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Research Article
Postharvest Treatments for Improving the Quality of Fresh and Processed Costata Persimmon Fruits

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Abstract

Background and Objective: Kaki (Costata) is ripening differently than other fruits. Really, hard persimmons to ripen so expect to wait for several weeks for ripe. Persimmon contain relatively high content of dietary fibers, total and major phenolics, main minerals and trace elements make persimmon preferable for health. This study aimed to improve the quality of Kaki fruits through some postharvest treatments to remove astringency and ripening. Fruit leathers products provide attractive, colored and flavor, therefore, leather kaki of postharvest treated fruits were also prepared and evaluated to improve the quality of processed fruits. **Materials and Methods:** Postharvest pretreatment was carried out to improve the color quality of Kaki fruits by treating fruits separately with 0% (T1), 2% (T2), 3% (T3) calcium chloride solution and exposed to CO_2 (T4). Moisture, protein, fat, fiber, ash, total solids, total sugars, reducing and non reducing sugars, total flavonoid, antioxidant of the samples were determined. **Results:** Postharvest treatments caused a noticeable increase in color parameters of Kaki fruits compared to untreated fruits. Where, T2 and T3 had the highest lightness value (L = 37.61 and 37.23); followed with T4 (35.76). While, redness (a*) maximized in T4 (19.61), followed with T2 (17.18) and T3 (15.50). Also chemically, protein content was maximized in postharvest treated fruits by CO_2 (5.41%), followed with treated fruits with 3% Ca Cl_2 (2.50%). But, TSS of treated kaki fruit juice was decreased slightly, where they ranged between 18.4-18.6 compared to untreated fruits (20.1). Furthermore, post harvest Kaki fruits were evaluated to produce leather product. The obtained Hunter color parameter showed that the lowest color parameters was found in leather of untreated fruits, while the highest value was found in leather of treated fruits with CO_2. **Conclusion:** Sensory evaluation indicated that treated fruits not affected significantly in color, odor, appearance and overall acceptability of leather product.

Key words: Persimmon "Costata" cultivar, Kaki fruits, postharvest treatments, astringency removal and ripening, fruits leather

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Kaki (Costata) is ripening differently than other fruits. Really, hard persimmons to ripen so expect to wait for several weeks for ripe. Immature Kaki fruits have a high proanthocyanidin-type tannin content which it makes astringent and bitter. The astringent type persimmon fruit is not edible at harvest due to the presence of soluble tannins that cause an astringent taste in the mouth[1]. The fruit becomes edible during postharvest ripening, when soluble tannins polymerize and become insoluble[2]. A higher CO_2 concentration always produces more acetaldehyde and makes astringency removal faster. Also, temperature plays an important role in anaerobic metabolism; more acetaldehyde and ethanol accumulate at higher temperatures[3]. The eating quality of persimmon is considered best at the end of the pre-climacteric stage owing to presence of maximum sugars and desired orange color[4,5]. One of the most important mineral elements determining fruit quality is Calcium. Postharvest Ca treatments used to increase Ca content of the cell wall which delaying senescence, resulting in firmer, higher quality fruit and with less susceptible to disease[6,7].

Persimmon (*Diospyros kaki* L.) is the main and leading that consumed in the Egyptian market. It is not left to ripe on the trees and harvested at mature stage to ripened for commercial production and marketing[8]. Persimmon is relatively high content of dietary fibers, total and major phenolics, main minerals and trace elements make persimmon preferable for healthy[9]. It is also a good source of fiber and vitamins, mainly A and C. It is mainly eaten fresh, but can be frozen, canned or dried and can be stored for up to 6 month in modified or controlled atmospheres[10]. The dried persimmon portions could be used as ingredient in products such as muesli, snacks and breakfast cereals[11].

Fruit leather, also called a fruit sheet, is a dehydrated fruit based confectionery dietary product which is often eaten as snack, dessert or after rehydration. It is chewy and flavorful, low in fat and high in fiber and carbohydrates; it is also light weight and easily for storing and packaging. Fruit leathers made from fresh fruit pulp or a mixture of fruit juice concentrates and other ingredients after a complex operation that involves a dehydration step[12,13]. Fruit pulp-based fruit leathers are nutritious and sensorially acceptable to customers. They contain substantial quantities of dietary fibers, carbohydrates, minerals, vitamins and antioxidants that remain in finished product[14].

Most fresh fruits have a short harvest season and are sensitive to deterioration; therefore, making fruit leather from fresh fruits is an effective method to preserve fruits[13]. Fruit leathers are manufactured by dehydrating a fruit puree into a leather like sheet. Fruit leathers are often considered as a health food, therefore there are large numbers of fruit leather products available on the market, i.e., apricot leather and mango leather.

Basically, fruit pulps are mixed with appropriate quantities of sugar, pectin, acid and color and then dried into sheet-shaped products. Gujral and Brar[14] added sugars and pectin to mango leathers. The sugar gave the product a sweeter taste and increased the solids content; then pectin was used to thicken the pulp, modify the flexible texture and ensure the retention of the shapes of the dried product. Furthermore, they also prepared mango leather with the addition of potassium meta bisulphite to get better sensory qualities and the results were satisfactory for consumers. Various additives can be used, such as glucose syrup, sodium metabisulphite and ascorbic acid, depending on the types of fruit leather[15-17].

Fresh fruits are known to be excellent sources of vitamins, minerals, fibers, carbohydrates and other bioactive compounds. The objectives of this study were to improve the quality of Kaki fruits through some postharvest treatments to remove astringency and ripening. Fruit leathers provide attractive, colored and flavorsome products for people, therefore, leather kaki fruits were also prepared and evaluated to improve the quality of fresh and processed fruits.

MATERIALS AND METHODS

Plant sample: Kaki fruits (Costata cultivar) an astringent persimmon cultivar were harvested at maturity stage and coloring (two thirds of the surface) at mid of October 2015, from productive trees 12 years old planted at 4×4 m distant and grow in a loamy soil under flood irrigation system, in a private orchard located at Qalyubia Governorate Egypt. The productive trees were similar in growth vigor had a good physical condition and received similarly the recommended horticultural practices. The soil had 2.04% organic matter, 8.4 pH, 0.32 dsn^{-1} EC, 1.6% $CaCO_3$, 2.8% P, 47.2% K, 1000% Ca, 114% Mg, 15.8% Na, 7.6 ppm Fe, 3.4 ppm Mn, 1.4 ppm Zn and 1.7 ppm Cu.

Post harvest treatments: Four hundred and twenty mature fruits (60 kg) "greenish-yellow color" were selected free from visual defects "undamaged, uniformed in shape, free from blemishes and pathogen infection" were divided into 4 treatments, every treatment contained 105 fruits (15 kg) and washed separately with tap water, air dried, placed into plastic baskets. The four treatments were: T_1 untreated fruits as a

control. The T_2 and T_3 fruits were immersed for 5 min in 20 L tanks containing 2 and 3% (w/v) calcium chloride solution, respectively. The T_4 fruits were exposed with CO_2 treatment[18]. All treatments were stored at 20°C for 2 days, then immediately transported to the laboratory of food technology, National Research Centre (NRC)-Dokki Giza-Egypt.

Preparing kaki leather: Fruit was rinsed, chopped, mixed, homogenized with 12% water and 0.03% citric acid; then cooked at low heating through uncovered kettle and stirred during cooking. Simmer and stir were continued until the fruit purée has thickened. The purée should be very smooth. Puree was poured into line baking sheet. Baking sheet was placed in the oven at low temperature (40°C). The fruit leather is ready when it is no longer sticky, but has a smooth surface. After which, the fruit leather was peeled up from the plastic wrap and stored in the refrigerator.

Chemical analysis: Moisture, protein, fat, fiber, ash, total solids, total sugars, reducing and non reducing sugars of the samples were determined according to the methods of AOAC[19]. Total soluble solids (TSS) were determined using a Hand refractometer (ATAGO, Japan) and expressed as Brix value. Acidity was measured according to the method of AOAC[19] and expressed as citric acid (%). Brix/acid ratio was calculated by dividing the total soluble solids on the total acidity values for each sample. The pH was measured using Hanna pH-meter HI 9021 m Germany. Also, vitamin C content was determined according to AOAC[19] using 2, 6 di-chlorophenol-endo-phenol. Viscosity was measured using HAAKE viscometers (Haake, Mess-Technik Gmbhu. Co., Germany), thermostatic bath was used to control working temperature within 25°C. Viscosity result was determined in centipoise (cP) unit according to the method of Ibarz *et al.*[20].

Determination of hunter color parameters: Color parameters (L*, a* and b*) of jam samples were determined using a spectro-colorimeter (TristimulusColour Machine) with the CIE lab color scale (Hunter, Lab Scan XE-Reston VA, USA) in the reflection mode. The instrument was standardized with white tile of Hunter Lab Color Standard (LX No.16379): X = 72.26, Y = 81.94 and Z = 88.14 (L* = 92.46; a* = -0.86; b* = -0.16) according to Sapers and Douglas[21].

Total phenolics and flavonoids contents: Total phenolics content of sheet samples were determined using the method of Folin-Ciocalteu[22]. Results were expressed as gallic acid equivalent (mg GAE/g dry weight). Flavonoids contents of sheet samples were determined using AlCl 3 method[23] and expressed as catachine equivalents (mg CAT/g sample dry weight).

Antioxidant activity: Antioxidant activity was determined using DPPH radical-scavenging assay and assay as reported by Grzegorczyk *et al.*[24]. Various concentrations of ethanol and ethanol extracts of tested samples (50, 100, 150 and 200 μg mL^{-1}) were added to 4 mL of 0.1 mM DPPH solution in methanol and the mixture was shaken vigorously. After incubation for 30 min at room temperature the absorbance was recorded at 517 nm. TBHQ used as a reference in the same concentration range of tested extract. A control solution, without a tested compound was prepared in the same manner as the assay mixture. All analyses were carried out in triplicate. The degree of decolorization indicates the radical-scavenging efficiency of the extract. The antioxidant activity of tested samples was calculated as an inhibitory effect (I%) of the DPPH radical formation as follows:

$$\text{Inhibition (\%)} = 100 \times \frac{\text{A 517 (control)-A 517 (sample)}}{\text{A 517 (control)}}$$

The EC50 value was defined as the concentration (μg mL^{-1}) of the compound required to scavenge the DPPH radical by 50%.

Sensory evaluation: Sensory evaluation of sheet samples was carried out through evaluating taste, odor, color, mouth feel, appearance and overall acceptability as described by Hussein and Shedeed[25].

Statistical analysis: Statistical analysis of tested samples was carried out using SPSS program to calculate standard deviations, one way analysis of variance (ANOVA), with multiple ranges least significant difference (LSD) test ($p<0.05$).

RESULTS AND DISCUSSION

Chemical properties of postharvest treatment kaki fruits ("Costata" cv.) were determined and compared with untreated fruits sample. Table 1 showed that the chemical composition of treated kaki fruits was affected slightly compared to non-treated sample, where moisture content of untreated or treated fruits ranged between 18.10-23.88%. Ash content was slightly higher in treated fruits with CO_2 followed with untreated fruits and treated fruits with 3% $CaCl_2$. Also, protein content was slightly higher in post-harvest treated fruits with CO_2 followed with treated fruits with 3, 2% Ca Cl_2

Table 1: Effect of postharvest treatments of kaki fruits on their physicochemical properties of juice

Physicochemical properties	Untreated fruits (T1)	Fruits immersed in $CaCl_2$/5 min 2% (w/v) (T2)	3% (w/v) (T3)	Fruits exposed to CO_2 (T4)
Moisture (%)	20.63±0.25	18.10±0.34	23.88±0.45	22.31±0.32
Ash (%)	0.55±0.09	0.18±0.01	0.42±0.03	0.87±0.05
Protein (%)	0.36±0.02	0.60±0.04	2.50±0.21	5.41±0.18
Fiber (%)	36.36±0.65	29.77±0.52	83.31±0.33	60.09±0.29
pH	6.10±0.11	6.11±0.250	6.06±0.30	6.09±0.15
Acidity (%)	0.28±0.01	0.19±0.01	0.96±0.02	0.21±0.01
TSS (%)	20.1±0.09	18.6±0.110	18.6±0.070	18.4±0.080

Table 2: Effect of calcium chloride and CO_2 postharvest treatments on the hunter color parameters of Kaki fruits

Samples	L	a	b	a/b	ΔE	Satu-ration	Hue
Rawfruits (T1)	26.12±.015	13.94±0.13	30.85±0.25	0.45±0.01	42.76±0.13	33.85±0.15	85.31±0.67
Fruits were immersed for 5 min in 20 L tanks containing $CaCl_2$ solution							
2% w/v (T2)	37.61±0.19	17.18±0.15	48.24±.32	0.36±0.05	63.54±0.22	51.21±0.32	88.81±0.52
3% w/v (T3)	37.23±0.24	15.50±.0.19	46.58±0.17	0.33±0.09	61.61±0.35	49.09±0.39	86.31±0.70
Fruits exposed							
CO_2 (T4)	35.76±0.29	19.61±.0.22	50.40±0.22	0.39±0.03	64.83±0.28	54.08±0.44	87.58±0.46

and untreated fruits. The lowest fiber content was found in untreated fruits (36.36%), while it was higher in treated fruits with 2% $CaCl_2$ (27.77%) and CO_2 (83.81 and 60.09%). The obtained results were agreed with Baltacioglu and Artik[26], where they stated that the ash, crude fiber, moisture, protein and total fat contents of the persimmon fruits were similar in astringent and non-astringent species.

On the other hand, pH of untreated fruits not affected with post-harvest treatment, where pH ranged between 6.06-6.11 in untreated or treated fruits. But the acidity was higher in treated fruits with 3% $CaCl_2$. Also, total soluble solids (TSS) of treated kaki fruit juice decreased slightly compared to untreated fruits.

Fruits color is one of the most important sensory properties that affected on the consumer preference. Postharvest pretreatment was carried out to improve the color quality of Kaki fruits by immersing fruits separately in tanks containing 2% (T2), 3% (T3) calcium chloride solution for 5 min and exposed to CO_2 (T4). The effect of previous postharvest treatment on the color parameters (L*, a* and b*) of Kaki fruits were evaluated and compared with raw fruits (T1). Table 2 showed that $CaCl_2$ or CO_2 treatments improved color parameters of fruits, where T2 and T3 had the highest lightness value followed with T4. Also, fruits redness (a*) maximized in T4 followed with T2 and T3. The same trend was also noticed in yellowness (b*), saturation and hue values of fruits. It could be concluded that $CaCl_2$ or CO_2 post-harvest treatments caused a noticeable increase in color parameters of Kaki fruits compared to untreated fruits.

Post harvest Kaki fruits were processed to produce kaki fruit leather. The amount of the obtained leather product was referred to fruits weight and expressed as a yield. Data in

Table 3: Effect of calcium chloride and CO_2 postharvest treatments on the yield of kaki leather

Samples	Fruits weight (g)	Kaki fruit leather weight (g)	Yield (%)
Untreated fruits (T1)	1400	418	29.86
Fruits were immersed for 5 min in 20 L tanks containing $CaCl_2$ solution			
2% (w/v) (T2)	1400	471	33.64
3% (w/v) (T3)	1400	499	35.64
Fruits exposed to CO_2 (T4)	1400	503	35.93

Table 3 indicated that the kaki leather yield of untreated fruits was lower than kaki leather of treated fruits with 2%, 3% $CaCl_2$ and CO_2.

Color quality of the obtained fruits leather were evaluated and compared with leather of untreated fruit. Table 4 showed that the lowest lightness was found in leather of untreated fruits (control sample), while L* was higher in leather of post-harvest treated fruits with CO_2 (T4), followed with treated fruits with calcium chloride (T2 and T3). The same trends were found in redness and yellowness of the obtained leather, where a* and b* declined in control sample and was higher in T4, T2 and T3. Results concluded that the lowest Hunter color parameter were found in leather of untreated fruits and the highest color parameter were found in leather of post-harvest fruits with CO_2 (T4). This result could be due to the higher polyphenolic and flavonoid compounds and their antioxidant activities in treated fruits.

Bioactive compounds particularly phenolics and flavonoids are major interests in persimmon fruit. Table 5 compared these total phenolics, total flavonoids and their antioxidant activity in leather of untreated and treated kaki fruits. The obtained results showed that the total phenolics and antioxidant activity of leather affected slightly during preparing leather using untreated or treated fruits. The total phenolic compounds of Kaki leather of treated fruits with CO_2

Table 4: Effect of postharvest treatments of kaki fruits on color parameter of leather product

Leather	L*	a*	b*	a/b	ΔE	Saturation	Hue
Untreated fruits (T1)	35.38±0.15	9.88±0.06	19.14±0.14	0.52±0.07	41.42±0.40	21.54±0.14	87.00±0.70
Fruits immersed for 5 min in 20 L tanks containing $CaCl_2$ solution							
2% (w/v) (T2)	38.59±.0.17	12.77±0.19	23.45±0.11	0.54±0.05	46.93±0.35	26.70±0.19	87.56±0.65
3% (w/v) (T3)	36.91±0.21	11.67±0.09	23.11±0.13	0.50±0.04	45.08±0.28	25.89±0.11	87.52±0.59
Fruits exposed to CO_2 (T4)	40.13±0.25	14.18±0.12	28.31±0.16	0.50±0.02	51.12±0.22	31.66±0.17	87.98±0.50

Table 5: Total phenolics, total flavonoids and antioxidant activity (DPPH) in fruits leather of untreated and postharvest treated kaki fruits

		Kaki leather of fruits immersed in $CaCl_2$/ 5 min		
Phytochem and activities	Kaki leather of untreated fruits	2% w/v	3% w/v	Kaki leather of fruits exposed to CO_2
Total phenolics (mg g^{-1})	0.3594	0.3336	0.3675	0.4330
Total flavonoids (mg g^{-1})	ND	ND	ND	ND
DPPH (Trolox mg g^{-1})	0.0824	0.0905	0.0839	0.1090

ND: Not detected

Table 6: Effect of preparing kaki leather of untreated and post-harvest treated fruits on its phenolic compounds

	Fresh fruits				Kaki leather of fruits			
		Immersed in $CaCl_2$/5 min				Immersed in $CaCl_2$/ 5 min		
Compound (µg g^{-1})	Untreated	2%	3%	Exposed to CO_2	Untreated	2%	3%	Exposed to CO_2
Gallic	1556.01	1565.02	2113.97	1665.29	3993.99	4244.75	4071.06	3633.55
Protocatechuic	23.94	19.88	26.66	18.78	31.04	33.71	36.63	35.61
Gentisic	4.50	6.57	5.50	6.01	14.83	19.61	9.96	14.26
Chlorogenic	1.36	0.76	1.16	1.98	2.31	3.26	3.37	3.48
Vanillic	1.90	2.50	4.39	3.63	17.37	18.65	20.52	16.19
Ferulic	0.72	0.23	7.13	0.79	ND	ND	ND	ND
Sinapic	1.47	ND	5.23	ND	9.91	2.18	4.95	9.22
Rutin	3.07	2.82	7.16	2.78	7.26	9.37	12.64	9.47
Myricetin	1.90	0.47	3.98	3.27	1.40	6.26	1.42	4.20
Cinnamic	0.21	1.08	0.10	0.30	0.54	0.65	0.77	0.62
Quercetin	0.68	0.70	0.65	0.36	0.40	1.19	1.57	0.66
Kaempferol	0.95	0.90	0.55	0.32	ND	ND	1.74	0.78

were higher than Kaki leather of untreated or treated fruits with $CaCl_2$. Also, antioxidant activity (DPPH) of kaki leather of treated fruits with CO_2 was slightly higher than kaki leather of untreated or treated fruits with $CaCl_2$. But, Novillo *et al.*[27] found that submitted fruit to deastringency treatment with CO_2, lowered the values of both soluble polyphenols content and total antioxidant capacity. It was noticed also that total flavonoids compounds not detected in kaki leather of untreated or treated fruits.

Phenolic compounds of post-harvest treated kaki fruits were determined and evaluated to produce fruits leather. About 12 phenolic compounds were detected in fresh kaki fruits. Table 6 showed that gallic was the main phenolic compound in untreated kaki fruits followed with protocatechuic, gentisic, rutin, vanillic and myricetin. Also, gallic was maximized in treated kaki fruits with 3% $CaCl_2$ to reach 2113.97 µg g^{-1} followed with treated fruits with CO_2. Also, Kaki leather of untreated or treated fruits characterized with its higher percentage of phenolic compounds. This result could be due to concentration of Kaki fruits in leather products. While, ferulic was not detected in kaki leather of untreated or treated fruits. These results agreed with Yaqub *et al.*[28] who stated that major phenolic compounds that present in persimmon are ferulic acid, p-coumaric acid and gallic acid.

Table 7: Effect of preparing kaki leather of untreated and post-harvest treated fruits on total tannins and carotenoids

		immersed in $CaCl_2$/5 min		
Compound (µg g^{-1})	Untreated	2%	3%	Exposed to CO_2
Fresh fruits				
Total tannins (µg g^{-1})	40.892	36.464	47.016	38.545
Total carotenoids (µg g^{-1})	14.591	15.385	15.076	19.400
Leather				
Total Tannins (µg g^{-1})	225.473	211.101	184.014	159.875
Total carotenoids (µg g^{-1})	107.426	73.540	112.077	104.433

Persimmon fruit can be used in the manufacturing of products with functional characteristics because of its bioactive properties. It is an excellent source of ascorbic acid, tannins and carotenoids, having healthy aspects owing to their antioxidant and other health protecting activities[29]. Therefore, total tannins and carotenoids of postharvest treated kaki fruits and its leather products were evaluated. Table 7 showed that post harvest treated fruits affected on total tannins where untreated fruits was 40.892 µg g^{-1}, while

Table 8: Sensory evaluation of kaki leather

	Kaki leather				
		Fruits immersed in $CaCl_2$/5 min			
Sensory properties	Untreated fruits	2% w/v	3% w/v	Fruits exposed to CO_2	LSD at 0.05
Taste (20)	16.29±2.82[b]	13.81±3.77[c]	18.11±2.20[a]	14.88±1.13[c]	2.55
Color (20)	18.13±1.01	18.11±1.06	18.25±0.33	18.02±0.19	NS
Odor (20)	17.17±2.17	18.35±2.38	17.14±2.26	18.24±3.15	NS
Texture (20)	18.71±0.68[b]	17.82±1.20[c]	19.65±1.03[a]	17.35±0.96[c]	1.04
Appearance (20)	19.15±0.61	18.33±1.09	18.61±1.19	17.65±0.95	ND
Overall acceptability (100)	89.45±0.85	86.42±0.96	91.76±0.80	86.14±0.75	ND

treated fruits with $CaCl_2$ decreased to 36.464 μg g^{-1}. This result could be due to the effect of CO_2 treatment to remove astringency based on the in solubilization of tannins by the acetaldehyde generated during anaerobic respiration, which was triggered when fruit was exposed to a high CO_2 atmosphere[30]. Also, total carotenoids of untreated fruits (14.591 μg g^{-1}) slightly increased to be ranged between 15.076-19.400 μg g^{-1} in $CaCl_2$ and CO_2. This result could be due to carotenoid contents rapidly increase as green mature fruit changes to soft mature persimmon[31].

On the other hand, total tannins and carotenoids were concentrated in leather products, where total tannins ranged between 159.875-225.473 μg g^{-1} in leather products of untreated and treated. Also total carotenoids of leather products were concentrated and ranged between 73.540-112.077 μg g^{-1} in leather products of untreated and treated fruits.

Sensory properties were evaluated in leather products of Kaki fruits before and after post-harvest treatment. Table 8 showed that, the highest taste and texture were found in kaki leather of post-harvest treated fruits with 3% $CaCl_2$. Furthermore, leather products of post-harvest treated fruits not affected significantly in color, odor, appearance and overall acceptability. From the obtained sensory evaluation it could be recommended to use post harvest kaki fruits to produce kaki leather.

CONCLUSION

The purpose of this study was to improve the quality of kaki fruits and evaluate its leather product. The obtained results concluded that treated fruits with $CaCl_2$ or CO_2 improved color parameters of fresh Kaki fruits and its leather product. Also, kaki leather of treated fruits characterized with its higher total phenolics compounds and antioxidant activity compared to leather of untreated fruits. Furthermore, sensory evaluation of treated fruits or its leather product not affected significantly in color, odor, appearance and overall acceptability.

SIGNIFICANCE STATEMENT

This study discovers a new leather kaki fruits product contain high concentration of several bioactive compounds. This product is characterized by its high healthy, nutritive value, good sensory and texture properties. This also opens the way for innovative research in the same field to produce more functional food products able to alleviate symptoms of several diseases.

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