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Processing Untraditional Formula from Snacks using Apple and Tomato Pomace Powder as a Source of Dietary Fiber and Antioxidants

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ABSTRACT

Fruits and vegetables generate large volume of wastes annually. They constitute an excellent source of bioactive compounds, which have a positive impact on health and are known to modulate the metabolic processes as well as influence the cellular activities in the human health due to their antioxidant, anti-cancer, anti-inflammation and anti-atherogenic properties; depending upon the pathway and their bioavailability in the body**.**This study aims to develop some snacks supplemented with apple-pomace powder and tomato-pomace powder as sources of antioxidant dietary fiber and thus improve their nutritional properties. Where wheat flour was partially replaced (10 and 20%) by both apple-pomace powder and tomato-pomace powder. The results showed that fortification of the snacks with both apple-pomace powder and tomato-pomace powder increased the contents of protein, ash, fiber, calcium, potassium and phenolic compounds of the supplemented snacks and this rise is proportional to the percentage of replacement. The results of the sensory evaluation showed an increase in the overall acceptability values for all snack mixtures, but the snacks prepared by replacing wheat flour with apple-pomace powder in both concentrations 10 and 20% gave higher sensory evaluation values compared to their equivalents processed from tomato pomace powder. So, it can be concluded that the replacement of wheat flour with pomace powder and tomato pomace in the manufacture of snacks up to 20% increased the content of total phenolic compounds and dietary fiber of the product. Hence, it can be used as a ready-to-eat food by consumers who are looking for a healthy diet.

Keywords: Snacks, tomato, apple, pomace, antioxidant, dietary fibers.

INTRODUCTION

Recently, enhanced demand for ready-to-eat, food products, such as snacks, biscuits, bread, and other pastry products has been recorded, mainly associated with the increased bakery products popularity [David, 2006]. In this context, new food products have been/are developed with the incorporation of food additives, especially in the production of snacks, convenient ready-to-eat foods consumed by young people in many countries [Forsido *et al*, 2019]. The general trend is increasing towards the re-use of by-products, such as some agricultural crop residues, as functional food ingredients in food formulation around the world [Abd Rabo *et al*, 2019], particularly exploiting fruit waste (such as fruit, seeds, pomace, or vegetable peels) due to their high amount of bioactive compounds and dietary fibers [Chaouch and Benvenuti, 2020].

Indeed, the manufacture of agricultural commodities, such as vegetable and fruit products, results in large quantities of waste that are difficult to dispose of and increase environmental pollution [Elgindy, 2020]. Therefore, it is necessary to exert a lot of effort to benefit from these wastes after improving their nutritional and industrial value [Khedr *et al*, 2016]. These wastes are important and economical sources of natural antioxidants that can replace synthetic antioxidants [Lourenço *et al*, 2019]. Apple juice represents about 65% of the processed apple amount [Shalini and Gupta, 2010: Kammerer *et al*, 2014]. In general, during juice processing, 25% of the weight of fresh apples is obtained as waste, the so-called pomace [Vendruscolo *et al*, 2008]. Recently, apple pomace is used in the food products industry as a functional ingredient due to its high content of biologically active substances and nutrients [Bhushan *et al*, 2008: Gómez and Martinez, 2018], which are extracted and used in many food products [Lyu *et al*, 2020]. Apple fibers, a source of antioxidants such as phenolic and flavonoids [García *et al*,2009: Alsuhaibani,2015], can be obtained from apple pomace by drying it and grinding it into a powder that mostly contains carbohydrates, dietary fibers, and small amounts of fat, ash, and protein. Similarly, during the manufacture of various tomato products, large quantities of waste (about 10- 30% of the total processed fresh tomato) are obtained and are quickly spoiled if not immediately disposed of [Bhat and Hafiza, 2016]. This waste, called tomato pomace, consists of tomato seeds, peels, and part of the pulp [Rahmatnejad *et al*, 2009] and usually is composed of total dietary fiber, proteins, ash, fats in high amounts and does not contain anti-nutrient components [Mehta *et al*,2018]. Thus, it is a good source of bioactive compounds like flavonoids, phenolic, minerals, and fiber, and hence may be used in value added food products development [Knoblich *et al*, 2005].

Studies have examined the impact of several food sources on enhancing snacks [Potter *et al*,2013,Cian *et al*,2014 and Basto *et al*,2016], however, as far as we know, the use of apple and tomato pomace powders as sources of antioxidant dietary fibers on the nutritional and sensory

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quality of the produced snacks has not reported. In this framework, the current work is aimed at evaluating the influence of the supplementation of common snacks with apple and tomato pomace powders as sources of antioxidant dietary fibers. The nutritional, physiochemical, and sensory properties of the produced snacks are completely characterized and compared.

MATERIALS AND METHODS

Apples (*Malus domestica* Borkh.), tomatoes (*Solanum lycopersicum*), and wheat flour (*Triticum sativum*) 72% extraction and other ingredients for snacks preparation were obtained from a local market in Egypt. Apples were washed using tap water for removing juice pressing and non-edible parts. Tomato processing wastes were collected after juice extraction by cold-break treatments. Apple and tomato residues (pomaces) were dried at 50 °C for 12 h in an air circulating oven, submitted to a milling process, sieved (110 mesh), and maintained in polyethylene bags, and stored at -18 °C until use (Isik and Topkaya 2016 :Curutchet *et al*,2021) .

Preparation of snacks

The flour blends, based on wheat flour (WF) and apple pomace powder (APP) or tomato pomace powder (TPP), were prepared according to the ratios presented in Table 1, mixing blended flour (100 g) with sodium chloride (1.5 g), active dry yeast (1.5 g), vanilla (1 g), and sugar (1 g). The obtained dough was fermented at a temperature of 30 °C and relative humidity of 85% for 1 h. Then, pieces of 20 mg weight were obtained from the total dough, were arranged on trays, left to ferment at 30 °C and 85% relative humidity for 45 min, then baking An extruder (US-made model 2013) at 230 °C for 10 min. Finally, the snacks were cooled on racks for 1 h before the investigation (Hussein, 2022).

Table 1. Flour blends used in snacks preparation

Sample	Blends (%)		
	Wheat flour (WF)	Apple pomace powder (APP)	Tomato pomace powder (TPP)
C	100	0	0
T1	90	10	0
T2	80	20	0
T3	90	0	10
T4	80	0	20

C: Snacks manufactured with wheat flour (72% ext.).
T1: Snacks manufactured with wheat and 10% apple pomace powder.
T2: Snacks manufactured with wheat and 20% apple pomace powder.
T3: Snacks manufactured with wheat and 10% tomato pomace powder.
T4: Snacks manufactured with wheat and 20% tomato pomace powder.

Chemical analysis

Protein, moisture, fat, ash, and crude fibers amounts of raw material (WF, APP, and TPP) and snack samples were estimated according to the AOAC [2005]. Available carbohydrate was calculated by difference (Total carbohydrates% = 100 – (%fat + %protein + %ash + %fiber +%moisture).while the mineral constituents of raw material and treated snacks were evaluated with a Hitachi Z6100 (Tokyo, Japan) atomic absorption spectrophotometer.

Colour Measurement

Colour attribute (L*, a* and b*) of snack samples were performed using Hunter lab colour analyzer (Hunter lab colour Flex Ez, USA) according to Roa *et al.* (2011). The L* value (lightness index scale) ranges from 0(black) to 100(white) while a* value indicates the redness (+a) or greenness (-a*) and the b* value refers to the yellowness (+b) or blue l (-b).

Determination of total phenolic content:

The extract's total phenolic content was measured by Folin-Ciocalteu assay, with gallic acid as the standard [Kaur and Kapoor, 2002]. The calibration curve of the gallic acid was obtained and total phenolic content was expressed as gallic acid equivalents (mg GAE/100 g dry weight).

Radical scavenging activity (Scavenging DPPH):

The extract's antioxidant activity was determined using a 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay [Thaipong *et al*,2006] and expressed as Trolox equivalents (μmol TE/100 g dry mass). In the case of DPPH values over the standard curve linear range, additional dilution was necessary.

Sensory Properties

The snack sample's sensory features were studied in terms of flavor (20), color (20), taste (20), appearance (20), crispiness (20), and overall acceptability (100), following the method reported in Hussein and Ali [2017].

Statistical analysis:-

The acquired results were statically analyzed through the computer statistic software (Analytical software, version 9, 2008). The differences were considered significant when they were higher than the least significant differences (LSD) at the 5% level (Boyd *et al*, 2018).

RESULTS AND DISCUSSION

Chemical and nutritional properties of wheat flour (WF), apple pomace (APP) and tomato pomace powder (TPP):

The WF, APP, and TPP chemical compositions are illustrated in Table 2. The results showed that there is a difference between the contents of each component. WF moisture, fat, protein, carbohydrate, fiber, and ash contents were (11.86, 1.56, 12.24, 74.33, 1.07, and 0.78 g/100 g) respectively, results in agreement with those values reported by [Isik and Topkaya, 2016: Elgindy, 2020]. Also, APP moisture, fat, protein, carbohydrate, fiber, and ash contents were (10.54, 2.84, 8.10, 76.62, 51.42, and 1.90 g/100 g) respectively, obtained results are in accordance with the results reported by [Antonic *et al*, 2020, Elgindy, 2020: Lyu *et al*, 2020]. While moisture, fat, protein, carbohydrate, fiber, and ash contents of TPP were (10.18, 4.42, 31.54, 51.28 45.92, and 2.58 g/100 g) respectively, obtaining comparable values with respect to those collected in [Bhat and Hafiza, 2016: Isik and Topkaya, 2016]. TPP showed higher protein, fat, and ash contents compared with WF and APP, while APP showed higher fiber and carbohydrate contents compared with WF and TPP. In the same data shows the average of potassium, calcium, sodium, and magnesium contents in WF, APP, and TPP; APP contained the highest calcium and magnesium amounts, while TPP have the highest potassium amount. These experimental evidences are comparable to those obtained by [Isik and Topkaya, 2016: Elgindy, 2020]. Also, in table 2, results revealed that the WF, APP, and TPP extracts total phenolic content were 170.20, 370.50, and 510.40 mg GAE/100 g, respectively, while the WF, APP, and TPP extracts total antioxidant activity was 52.60, 76.80, and 81.70 μmol TE/100 g, respectively. Obtained data were comparable to those described by Yu [2015] for WF, Antonic *et al.* [2020] for APP, and Isik, Topkaya [2016] for TPP. Concerning Hunter color values, TPP was characterized by higher *a* and *b* values in color than WF and APP ones, due to the tomato pomace higher carotenoid amounts, mainly lycopene which gives a red color to tomato [Sikora *et al*,2008: Isik and Topkaya, 2016].

Table 2. Chemical and nutritional properties (based on dry weight) of wheat flour (WF), apple pomace powder (APP), and tomato pomace powder (TPP).

Properties	Wheat flour	Apple pomace powder	Tomato pomace powder
Chemical composition (g/100 g)			
Moisture	11.86	10.54	10.18
Total protein	12.24	8.10	31.54
Fat	1.56	2.84	4.42
Ash	0.78	1.90	2.58
Carbohydrate	74.33	76.62	51.28
Fiber	1.07	51.42	45.92
Minerals (mg/100 g)			
Potassium	83.70	98.34	350.60
Calcium	55.24	625.62	95.33
Sodium	72.40	10.84	32.44
Magnesium	30.24	480.76	236.50
Phytochemical properties			
Total phenolic content(mg/100g)	170.20	370.50	510.40
Total antioxidant activity(µmol TE/ 100g)	52.60	76.80	81.70
Hunter color values			
L	92.24	74.20	57.36
a	0.52	5.14	14.82
b	8.84	14.74	22.04

Chemical composition of snacks fortified with apple and tomato pomace powder:

Chemical compositions of fortified snacks samples are shown in Table 3. The moisture content of the obtained snacks ranged from 5.68% to 6.32%. Incorporation of APP and TPP in the ranges of 10-20% in the moisture content compared with control snacks prepared with WF alone. The acquired data show that the supplementation of snacks with APP and TPP at both concentrations (10 and 20%) caused a significant and gradual rise in the protein, ash, and fiber contents, as well as a decrease in moisture content, in proportion to the fortification ratio compared to control snacks prepared with WF alone. Particularly, the proteins content was lower in APP fortified snacks with respect to the control snacks, whereas it proportionately increased with increasing the TPP amount, the highest content (14.20%) was achieved with 20% incorporation of TPP. The fiber content in the fortified snacks progressively increased with increasing APP and TPP proportions, achieving the highest content (10.92%) with 20% incorporation of APP and negligible amounts in the control snacks. APP incorporation (10-20%) caused a slight rise in the carbohydrates content, while TPP supplementation (10-20%) a reduction in the carbohydrates content compared with control snacks. Summarizing, the TPP snacks presented the highest protein, fat, and ash contents, whereas the APP snacks the highest moisture, fiber, and carbohydrate amounts. These results are in agreement with the data obtained by Isik, Topkaya [2016] who highlighted a significant ($p < 0.05$) increase in ash, dietary fiber, and protein amounts in the case of crackers fortified with the addition of TPP. Also, Elgindy [2020] found that the addition of APP to biscuits led to remarkable ($p < 0.05$) increased ash, dietary fiber, and protein levels. Bhat, Hafiza [2016] evidenced that the TPP addition (20-25%) to cookies promoted a significant ($p < 0.05$) increment in the crude protein and ash contents with respect to the control and rest of treatments. Salem [2020] indicated enhanced lipids, crude protein, crude fiber, and ash amounts in the case of WF partial replacement with TPP. Preethi *et al.* [2021] stated that the APP addition to the cereal-based extrudates remarkably incremented their starch, protein, and ash amounts.

Table 3. Chemical composition, of snacks fortified with apple pomace powder (APP) (T1 and T2) and tomato pomace powder (TPP) (T3 and T4).

Snacks samples	Moisture %	Protein %	Fat %	Ash %	Fiber %	Carbohydrates%
C	6.32^{A}	12.14^{C}	1.36^{D}	0.82^{C}	1.22^{E}	79.36^{C}
T1	6.08^{B}	11.72^{D}	1.44^{CD}	0.90^{BC}	6.04^{C}	79.86^{B}
T2	5.84^{C}	11.34^{E}	1.56^{AB}	1.02^{A}	10.92^{A}	80.24^{A}
T3	5.90^{C}	13.70^{B}	1.52^{BC}	0.98^{AB}	5.66^{D}	77.90^{D}
T4	5.68^{D}	14.20^{A}	1.64^{A}	1.05^{A}	9.98^{B}	77.43^{E}
LSD	0.1425	0.3520	0.1109	0.874	0.1021	0.0908

Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
L.S.D: Least significant difference
C: Snacks manufactured with wheat flour (72% ext.).
T1: Snacks manufactured with wheat and 10% apple pomace powder.
T2: Snacks manufactured with wheat and 20% apple pomace powder.
T3: Snacks manufactured with wheat and 10% tomato pomace powder.
T4: Snacks manufactured with wheat and 20% tomato pomace powder.

Minerals content and Hunter color values of snacks fortified with apple and tomato pomace powder:

On the basis of the data presented in Table 4, the WF partial replacement with APP and TPP increased the calcium, magnesium, and potassium contents of snacks samples in compared with control snacks, with a progressive increment associated with the substitution ratio. In particular, the WF partial replacement with TPP increased the potassium content of snacks samples compared with APP snacks samples, while the WF partial replacement with APP increased the calcium and magnesium content of snacks samples compared with TPP snacks samples. Similarly, Isik, Topkaya [2016] reported that the TPP addition to crackers led to a significant ($p < 0.05$) increase in calcium, magnesium, potassium, phosphorus, manganese, iron, and zinc amounts, and Preethi *et al.* [2021] found that the APP supplementation in the cereal-based extrudates remarkably enhanced their overall mineral content. Table 4 also shows Hunter color values of snacks fortified with apple and tomato pomace powder. From the collected results it can be seen that TPP snacks had higher *a* and *b* values in color than WF and APP snacks formulations, ascribable to the higher carotenoid contents of tomato pomace, especially lycopene which provides the red color to tomato [Sikora *et al*,2008]. These results are in agreement with the data obtained by Isik, Topkaya [2016] who evidenced that the TPP addition to crackers led to a significant (p < 0.05) increase in Hunter *a* and *b* color values, but a decrease in *L* value. Also, Preethi *et al.* [2021] reported that the color parameters *viz.* hue and chroma were also higher with the APP incorporated extrudates.

Table 4. Minerals content, and Hunter color values of snacks fortified with apple pomace powder (APP) (T1 and T2) and tomato pomace powder (TPP) (T3 and T4).

Snack formulations	Minerals (mg/100 g)				Hunter color values		
	Calcium	Sodium	Magnesium	Potassium	L	a	b
C	24.30^{E}	56.82^{A}	18.70^{E}	62.74^{E}	66.90^{A}	2.04^{E}	19.82^{E}
T1	90.24^{C}	49.84^{C}	66.24^{C}	65.20^{D}	62.08^{B}	5.84^{D}	21.02^{C}
T2	146.48^{A}	42.60^{E}	104.62^{A}	70.46^{C}	60.28^{C}	7.16^{C}	21.78^{B}
T3	84.72^{D}	51.76^{B}	42.74^{D}	92.46^{B}	55.20^{D}	10.12^{B}	22.44^{A}
T4	122.56^{B}	46.68^{D}	70.88^{B}	126.32^{A}	51.24^{E}	11.30^{A}	20.18^{D}
LSD	0.4628	0.1142	0.2580	0.2073	0.3256	0.6843	0.1649

Means followed by different small letters in the same column are significantly different ($p \leq 0.05$).
L.S.D: Least significant difference

Bioactive compounds of snacks fortified with apple and tomato pomace powder:

The APP and TPP fortified snack's total phenolic content and antioxidant activity are presented in Table 5. It can be observed that these values were remarkably higher in APP and TPP supplemented snacks with respect to the control snacks, and in the function of the substitution level. The total phenolic content proportionately increased with increasing TPP amounts, achieving the highest value in sample T4 being (164.62 mg GAE/100 g) with addition of 20% incorporation of TPP and negligible amounts in the control snacks.

Table 5. Total phenolic content and antioxidant activity of snacks fortified with apple pomace powder (APP) (T1 and T2) and tomato pomace powder (TPP) (T3 and T4).

Snack formulations	Total phenolic content (mg/100g)	Antioxidant activity (µmol TE/ 100g)
C	55.36^{E}	6.94^{E}
T1	76.54^{D}	9.82^{D}
T2	122.24^{B}	21.64^{B}
T3	93.46^{C}	16.70^{C}
T4	164.62^{A}	30.24^{A}
LSD	0.2274	0.2615

Means followed by different small letters in the same column are significantly different ($p \leq 0.05$).
L.S.D: Least significant difference

The antioxidant activity in the snack formulations increased in the function of the APP and TPP proportions, obtaining the highest amount of antioxidant activity (30.24 µmol TE/100 g) with 20% incorporation of TPP and negligible amounts in the control snacks. This experimental evidence can be ascribed to the high TPP phenolic content, in agreement with Isik, Topkaya [2016] who demonstrated that the TPP addition to crackers led to a significant (p < 0.05) increase in total phenolics and antioxidant capacity. Also, Salem [2020] indicated that the partial WF replacement with TPP progressively enhanced the total flavonoid and phenolic amounts of biscuit samples with respect to the control sample and on the basis of the fortification level. According to Preethi *et al.* [2021], the incorporation of APP into the cereal- based extrudates remarkably increased their phenolic, flavonoid, and total antioxidant activities.

Sensory Attributes of snacks fortified with apple and tomato pomace powder

According to the data presented in Table 6, the sensory features were evaluated as a function of APP and TPP replacement amount. Concerning to the color and appearance, no significant differences between control (C) and APP fortified snacks (T1 and T2) can be noticed, while in the case of observed using TPP fortified snacks (T3 and T4) low color values were recorded. Partial replacement of WF with APP and TPP increased the taste, flavor, crispiness, and overall acceptability scores and these increments were proportional to the replacement ratio. APP snacks had the highest scores for sensory attributes, followed by control snacks, and finally TPP snacks. These results are in agreement with the data obtained by Elgindy [2020] who evidenced no significant differences between control and APP incorporated cookies in terms of overall sensory attributes scores. Similarly, Salem [2020] indicated that the taste and flavor of biscuit samples were improved with the TPP partial replacement of WF.

Table 6. Sensory evaluation of snacks fortified with apple pomace powder (APP) (T1 and T2) and tomato pomace powder (TPP) (T3 and T4).

Snacks samples	Color (20)	Flavor (20)	Taste (20)	Crispness (20)	Appearance (20)	Overall acceptability (100)
C	19.2^{A}	18.4^{B}	18.8^{C}	18.2^{B}	19.4^{A}	93.70^{A}
T1	18.5^{AB}	18.8^{AB}	19.0^{BC}	18.8^{AB}	18.7^{B}	93.80^{A}
T2	18.0^{BC}	19.2^{A}	19.4^{AB}	19.5^{A}	18.2^{C}	94.30^{A}
T3	17.6^{CD}	19.0^{AB}	19.2^{BC}	18.4^{AB}	17.6^{D}	91.80^{B}
T4	17.0^{D}	19.6^{A}	19.7^{A}	19.0^{AB}	17.0^{E}	92.30^{B}
LSD	0.8900	0.6269	0.5349	1.239	0.3936	0.7182

Means followed by different small letters in the same column are significantly different ($p \leq 0.05$).
L.S.D: Least significant difference

CONCLUSION

Snack formulations, fortified with apple and tomato pomace powders, were successfully produced in two different WF replacement amounts, i.e., 10 and 20%. Replacing WF with apple and tomato pomace powders increased the phenolic and dietary fiber contents, improved the organoleptic properties and the nutritional value of the produced snacks. The results of this research could provide valuable knowledge to the bakery industry and its related applications

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انتاج خلطات غير تقليدية من الوجبات الخفيفة باستخدام مسحوق تفل التفاح والطماطم كمصدر للألياف الغذائية ومضادات الأكسدة

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تنتج الفواكه والخضروات عند صناعتها كميات كبيرة من المخلفات سنويًا .وهي في الحقيقة تشكل مصدرًا ممتازًا للمركبات النشطة بيولوجيًا ،مثل المواد الفينولية ,الفلافونويد, الفيتامينات , الأملاح المعدنية والألياف الغذائية والتي لها تأثير إيجابي على الصحة ومن المعروف أنها تعدل عمليات التمثيل الغذائي وكذلك تؤثر على الأنشطة الخلوية وتحسن من صحة الإنسان بسبب نشاطها المضاد للاكسدة والنشاط المضاد للسرطان والالتهابات ودورها في الوقاية من أمراض السمنة والسكر وأمراض القلب وتصلب الشرايين اعتمادًا على مسار تلك المركبات الحيوية وتوافرها الحيوي في الجسم. تهدف هذه الدراسة إلى تطوير بعض الوجبات الخفيفة المدعمة بمسحوق تفل التفاح ومسحوق تفل الطماطم كمصادر للألياف الغذائية المضادة للأكسدة وبالتالي تحسين خصائصها الغذائية والفيزوكيميائية والحسية. حيث تم في هذه الدراسة استبدال دقيق القمح جزئيًا بنسبة (10 و 20٪) بكل من مسحوق تفل الرمان ومسحوق تفل الطماطم .وأظهرت النتائج أن تدعيم الوجبات الخفيفة بكل من مسحوق تفل الرمان ومسحوق تفل الطماطم زاد من محتويات البروتين والرماد والألياف والكالسيوم والبوتاسيوم والمواد الفينولية والنشاط وكذلك النشاط المضاد للاكسدة للوجبات الخفيفة المدعمة وكان هذا الارتفاع متناسب مع نسبة الاستبدال. واظهرت نتائج الاختبارات الحسية ارتفاع قيم القبول الكلية لجميع خلطات الوجبات الخفيفة , ولكن الوجبات الخفيفة المجهزة باستبدال دقيق القمح بمسحوق تفل التفاح بكلا التركيزين 10 و 20 % أعطت قيم تقديرات حسية أعلي مقارنة بمثيلاتها المجهزة من مسحوق تفل الطماطم. لذايمكن استنتاج أن استبدال دقيق القمح بمسحوق تفل التفاح وتفل الطماطم في تصنيع الوجبات الخفيفة حتى 20 ٪ زاد من محتوى المواد الفينولية الكلية والألياف الغذائية للمنتج. وبالتالي ، يمكن استخدامه كغذاء جاهز للأكل من قبل المستهلكين الذين يبحثون عن نظام غذائي صحي.