reactions (i.e. Maillard reaction) occur that change the quality parameters such as storage stability, sensory properties, nutritional properties of the food (Choe and Min, 2007). Heat treatments can also reduce food quality. It is known that most bioactive compounds are relatively unstable to heating (Roncero-Ramos et al., 2017). There are many suggestions regarding the healthy consumption of different vegetables. In particular, the boiling process is preferred in terms of health in consuming these products. However, the sensory properties of boiled products are significantly lower than those cooked by hot-air baking and deep/shallow frying techniques. For this reason, consumers prefer hot-air baking and frying processes more widely to provide the desired sensory quality, especially in terms of taste and smell (Tuta and Palazoglu, 2017).

Hot-air baking is a thermal process performed at high temperatures and a complex process in which some chemical and physical changes co-occur. It is essential not only for the shelf-life stability of the product but also for food quality, taste and texture. In addition to the desired quality properties, compounds formed during heat treatment, such as acrylamide and HMF, are also formed by baking (Mogol and Gökmen, 2014).

The frying process is generally divided into deep and shallow (contact) frying. In the deep-frying process, the heat transfer is equal at every point of the food, as the oil surrounds the food surface. For this reason, frying is uniform. The deep-frying process is more preferred than shallow frying due to the higher quality of the product obtained after frying in terms of desired colour, texture and flavour characteristics (Devseren et al., 2021).

After the food is consumed, the starch molecules in the composition of the food are broken down into branched α-limit dextrins, maltose and linear oligomers of glucose by pancreatic α-amylases. The released monosaccharides are absorbed into the bloodstream via glucose transporters and used as energy in the body (Shin et al., 2019).The ability of food containing carbohydrates to increase blood sugar after consumption is defined by the concepts of glycemic index or glycemic load (Pi-Sunyer, 2002).It is known that the glycemic index value of food, which is considered very important in terms of digestibility of foods, is also significantly affected by different cooking techniques (Allen et al., 2012).

The present study aims to determine the effects of hot-air baking and deep-frying on some physicochemical properties of potatoes, carrots and cultivated mushrooms. The main reason for choosing potato, carrot and cultivated mushroom in the study is that all three vegetables are rich in different components. Studies have reported that potatoes, carrots and mushrooms are rich in starch-based (Lachman et al., 2013), pectin-based (Sharma et al., 2012) and protein-based (Manzi et al., 2004) components, respectively. Therefore, this study was carried out to measure the reactions of foods rich in different ingredients to different cooking methods and examine the effects of cooking techniques on digestibility, thermal properties and functional compounds of these foods.

MATERIALS AND METHODS

Materials

The apparatus used for slicing within the scope of the present study was procured from a local firm. Fresh potatoes, carrots and cultivated mushrooms samples were obtained from the same batch from a greengrocer in Aydın, Turkey. The same batch production of refined sunflower oil was used for frying experiments.

Methods

Preparation and cooking methods of potato, carrot and cultivated mushroom slices

Fresh potato, carrot and cultivated mushroom samples were peeled (except mushroom), washed and dried with the help of paper towels. The samples were then cut with a slicer in 12x12x10 mm dimensions and immediately taken into the cooking process. The cooking processes were carried out under the conditions determined according to the Central Composite Rotatable Design in the Design Expert package program using the maximum and minimum temperature and time values determined by preliminary trials for each method.

Deep frying (DF) was carried out using an industrial fryer at a temperature of 180-200 °C and a time interval of 3-8 minutes. Previously prepared sliced samples were fried in 200 g portions in 2000 mL refined sunflower oil under the conditions specified according to the central composite design given in Table 1.

The hot-air baking (HAB) process was carried out in a domestic hot air oven (Arçelik, KMF833I, Turkey) at a temperature of 180-220 °C and 5-30 minutes. Sliced samples were spread in 200 g portions on the baking paper in a single layer and cooked according to the composite design given in Table 1.

Table 1. Central composite design (CCRD) for deep frying and hot air baking processes

Exp. No	Frying temperature (°C)	Frying time (min)	Baking temperature (°C)	Baking time (min)
1	180	3	180	5
2	200	3	220	5
3	180	8	180	30
4	200	8	220	30
5	180	5.5	180	17.5
6	200	5.5	220	17.5
7	190	3	180	5
8	190	8	180	30
9	190	5.5	180	17.5
10	190	5.5	180	17.5
11	190	5.5	180	17.5
12	190	5.5	180	17.5
13	190	5.5	180	17.5

Analysis of color changes

Color changes of the samples were determined by using a colorimeter (PCE-CSM-5, Deutschland). Color parameters were expressed as Hunter L [(0) dark - (100) light], a [(+) red – (-) green] and b [(+) yellow – (-) blue]. The total color difference (ΔE) was calculated using Equation 1 (Meena et al., 2021).

$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2} \quad (1)$$

Where L0, a0 and b0 are the color values of the fresh potatoes, carrots and cultivated mushrooms samples.

Determination of gelatinization temperature and gelatinization enthalpy

DSC (Perkin-Elmer, DSC 6000, Massachusetts, USA) analyzes were carried out to determine the thermal behaviour of potato, carrot and cultivated mushroom samples prepared with different cooking techniques. Approximately 5-8 mg of homogeneous sample was weighed into the aluminum sample cup. Inside, the DSC oven was conditioned with nitrogen gas with a flow rate of 50 ml/min and samples were heated from 25 °C to 90 °C with a temperature increase rate of 10 °C/min. By analyzing the thermograms obtained with the software of the device (Pyris Manager Software, Perkin-Elmer, Massachusetts, USA), the phase change starting temperature (T0) of the polymer compounds (i.e. starch, pectin, and protein) present in the samples and the required enthalpy change (ΔH) for gelatinization were calculated (Chuang et al., 2016).

Determination of antioxidant activity

The stable radical DPPH (2,2-diphenyl-1-picrylhydrazyl radical) was used to determine the free radical-scavenging activity of the samples by using the DPPH method (Anticona et al., 2021). The results calculated according to the calibration curve obtained using the Trolox standard were indicated as µmol Trolox equivalent antioxidant capacity (TEAC)/gram dry sample. The % inhibition rate was calculated according to Equation 2;

$$\%Inhibition = \frac{(A_C - A_S)}{A_C} X100 \qquad (2)$$

where Ac and As are the absorbance values of the control and cooked samples, respectively.

Determination of total phenolic content

The total phenolic content of the samples was determined by using the Folin-Ciocalteu method (Şahin et al., 2009). According to the method, 100 µL of diluted sample was mixed with 900 µL of ultra-pure water and 5 mL of 0.2 N Folin-Ciocalteu reagent and 4 mL of Na_2CO_3 (7.5% in water, w/w) was added to this mixture. The final mixture was incubated at room temperature for 1 hour in a dark place. The absorption of the samples was measured at 760 nm with a spectrophotometer (Shimadzu UV-1601, Shimadzu Scientific Instruments, Inc., Tokyo, Japan). The total phenolic content of the samples was expressed as gallic acid equivalents (GAE) in mg/100 g dry matter.

Estimated glycemic index

The estimated glycemic index (eGI) values of the samples were determined using the glucose oxidase kit (GOPOD-Megazyme, Ireland). For this purpose, samples were primarily subjected to in vitro digestion with some modifications (van Kempen et al., 2010). For this purpose, 20 mL sodium acetate buffer (0.1 M, pH 5.2) and 5 mL enzyme mix (0.7 g pancreatin, 0.05 mL amyloglucosidase and 3 mg invertase in water) were added to 0.8 g of cooked sample. The mixture was incubated at 39 °C under horizontal agitation. During the incubation period, 0.5 mL of the sample was taken from this mixture at 0, 20, 60, 120 and 180 minutes and 2 mL 96% ethanol was added to stop the enzymatic reaction. Before the analysis, the sample and ethanol mixture were centrifuged at 1790 g for 5 min. The glucose content of the supernatant was measured using a glucose oxidase–peroxidase (GOPOD-Megazyme) kit. The hydrolysis index (HI) was determined by dividing the area under the samples' curve by the area obtained for white bread. The estimated glycemic index (eGI) was calculated by using Equation (3) described by (Saraswat et al., 2020).

$$eGI = 39.71 + 0.549\ (HI) \qquad (3)$$

Sensory analysis

The sensory characteristics of potato, carrot and cultivated mushroom samples prepared with different cooking techniques were evaluated by a panel of 10 people, consisting of graduate students of Aydın Adnan Menderes University Food Engineering Department, who had knowledge and experience about the sensory panel. Five randomly coded samples were evaluated in each panel, and analyses were carried out in 2 replications. It was ensured that the panellists consumed water before and after the evaluation. The samples presented in the sensory panel were evaluated with a hedonic scale scored between 1 and 5 points (1-not like and 5-extremely like) in terms of appearance, color, odor, taste, texture and global preference (Gomes et al., 2013).

Statistical analysis

The effect of different cooking techniques on digestibility, thermal properties and functional compounds of the samples was determined according to the Central Composite design using the response surface method with Design Expert 10.01 (Stat.-Ease Co., Mineapolis, USA) package program. The results were statistically evaluated by Variance analysis and Duncan's multiple range tests using the Statistical Analysis System software (SAS system for Windows V7 prepared by SAS Institute (Cary, NC, ABD)).

RESULTS AND DISCUSSION

Effects of different cooking methods on the color changes of the samples

The results for color changes of potatoes are given in Table 2. According to the results, it was observed that the Hunter *L, a, b* color values of the potatoes vary between 19.12-60.55, -4.93-23.85 and 5.46-37.20, respectively. Different cooking methods affected significantly ($p<0.05$) the color properties of the potato samples (Table 4).

Similar studies in the literature on the subject also support the results. In one study, it has been observed that the cooking process has a significant effect on the color change. At the same time, high temperature causes undesirable color, and the color change in the food gives information about the product quality and the applied process (Palazoglu et al., 2010).

Table 2. CCRD experimental data for the color values of cooked potatoes

Cooking Method	Exp. No	*L*	*a*	*b*	ΔE
Deep Frying	1	30.34±0.55	20.13±0.95	32.47±0.26	37.75±0.22
	2	30.41±0.34	20.26±0.33	31.92±0.30	37.66±0.15
	3	35.33±0.91	18.32±0.51	27.70±0.15	32.01±0.33
	4	32.20±0.56	19.36±0.11	31.92±0.54	35.70±0.15
	5	44.80±0.81	7.78±0.14	25.37±0.64	18.50±0.31
	6	27.79±0.73	21.60±0.34	34.59±0.55	41.06±0.55
	7	30.17±0.54	20.44±0.23	32.34±0.34	38.03±0.26
	8	25.99±0.66	22.58±0.66	35.89±0.25	43.35±0.55
	9	22.94±0.25	23.85±0.50	37.20±0.15	46.84±0.14
	10	30.19±0.60	20.56±1.23	32.42±0.11	38.10±0.33
	11	29.96±0.33	19.90±1.54	30.47±0.36	37.63±0.52
	12	44.29±0.15	15.58±1.66	26.10±0.15	23.16±0.14
	13	30.47±0.22	20.46±0.25	32.54±0.60	37.83±0.25
Hot air Baking	1	47.57±0.33	-0.96±0.55	17.88±0.61	16.15±0.26
	2	45.28±0.74	2.37±0.14	16.40±0.54	18.93±0.96
	3	45.29±0.88	0.95±0.36	21.23±0.34	17.01±0.36
	4	46.43±0.33	0.49±0.60	24.60±0.51	15.34±1.61
	5	45.58±0.84	-0.04±0.22	21.33±0.50	16.70±0.54
	6	40.76±0.64	0.74±0.57	21.34±0.31	21.40±1.45
	7	57.17±0.44	1.47±0.51	22.82±0.25	15.42±0.22
	8	43.85±0.20	0.62±0.33	18.53±0.24	19.21±1.22
	9	43.17±0.55	0.45±0.12	22.42±0.64	18.83±0.34
	10	42.42±0.54	0.64±0.44	22.49±0.11	19.56±1.35
	11	42.69±0.64	0.49±0.22	22.50±0.25	19.29±0.55
	12	42.55±0.84	0.72±0.34	22.76±0.34	19.39±0.15
	13	42.53±0.14	0.66±0.11	22.57±0.15	19.44±0.15

Color is the first physical quality criterion evaluated by consumers in fried potatoes. Color parameters differed significantly ($p < 0.05$) depending on the temperature of the frying potatoes. While no trend could be determined for the Hunter *L* value, the redness (Hunter *a*) values showed an increasing trend due to the temperature increase. It is stated that this change is caused by the color compounds released due to non-enzymatic browning reactions that occur during the frying process (Pedreschi, 2012). Similarly, in a study by Pedreschi and Moyano (2005), a darker red color was determined as a result of non-enzymatic browning reactions in potatoes due to an increase in frying temperature from 120 °C to 180 °C.

Color parameters were affected significantly ($p<0.05$) in hot-air baked potatoes depending on the temperature. In the study, the total color change was 15.34-21.40 in baked potatoes. In a study conducted by Tuta and Palazoğlu (2017), the color values of potato chips were defined as orange-yellow in baked samples, bright yellow in fried samples, and the total color change was found to range from 16.7-22.3 for fried products and 21.7-37.4 for baked samples.

Table 3. CCRD experimental data for the thermal and chemical properties of cooked potatoes

Cooking Method	Exp. No	To (°C)	ΔH (J/g)	GI	AA (μmol trolox/g)	TPC (mg GA/g dm)
Deep Frying	1	31.70±0.22	37.01±0.26	48.83±0.41	198.28±0.78	15.97±0.48
	2	37.09±0.15	30.24±1.52	51.23±1.12	197.17±0.55	14.54±0.19
	3	32.86±0.35	46.55±1.30	50.99±1.24	197.67±1.35	13.32±0.19
	4	36.32±0.34	42.60±0.26	49.67±0.15	195.45±1.22	9.66±0.38
	5	32.07±0.64	35.10±2.13	50.05±0.42	197.83±0.95	14.75±0.48
	6	36.93±0.51	36.10±2.30	52.38±0.56	196.69±1.12	11.84±0.38
	7	37.28±0.94	28.04±1.54	50.18±0.05	197.82±0.55	15.63±0.19
	8	36.37±0.67	31.87±1.56	53.65±0.15	196.60±0.75	12.04±0.29
	9	30.39±0.60	24.54±1.47	51.10±0.31	197.29±0.22	13.46±0.19
	10	29.02±0.90	24.44±0.25	50.77±0.14	197.05±0.96	13.60±0.38
	11	29.19±0.55	23.80±0.33	50.69±0.11	196.93±0.36	13.73±0.77
	12	28.97±0.24	24.65±0.32	50.53±0.10	196.40±0.14	13.87±0.19
	13	29.32±0.28	24.49±0.40	50.38±0.30	197.29±0.22	13.46±0.00
Hot air Baking	1	29.51±0.22	27.77±0.25	52.08±0.25	196.31±.55	28.38±0.38
	2	30.15±0.15	42.21±0.36	49.53±0.15	195.57±0.99	29.19±0.38
	3	33.23±0.35	32.86±0.15	57.18±0.34	195.75±0.41	25.53±0.19
	4	32.95±0.12	28.41±0.51	56.48±0.41	194.95±0.84	30.07±0.29
	5	33.12±0.31	38.98±0.44	52.80±075	195.94±0.55	26.28±0.29
	6	32.07±0.22	36.64±0.15	51.10±0.66	195.11±0.39	29.87±0.38
	7	34.89±0.35	47.14±0.11	49.14±0.10	195.89±0.44	27.36±0.29
	8	29.06±0.14	27.17±0.40	59.11±1.10	195.35±0.14	29.12±0.29
	9	33.28±0.36	74.84±0.36	51.58±1.35	195.73±0.55	29.12±0.48
	10	31.85±0.25	67.36±0.50	51.16±1.45	195.73±0.14	28.85±0.48
	11	32.14±0.11	65.17±0.22	50.93±0.25	195.67±0.51	29.12±0.29
	12	34.30±0.25	71.20±0.39	51.12±1.14	195.85±0.12	29.67±0.29
	13	31.36±0.22	73.18±0.45	51.16±0.88	195.85±0.23	29.67±0.38

GI: Glycemic index, AA: Antioxidant activity, TPC: Total phenolic content

The Hunter *L*, *a*, and *b* values of the carrot varied between 13.34-50.75, 3.28-30.64 and 2.11-48.28, respectively (Table 5). Red, yellow and orange-colored fruits and vegetables are rich in carotenoids such as β-carotene, α-carotene and lycopene. The composition and concentration of carotenoids in foods vary due to variety, maturity, climate or growing region, and accordingly, different color values are observed. According to the results, significant losses ($p<0.05$) occurred in the color values of carrots with the cooking process (Table 7). When carrot tissue is exposed to cooking processes, color loss occurs due to the oxidation of polyunsaturated molecules (Karaaslan, 2010). When compared with other studies in the literature, it was observed that the color values of carrots using different cooking techniques were similar. As a result, as the cooking temperature and duration increase, the color values of Hunter *L, a, b*, and ΔE also change. The difference in color values is that water leaks through the pores between the tissues during cooking of the carrots, which changes the wavelength of the light reflected from the carrot surface (Koca et al., 2007; Alibas, 2007).

The analytical results of the mushroom samples cooked with different cooking techniques are given in Table 8. According to the results, it is seen that the Hunter *L, a,* and *b* values of the cultivated mushroom samples varied between 17.28-74.38, 0.52-13.52 and 1.62-22.49, respectively. Different cooking techniques significantly ($p<0.05$) affected the color properties of the cultivated mushroom samples (Table 10). Color variables are associated with several factors, such as the type and amount of color compounds present in foods, and the moisture content of the samples (Stich, 2016). The color values of the cooked cultivated mushroom samples decreased significantly compared to the fresh ones. When the data obtained after the cooking process were examined, it was seen that both methods were influential on the total color change.

Table 4. ANOVA evaluation of linear, quadratic and interaction terms for each response variables for potatoes

Variation Coefficients	*p*-Values for deep frying								
	L	*a*	*b*	ΔE	To (°C)	ΔH (J/g)	GI	AA (µmol trolox/g)	TPC (mg GA/g dm)
Model	<0.0001	0.1161	0.0016	<0.0001	0.0594	0.2619	< 0.0001	0.0001	< 0.0001
β_1	<0.0001	0.1448	0.0003	<0.0001	0.4172	0.5319	< 0.0001	<0.0001	< 0.0001
β_2	<0.0001	0.6248	0.2874	<0.0001	0.0140	0.9556	< 0.0001	<0.0001	0.0002
$\beta_1\beta_2$	0.0015	0.0208	0.3121	0.0009	0.8862	0.4116	0.0348	0.0199	0.0635
β_1^2	<0.0001	0.2617	0.0033	0.0002	0.0618	0.2104	0.0109	0.0197	0.0028
β_2^2	0.9224	0.4764	0.8868	0.1300	0.6272	0.0338	0.0005	0.2055	0.6699
Lack of Fit	0.0006	<0.0001	0.0001	0.0011	0.4744	0.0004	0.5226	0.0180	0.0524
R^2	0.9900	0.6564	0.9084	0.9874	0.7246	0.5422	0.9927	0.9586	0.9875
Adj-R^2	0.9829	0.4109	0.8430	0.9784	0.5278	0.2152	0.9875	0.9290	0.9786
	p-Values for hot air baking								
Model	< 0.0001	< 0.0001	<0.0001	< 0.0001	0.1675	0.7885	<0.0001	< 0.0001	< 0.0001
β_1	< 0.0001	0.0001	<0.0001	< 0.0001	0.6508	0.4135	<0.0001	< 0.0001	< 0.0001
β_2	0.0003	< 0.0001	<0.0001	0.0004	0.8594	0.5916	<0.0001	< 0.0001	< 0.0001
$\beta_1\beta_2$	0.0214	0.0062	0.0461	0.0319	0.6064	0.4165	0.0251	0.5355	0.5892
β_1^2	< 0.0001	< 0.0001	0.1812	< 0.0001	0.0156	0.6529	<0.0001	0.0106	0.0115
β_2^2	0.1892	0.8247	0.0994	0.2121	0.1239	0.5091	0.0083	0.4795	0.5014
Lack of Fit	< 0.0001	0.1973	0.0039	0.0001	0.0003	<0.0001	0.0523	0.7179	0.7021
R^2	0.9550	0.9923	0.9768	0.9731	0.6102	0.2513	0.9945	0.9790	0.9787
Adj-R^2	0.9550	0.9868	0.9603	0.9539	0.3318	-0.2834	0.9906	0.9640	0.9635

β_1: Cooking temperature, β_2: Cooking time, GI: Glycemic index, AA: Antioxidant activity, TPC: Total phenolic content

Effects of different cooking methods on the gelatinization temperature and enthalpy of the samples

The gelatinization enthalpy (ΔH) of potato varies between 60.74-23.69 J/g and the gelatinization temperature (T_0) varies between 37.25-28.95 J/g (Table 3). While the hot-air baking process did not make a statistically significant ($p>0.05$) difference in ΔH and T0values of potato samples, the deep-frying process significantly ($p<0.05$) affected ΔH values (Table 4). Semi-crystalline polymers, generally found in foods, are proteins and polysaccharides. Starch stands out as a gelatinizing polymer in potatoes. For this reason, gelatinization occurs before melting, not at the melting temperature (Chung and Lim, 2006).

According to the results in Table 6, it is seen that ΔH values of the cooked carrot samples vary between 74.62-24.11 J/g while To values vary between 41.50-27.97 J/g. Pectin is a crucial polysaccharide that shows gelation in carrots. When the results of the DSC analysis were examined, the effect of different cooking techniques showed a significant ($p<0.05$) difference in the thermal properties of the cooked carrots. The To values of the samples were not affected ($p>0.05$) by temperature and time, while the ΔH values were significantly ($p<0.05$) affected by the temperature and interaction of temperature and time (Table 7).

Table 5. CCRD experimental data for the color values of cooked carrots

Cooking Method	Exp. No	*L*	*a*	*b*	ΔE
Deep Frying	1	41.33±0.77	20.19±0.15	32.37±0.34	10.47±0.26
	2	25.08±0.64	11.72±0.61	14.39±0.12	36.13±0.33
	3	18.65±0.21	6.05±0.50	2.11±0.30	50.76±0.25
	4	15.19±0.20	7.09±0.34	8.42±1.66	48.26±050
	5	19.85±0.52	11.39±0.15	5.49±1.25	45.89±0.22
	6	19.37±0.60	8.27±0.13	10.20±1.61	43.87±0.35
	7	31.87±0.34	14.25±0.62	22.34±0.35	25.46±0.35
	8	27.14±0.44	9.41±0.51	11.88±0.25	37.50±0.68
	9	30.12±0.54	10.23±0.35	13.89±0.25	34.05±0.68
	10	30.22±0.51	10.85±0.22	13.26±0.24	34.24±0.34
	11	31.15±0.33	10.22±0.85	14.11±0.25	33.36±0.26
	12	30.14±0.41	10.96±0.44	13.82±0.38	33.81±0.22
	13	30.12±0.50	11.05±0.46	13.85±0.56	33.77±0.82
Hot air Baking	1	50.33±0.22	28.95±1.33	40.07±0.81	5.57±0.33
	2	35.34±0.14	17.50±0.25	34.61±0.26	15.16±0.22
	3	45.36±0.51	23.69±1.54	33.43±0.53	6.55±0.11
	4	28.52±0.32	13.36±0.26	25.31±0.56	26.38±0.36
	5	45.50±0.25	30.64±0.25	43.06±0.84	8.28±0.22
	6	33.25±0.14	16.44±0.33	29.47±0.64	19.43±0.36
	7	44.90±0.35	24.33±0.54	38.28±0.13	3.58±0.22
	8	36.11±0.22	15.36±0.64	39.26±0.15	14.84±0.10
	9	47.21±0.50	20.35±0.34	33.38±0.22	6.93±0.25
	10	47.17±0.61	20.25±0.84	33.13±0.25	7.20±0.15
	11	47.41±0.34	20.14±0.34	33.37±0.32	7.03±0.35
	12	47.29±0.22	20.06±0.22	33.13±0.22	7.28±0.22
	13	47.32±0.51	20.40±0.14	32.54±0.21	7.63±0.56

T_0 and ΔH results of the cultivated mushroom samples cooked by different cooking techniques are given in Table 9. It is seen that the ΔH of the cultivated mushroom samples varies between 68.39-24.42 J/g and the T_0 value varies between 39.01-27.76 J/g. T_0 and ΔH values of fried samples were significantly ($p<0.05$) affected by temperature and temperature x temperature interaction. In contrast, only T0 values of hot-air baked samples were significantly ($p<0.05$) affected by temperature x temperature interaction (Table 10). Mushrooms are known to be rich in protein. Heat treatment damages the natural structure of proteins. As a result, the protein structure is changed. When conditions are suitable, degraded polypeptides form a three-dimensional gel structure. These gels increase both texture and nutritional properties. Such denaturation due to heat effect is determined by thermal analysis. While these processes provide information about the techniques applied to foods, they also calculate the thermal energy required for protein denaturation (Özdalyan and Karaali, 2002).

Table 6. CCRD experimental data for the thermal and chemical properties of cooked carrots

Cooking Method	Exp. No	To (°C)	ΔH (J/g)	GI	AA (µmol trolox/g)	TPC (mg GA/g dm)
Deep Frying	1	32.04±0.15	36.41±1.15	52.86±0.35	788.69±0.93	149.25±0.67
	2	40.29±0.23	44.19±1.35	56.22±0.55	1521.82±0.55	131.76±1.63
	3	30.25±0.51	39.41±1.64	62.79±0.61	1248.12±0.47	133.38±0.67
	4	30.29±0.33	29.48±1.92	68.50±0.81	2079.00±0.96	116.10±0.19
	5	39.01±0.11	26.43±1.08	52.99±0.24	909.249±1.32	140.43±0.21
	6	38.76±0.82	29.42±1.23	56.30±0.51	1580.47±0.88	126.47±0.67
	7	34.66±0.77	45.06±0.55	55.43±0.41	554.089±0.47	140.30±1.44
	8	40.65±0.61	28.08±1.30	66.47±0.34	1150.37±0.64	115.08±0.86
	9	40.59±0.66	26.40±1.64	55.54±0.24	648.581±0.54	132.30±1.63
	10	41.50±0.22	35.87±0.55	55.02±0.15	664.873±0.33	131.96±2.68
	11	37.41±0.35	35.71±0.12	55.48±0.41	622.514±0.14	130.81±1.82
	12	41.09±0.38	34.67±0.33	54.69±0.44	648.581±0.21	126.20±1.25
	13	40.33±0.46	35.68±0.14	55.24±0.51	703.973±0.33	131.15±0.00
Hot air Baking	1	30.60±1.64	32.57±1.20	49.77±0.27	1124.30±0.50	203.75±0.29
	2	33.33±0.55	30.90±1.52	51.06±0.22	1407.78±0.44	200.02±0.58
	3	34.46±0.60	74.62±1.34	50.73±0.41	730.04±0.14	198.39±1.15
	4	33.43±0.16	23.79±0.66	52.41±0.13	1899.79±0.33	196.63±0.58
	5	32.83±0.92	41.09±0.61	50.23±0.21	560.60±0.51	201.92±0.38
	6	35.11±0.33	38.33±0.45	51.60±0.22	1782.49±0.12	199.07±0.19
	7	32.62±0.15	42.45±0.84	50.25±0.25	1169.92±0.95	202.80±0.29
	8	34.90±1.34	27.59±0.64	52.41±0.31	1463.17±0.22	196.70±1.44
	9	32.54±1.54	42.94±0.45	50.90±0.30	1238.34±0.21	201.38±0.00
	10	32.61±1.37	43.28±0.51	51.01±0.84	1248.12±0.14	201.17±0.67
	11	29.91±1.25	42.81±0.22	51.43±0.51	1241.60±0.13	201.31±1.05
	12	32.97±1.55	43.30±0.39	51.58±0.55	1267.67±0.32	200.77±0.67
	13	32.32±0.52	42.97±0.54	51.60±0.43	1280.7±0.54	200.50±0.86

GI: Glycemic index, AA: Antioxidant activity, TPC: Total phenolic content

Effects of different cooking methods on the antioxidant activity and total phenolic content of the samples

Antioxidant activity and total phenolic content results of potato samples cooked by hot-air baking and deep frying are given in Table 3. According to the results, it was observed that the antioxidant activity values of the cooked potato samples varied between 194.95 and 198.28 µmol trolox/g, while the total phenolic contents varied between 9.66 and 30.07 mg GA/g dry matter. It was determined that temperature and time variation in both deep frying and hot-air baking processes significantly ($p<0.05$) affected the antioxidant activity and total phenolic contents of cooked potato samples (Table 4). An increase in cooking temperature and time decreased antioxidant activity and total phenolic content of the cooked potato samples.

Table 7. ANOVA evaluation of linear, quadratic and interaction terms for each response variables for carrots

Variation Coefficients	*L*	*a*	*b*	ΔE	To (°C)	ΔH (J/g)	GI	AA (µmol trolox/g)	TPC (mg GA/g dm)
	p-Values for deep frying								
Model	0.0121	0.0002	0.0019	<0.0001	0.1088	0.0859	<0.0001	< 0.0001	0.0004
β_1	0.0677	0.0045	0.3782	0.0551	0.3362	0.9419	< 0.0001	< 0.0001	0.0003
β_2	0.0053	<0.0001	0.0004	<0.0001	0.4806	0.0359	< 0.0001	< 0.0001	0.0001
$\beta_1\beta_2$	0.1375	0.0027	0.0051	0.0148	0.2376	0.0910	0.0190	0.2552	0.9734
β_1^2	0.0122	0.3002	0.0452	<0.0001	0.1847	0.3746	0.0202	< 0.0001	0.0629
β_2^2	0.3710	0.0792	0.0321	0.0003	0.0724	0.0612	< 0.0001	0.0001	0.3325
Lack of Fit	0.0001	0.0133	<0.0001	0.0610	0.0387	0.3388	0.3311	0.1805	0.2580
R^2	0.8324	0.9475	0.9045	0.9962	0.6638	0.6893	0.9966	0.9960	0.9414
Adj-R^2	0.7127	0.9099	0.8363	0.9934	0.4236	0.4673	0.9941	0.9931	0.8995
	p-Values for hot air baking								
Model	0.0009	0.0001	0.1281	< 0.0001	0.2397	0.0976	0.0022	0.0006	< 0.0001
β_1	0.0002	< 0.0001	0.0188	< 0.0001	0.2511	0.0431	0.0011	< 0.0001	0.0002
β_2	0.0122	0.0010	0.1379	< 0.0001	0.0906	0.4000	0.0009	0.2343	< 0.0001
$\beta_1\beta_2$	0.7228	0.6984	0.7255	0.0001	0.1910	0.0312	0.5717	0.0086	0.0886
β_1^2	0.0226	0.0329	0.6681	< 0.0001	0.4719	0.8750	0.1093	0.4735	0.3523
β_2^2	0.0674	0.1162	0.5097	0.4712	0.6381	0.5133	0.8117	0.2665	0.0101
Lack of Fit	<0.0001	< 0.0001	< 0.0001	0.0211	0.3978	<0.0001	0.4553	0.0003	0.1815
R^2	0.9231	0.9556	0.6447	0.9944	0.5569	0.6758	0.9001	0.9318	0.9689
Adj-R^2	0.8682	0.9239	0.3909	0.9904	0.2405	0.4442	0.8287	0.8830	0.9466

β_1: Cooking temperature, β_2: Cooking time, GI: Glycemic index, AA: Antioxidant activity, TPC: Total phenolic content

The antioxidant activity and phenolic content of the cooked carrot samples varied between 397.68-2079.00 µmol trolox/g and 115.08-218.39 mgGAE/g dry matter, respectively (Table 6). Different cooking techniques affected significantly ($p<0.05$) antioxidant activity and total phenolic content of the cooked carrot samples (Table 7). While the antioxidant activity increased with increasing temperature and time during the cooking process, the total phenolic content decreased. It has been observed that the results are generally consistent with the studies in the literature. A study reported that the antioxidant levels of pureed carrots are higher than fresh ones. The antioxidant capacity of carrots was increased by heat treatment at 34.3%. In addition, it has been reported that processing the peeled carrot puree increases the antioxidant level by approximately 8.19% (Talcott et al. 2000). It is stated that the antioxidant activity of different vegetable juices also increases after heat treatment (Gazzani et al. 1998). The previous study has shown that carrot samples' carotenoid content increases with the chopping and heat treatment (Fabbri and Crosby, 2016). It is also known that carotenoids have high antioxidant activity (El-Agamey et al., 2004); therefore, it was thought that antioxidant activity increased with heat treatment in carrot samples.

Table 8. CCRD experimental data for the color values of cooked mushrooms

Cooking Method	Exp. No	*L*	*a*	*b*	ΔE
	1	46.37±0.30	8.34±0.25	20.35±0.22	23.73±0.12
	2	22.62±0.22	11.65±0.35	11.56±0.15	46.14±0.15
	3	30.21±0.52	13.52±0.50	22.49±1.32	40.49±0.66
	4	17.28±0.23	8.42±0.61	8.40±0.35	51.13±0.45
	5	38.55±0.64	14.25±0.22	27.34±0.64	34.91±0.31
	6	20.23±0.84	10.36±0.35	10.15±0.22	48.33±0.22
Deep Frying	7	25.47±0.95	12.48±0.24	15.07±0.15	43.60±0.15
	8	19.58±1.51	8.77±0.35	9.24±0.36	48.83±0.36
	9	22.61±1.65	10.00±0.10	10.00±0.15	45.93±0.22
	10	22.13±1.54	10.36±0.33	9.56±0.33	46.48±0.50
	11	22.30±1.12	10.26±0.51	9.35±0.26	46.31±0.36
	12	22.54±0.12	10.02±0.15	10.02±1.38	46.00±0.40
	13	22.40±0.35	10.16±0.22	9.73±1.92	46.18±0.33
	1	49.22±0.22	8.03±0.20	17.63±0.25	20.16±0.23
	2	25.41±0.14	7.20±0.30	13.11±0.15	42.82±0.15
	3	32.32±0.2	6.71±0.52	14.64±0.51	35.98±0.22
	4	19.35±0.34	3.43±0.64	17.67±0.33	48.92±0.36
	5	35.59±0.51	7.59±0.35	17.34±0.25	33.16±0.11
	6	24.32±0.60	5.63±0.54	11.91±0.12	43.80±0.35
Hot air Baking	7	45.39±0.44	2.74±0.55	16.31±0.31	23.14±0.25
	8	38.35±0.51	0.98±0.25	12.68±0.35	29.88±0.55
	9	40.59±0.61	1.74±0.23	14.19±0.61	27.66±0.45
	10	40.31±0.34	1.85±0.51	14.19±0.82	27.93±0.55
	11	40.19±0.52	1.34±0.15	14.45±0.60	28.11±0.45
	12	40.06±0.23	1.37±0.22	14.44±1.66	28.23±0.35
	13	40.23±0.15	1.34±0.14	14.47±1.45	28.08±0.54

The chemical analysis results of the cooked cultivated mushroom samples with different cooking techniques are shown in Table 9, and the ANOVA results showing the effects of the selected independent variables on the chemical properties of the cooked cultivated mushroom samples are in Table 10. According to the results, the total phenolic content and antioxidant activity values of the hot-air baked mushroom samples were higher than the deep-fried mushroom samples. The total phenolic contents and antioxidant activity of cooked mushroom samples were similar to the literature. In a study by Vivar-Quintana (1999), a decrease in the total amount of phenolic substance was observed in mushroom samples due to the soaking and boiling process during canning. Choi et al. (2006) determined that the amount of bound and free phenolic substances in mushrooms that were heat-treated at 121 °C for 15 and 30 min decreased significantly compared to fresh mushrooms. It is stated in some studies that the amount of phenolic substances increases due to the deterioration of the cell wall and cell structure with heat treatment. In contrast, some others state that there is no decrease or change in phenolic components and antioxidant activity with heat treatment (Kim et al., 2006).

Table 9. CCRD experimental data for the thermal and chemical properties of cooked mushrooms

Cooking Method	Exp. No	To (°C)	ΔH (J/g)	GI	AA (µmol trolox/g)	TPC (mg GA/g dm)
Deep Frying	1	39.01±0.12	36.76±0.52	42.82±0.11	925.51±0.47	101.52±3.55
	2	36.33±0.50	39.90±0.65	43.23±0.31	1155.62±0.84	81.39±0.58
	3	32.81±0.34	32.57±0.84	44.91±0.25	1198.36±0.44	93.39±0.29
	4	29.36±0.37	41.17±1.25	45.83±0.52	1737.48±0.34	77.52±0.86
	5	35.71±0.61	34.06±1.64	43.58±0.85	1076.73±0.84	95.42±0.67
	6	36.36±0.34	27.36±1.45	44.18±0.82	1366.01±0.47	79.76±0.58
	7	37.11±0.33	37.02±1.45	42.99±0.37	1244.38±0.58	92.44±0.29
	8	29.61±0.15	39.51±1.25	45.07±0.55	1471.21±0.96	87.49±0.38
	9	28.02±0.14	35.47±1.84	43.70±0.35	1303.55±0.25	91.22±0.29
	10	33.27±0.11	34.74±1.64	43.64±0.61	1273.97±0.33	92.03±0.29
	11	29.08±0.55	35.58±1.35	43.75±0.22	1313.41±0.15	91.02±0.00
	12	28.15±0.34	35.33±0.20	43.65±0.10	1300.26±0.14	91.49±0.29
	13	32.88±0.64	34.45±0.40	43.48±0.11	1333.14±0.22	90.61±0.58
Hot air Baking	1	29.74±0.44	34.46±0.23	48.86±0.12	1793.36±0.31	162.47±0.32
	2	31.51±0.15	30.52±0.24	52.14±0.31	2039.91±0.25	157.31±0.42
	3	29.16±1.64	42.34±0.33	51.16±0.25	1911.70±0.13	160.03±0.77
	4	33.11±1.94	26.97±0.25	55.45±0.22	2184.55±0.41	154.40±0.55
	5	32.71±1.20	37.65±0.16	49.75±0.31	1882.12±0.75	160.64±0.21
	6	29.33±1.35	42.86±0.85	53.97±0.55	2118.81±0.34	155.75±0.14
	7	37.97±0.33	42.51±0.16	52.25±0.34	1951.15±0.24	159.21±045
	8	36.04±0.40	47.29±0.38	55.39±0.74	2115.52±0.35	155.82±0.34
	9	32.28±0.34	33.30±0.77	53.19±0.91	2033.34±0.24	157.52±0.57
	10	33.09±1.65	32.86±0.58	53.15±0.93	2007.04±0.52	158.06±0.75
	11	32.79±0.51	33.52±1.26	53.21±0.82	2016.90±0.95	157.86±0.34
	12	32.69±0.38	33.33±1.30	53.26±0.87	2049.77±0.88	157.18±0.24
	13	32.97±0.77	33.51±1.54	53.43±1.15	2062.92±0.63	156.91±0.24

GI: Glycemic index, AA: Antioxidant activity, TPC: Total phenolic content

The food composition, the interaction of components with each other, the technological processes, the time and temperature of the heat treatment, the solvents used to extract the phenolic substances during the analysis can influence antioxidant activity and phenolic components. Some phenolic and antioxidant substances can be destroyed or reduced by heat treatment. It is expected that the antioxidant activity and the total amount of phenolic substance would decrease with the heat treatment. Perla et al. (2012) stated that the heat treatment reduced the antioxidant activity and the total amount of phenolic substances of different potato varieties. Amin and Lee (2005) found that the antioxidant activity and phenolic components were significantly reduced in cabbage species with 5-10 minutes of boiling at 98 °C. In our study, when the analysis results of potatoes, carrots and mushrooms cooked by different cooking techniques were examined, antioxidant capacity and total phenolic content decreased due to the increase in cooking temperature and time.

Effects of different cooking methods on the estimated glycemic index (eGI)

According to the results, the eGI values of the cooked potatoes, carrots, and cultivated mushrooms were ranged in 48.83-59.11 (Table 3), 49.77-68.50 (Table 6), and 42.82-55.45 (Table 9), respectively. ANOVA analyses results showed that both deep-frying and hot-air baking affected significantly ($p<0.05$) the eGI values of all samples (Tables 4, 7, and 10). The eGI values of the deep-fried potato and carrot samples were higher than their baked counterparts were higher than the hot-air baked equivalents. In contrast to cooked potatoes and carrots, the eGI values of the deep-fried cultivated mushrooms were determined lower than the hot-air baked samples. Based on the glycemic index considering glucose as a reference, foods are classified as low glycemic index food and high glycemic index food when the glycemic index lower than 55 and higher than 70, respectively (Ferng et al. 2016). According to this classification, all samples tested in our study appear to have low glycemic indexes, with the exception of deep-fried carrot samples.

Table 10. ANOVA evaluation of linear, quadratic and interaction terms for each response variables for mushrooms

Variation Coefficients	*p*-Values for deep frying								
	L	*a*	*b*	ΔE	To (°C)	ΔH (J/g)	GI	AA (µmol trolox/g)	TPC (mg GA/g dm)
Model	<0.0001	0.1161	0.0016	<0.0001	0.0594	0.2619	< 0.0001	0.0001	< 0.0001
β_1	<0.0001	0.1448	0.0003	<0.0001	0.4172	0.5319	< 0.0001	< 0.0001	< 0.0001
β_2	<0.0001	0.6248	0.2874	<0.0001	0.0140	0.9556	< 0.0001	< 0.0001	0.0002
$\beta_1\beta_2$	0.0015	0.0208	0.3121	0.0009	0.8862	0.4116	0.0348	0.0199	0.0635
β_1^2	<0.0001	0.2617	0.0033	0.0002	0.0618	0.2104	0.0109	0.0197	0.0028
β_2^2	0.9224	0.4764	0.8868	0.1300	0.6272	0.0338	0.0005	0.2055	0.6699
Lack of Fit	0.0006	<0.0001	0.0001	0.0011	0.4744	0.0004	0.5226	0.0180	0.0524
R^2	0.9900	0.6564	0.9084	0.9874	0.7246	0.5422	0.9927	0.9586	0.9875
Adj-R^2	0.9829	0.4109	0.8430	0.9784	0.5278	0.2152	0.9875	0.9290	0.9786
	p-Values for hot air baking								
Model	< 0.0001	< 0.0001	<0.0001	< 0.0001	0.1675	0.7885	<0.0001	< 0.0001	< 0.0001
β_1	< 0.0001	0.0001	<0.0001	< 0.0001	0.6508	0.4135	<0.0001	< 0.0001	< 0.0001
β_2	0.0003	< 0.0001	<0.0001	0.0004	0.8594	0.5916	<0.0001	< 0.0001	< 0.0001
$\beta_1\beta_2$	0.0214	0.0062	0.0461	0.0319	0.6064	0.4165	0.0251	0.5355	0.5892
β_1^2	< 0.0001	< 0.0001	0.1812	< 0.0001	0.0156	0.6529	<0.0001	0.0106	0.0115
β_2^2	0.1892	0.8247	0.0994	0.2121	0.1239	0.5091	0.0083	0.4795	0.5014
Lack of Fit	< 0.0001	0.1973	0.0039	0.0001	0.0003	<0.0001	0.0523	0.7179	0.7021
R^2	0.9550	0.9923	0.9768	0.9731	0.6102	0.2513	0.9945	0.9790	0.9787
Adj-R^2	0.9550	0.9868	0.9603	0.9539	0.3318	-0.2834	0.9906	0.9640	0.9635

β_1: Cooking temperature, β_2: Cooking time, GI: Glycemic index, AA: Antioxidant activity, TPC: Total phenolic content

Miao et al. (2015) stated that the eGI is affected by the specific properties of the food, the properties of the applied process, lipid and protein matrix, and starch content. Tian et al. (2016) reported that crushed and boiled potatoes had a higher eGI than fried, microwaved or conventionally baked potatoes due to the effects of the degree of gelatinization. They stated that during frying, the water in the cells inside the food causes the starch to be fully gelatinized; on the other hand, the high temperature on the surface causes the amylose-lipid complex (resistant starch) to form. Our study found similar results for specifically cultivated mushrooms and partly for potato samples. On the other hand, Tuta et al. (2017) have reported that the eGI of potatoes was low in the baking process recommended as a healthy cooking method.

Sensory properties of the samples

ANOVA of the sensory analysis results of potato, carrot and mushroom samples cooked with different cooking techniques is given in Table 11. When the color, odor and taste characteristics of different cooking techniques were averaged, the most accepted samples were deep-fried samples.

Table 11. Sensory properties of the cooked potatoes, carrots and cultivated mushrooms

Sensory properties	Potatoes		Carrots		Cultivated mushroom	
	Deep frying	Hot-air baking	Deep frying	Hot-air baking	Deep-frying	Hot-air baking
Appearance	3.69[a] ± 0.52	3.61[a] ± 0.78	3.53[a] ± 0.08	3.03[b] ± 0.01	3.26[b] ± 0.08	3.53[a] ± 0.14
Color	4.00[a] ± 0.05	3.88[b] ± 0.36	3.42[a] ± 0.03	3.38[a] ± 0.16	3.61[b] ± 0.03	3.76[a] ± 0.02
Odor	3.84[a] ± 0.02	3.76[a] ± 0.04	3.76[a] ± 0.11	3.80[a] ± 0.09	2.92[b] ± 0.03	3.69[a] ± 0.07
Taste	4.00[a] ± 0.12	3.30[b] ± 0.06	3.38[a] ± 0.06	3.30[b] ± 0.02	3.30[a] ± 0.01	3.30[a] ± 0.04
Texture	3.07[a] ± 0.07	3.03[a] ± 0.05	2.84[a] ± 0.07	2.34[a] ± 0.03	3.30[a] ± 0.10	3.03[b] ± 0.08
General acceptance	4.07[a] ± 0.13	3.53[b] ± 0.07	3.23[a] ± 0.02	2.76[b] ± 0.11	2.84[b] ± 0.06	3.26[a] ± 0.04

Results are means ± standard error, different letter is same row for each factor shows significant ($p<0.05$) difference.

Xu and Kerr (2012) produced corn chips by vacuum drying and deep-frying methods. They reported that the deep-fried samples got higher scores in all sensory criteria than the vacuum dried samples. In another study, carrot samples were deep-fried and the sensory analyzes were carried out during storage. It was determined that deep-fried carrot samples were appreciated by the panellists and received high scores on the hedonic scale (Sulaeman et al., 2003). Guiné et al. (2019) obtained different products using mushrooms in their study. They served the mushroom-based products to the panelists by frying them in deep oil. It has been reported that deep-fried mushrooms and mushroom-based products receive high scores from panelists. In a previous study, mushroom samples were fried and baked, similar to our current study; the most liked samples by the panelists were the samples in which the frying process was applied (Doğan et al., 2020). In many fruits and vegetables that have been tried with different cooking methods, the panelists most liked the method of frying. It has been reported that frying increases the sensory properties of vegetables and is preferred by panellists (Troncoso et al., 2009; Devi et al., 2020).

CONCLUSION

In conclusion, potato, carrot and cultivated mushroom samples, rich in different main compounds such as starch, pectin and protein, respectively, gave different reactions to deep-frying and hot-air baking methods. The deep-frying process caused significant differences in the samples' Hunter *L*, *a*, and *b* values. It was observed that deep-fried samples had redder and darker color due to advanced non-enzymatic browning reactions. According to the thermal analysis results, To and ΔH values changed significantly depending on cooking. Different cooking techniques change the granular structure of the starch of the samples and make it easier to gelatinize. All samples tested in our study appear to have low (<55) glycemic indexes, except for deep-fried carrot samples, which have still moderate eGI values (<70). The samples' antioxidant activity and total phenolic contents were also significantly influenced by different cooking techniques and baking provided higher functional properties. As a result, deep-frying is not recommended due to the loss of functional compounds, although consumers appreciate the process due to its desired sensory properties. It has been determined that the baking technique stated in many studies in the literature as a healthy method can also be used for potatoes, carrots and mushrooms.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contribution

Ayşe Nur Edis: conceptualization, data curation, formal analysis.

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Hilal Şahin-Nadeem: Conceptualization, data curation, formal analysis, funding procurement, original draft writing, review, and editing.

Zehra Günel: Conceptualization, data curation, formal analysis, funding acquisition, writing (original draft), writing (review & editing)

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