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Addition effect of *Phoenix canariensis* date and different food by-products on the physicochemical and sensory properties of jelly candy

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ABSTRACT

Jelly candy is an appreciated food for consumers, especially children. Its fortification with functional ingredients could show an interesting effect on human health. This study aimed to define the structural and chemical characteristics, especially that of polyphenolic amounts, of apple candies prepared with different percentages (2, 4, and 6%) of grape by-products (Moscato, Chardonnay, Barbera, and Pinot noir), cocoa bean shell (CBS), coffee silverskin and canary date powder, and to evaluate the consumer overall acceptance of these products. The fortification was achieved by replacing different percentages of apple puree with by-product powders. The jelly candies with the canary date and Pinot noir by-product showed the highest quantities of polyphenolic compounds (6.18 and 4.54mg GAE/g DW, respectively) and the greatest antioxidant capacity (24.04 and 26.54µmol TE/g DW, respectively) while the coffee silverskin candy had the lowest values. In general, the use of canary dates and by-product powders in candy production increased hardness, polyphenol and fiber contents, and antioxidant capacity. Sensory analysis showed that the candies obtained with coffee silverskin powder had the least overall liking at 6% substitution. However, no significant differences were recorded between the control and candies at 2 and 4% substitution for all studied functional ingredients.

Keywords: candy, by-product, valorization, polyphenol, antioxidant capacity, Phoenix canariensis date

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Introduction

Food by-products are a universal theme of concern as, around the world, the food industry generates each year huge amounts of waste and by-products from a variety of sources. Indeed, these by-products can pose sustainability issues due to the tremendous organic quantities generated in a short period (Coderoni & Perito, 2020). Hence, their disposal would have a negative impact on the environment which differs according to the type of by-product (Grillo et al., 2019; Rojo-Poveda et al., 2019). By focusing on the agricultural sector, fruit processing industries produce by-products of high concentrations of polyphenols and fibers (Mateos-Aparicio et al., 2020) and could represent a potent source of ingredients.

Grape production reached 2018, 77.8 million tons, of which 57% goes to the wine industry (OIV, 2019), where different by-products are produced, such as grape pomace (pulp, leaves, skins, seeds), stems, and wine lees accounting for about 9 million tons generated annually (Gouvinhas et al., 2019). Overall, the volume of waste produced represents a respectable percentage varying between 20-30% of total wine production (Nakov et al., 2020). Wine industry by-products are particularly rich in polyphenols due to poor extraction during winemaking (Maier et al., 2009). Indeed, Cappa et al. (2015) recorded an increase in anthocyanins, flavonols, and procyanidins contents of candies enriched with grape skin powders, which led to an increase in antioxidant activity.

In recent years, the consumption of cocoa and coffee has increased. Consequently, considerable amounts of by-products are generated by the cocoa and coffee industry which creates a significant disposal problem (Grillo et al., 2019). Coffee silverskin has gained attention as a renewable biomass characterized by a rich bioactive composition and promoted applications, especially in the food industry (Gocmen et al., 2019). Moreover, this by-product is a precious natural resource rich in phenolic compounds that may be beneficial to health such as caffeine, caffeoylquinic alactonectone, and feruylquinic acid (Barbero-López et al., 2020). Cocoa bean shells, also known as husks, are the most important part of the residual materials obtained from the roasting process throughout chocolate production (Barbosa-Pereira et al., 2018). They have been reported to be a considerable source of protein and dietary fiber, with a low-fat content compared to cocoa beans but with a similar profile of volatile compounds (Rojo-Poveda et al., 2019). This by-product is also rich in antioxidants (mainly flavonoids) and is a potential source of food and beverage ingredients (Grillo et al., 2019).

Phoenix canariensis (*P. canariensis*), commonly named canary dates, are edible but used only for feed as they are astringent. It was used as an ingredient in the biscuit application. Indeed, substituting a percentage of apple pure with canary date powder has given biscuits two-fold fiber and four-fold polyphenolic content compared to biscuits made with wheat flour alone (Turki et al., 2020). Since *P. canariensis* is widely planted and produces a large amount of fruit, there is a great amount of available biomass that can be valorized directly or by recovering its bioactive molecules for use as ingredients in food, pharmaceuticals, and cosmetics.

Considering the different studies analyzed, the beneficial effects that derive from the bioactive compounds of the residues, and the need to reduce the by-product of food companies, the aims of this study were to investigate the effect of the substitution of apple puree by canary date and different by-products powders, at different percentages on the physicochemical characteristics and bioactive, structural and sensory properties of jelly candy and then to choose the best suitable percentage and functional ingredient for the gelatin-based candy production from an organoleptic and chemical-physical point of view.

Experimental

Chemicals

Ethanol (≥ 99.9%), gallic acid (3,4,5-trihydroxy benzoic acid) (≥ 98%), 6-hydroxy-2,5,7,8-tetramethyl chroman-2-carboxylic acid (97%; Trolox), Folin-Ciocalteu's phenol reagent (2 M), sodium carbonate (≥ 99.5%), 2,2-diphenyl-1-picrylhydrazyl (DPPH) were of analytical grade and were purchased from Sigma-Aldrich, Co (Milan, Italy). Ultrapure water was prepared in a Milli-Q filter system (Millipore, Milan, Italy).

Canary date and by-products samples

P. canariensis dates were purchased from "Nizar Jlassi, Aménagement espaces verts" company from the region of Borj El Amri (30 Km, South-west of Tunis, Tunisia). The fruits were washed, manually pitted, and dried in an oven UFE 550 model (Memmert, Schwabach, Germany) at 40 °C with forced air until 5% of moisture was reached, then ground using a ZM200 grinder

(Retsch Gmbh, Haan, Germany). Grape marc powders (Moscato, Chardonnay, Barbera, Pinot noir) were provided by Cantine Batasiolo (La Morra, Cuneo, Italy), coffee silverskin by Lavazza SpA and cocoa bean shell by Castagna (Giaveno, Torino, Italy). The powders were stored in vacuum-sealed polyethylene bags at 4 °C until analysis.

Candy preparation

Candies were produced according to Cappa et al. (2015), with several modifications, using sugar, agar, water, apple puree, by-product powder (grape marc powders, coffee silverskin, cocoa bean shell), and canary date powder. In short, the powder of the studied ingredient was first mixed with the water then, sugar, and apple puree was added consecutively by stirring. The resulting mixture was concentrated using a constant temperature cooktop while stirring uniformly to standardize the processing conditions. The concentration process continued until the mixture reached 37 °Brix. The concentrated mixture was then poured into a plate of ten rectangular molds. After 45 minutes of rest at 4° C, the sweets were extracted from the molds. A preliminary consumer test was performed with 20 consumers (data not shown), and obtained results showed that the maximum percentage acceptable for powder of different studied ingredients was 6%.

According to these results, candies were produced with an aliquot of apple puree replaced by seven different powders in purity to obtain final products with different percentages (2, 4, and 6%) of powders (Table 1). All productions were done in duplicate.

Table 1. Composition (g) of candies with different quantities of studied powders

Ingredients	control	2%	4%	6%
Water	70	70	70	70
Sugar	32	32	32	32
agar	1	1	1	1
Apple puree	67	65	63	61
Studied powder	0	2	4	6

Physico-chemical analysis

The dry matter content of different powders and candies was determined at 105°C using an infrared moisture analyzer (Gibertini Elettronica, Novate Milanese MI, Italy), using 3 g of sample. The water activity of candies was determined at 25±0.02 °C using an AquaLab Pre water activity meter CX-2T (Decagon Devices, Pullman, WA, USA).

The pH and the concentration of soluble solids (°Brix) of candies were measured with a Sension+ pH-meter (HACH, Milan, Italy) and an HI 96801 refractometer (Hanna Instruments, Michigan, USA), respectively.

Color analysis was carried out in transmittance mode on a CM-5 spectrophotometer (Konica Minolta, Tokyo, Japan). L*, a*, and b* CIELab parameters were used to determine the color, where L* is the coefficient of lightness, ranging from 0 black) to 100 (white), a* denotes the colors red and purple (when positive a*) and bluish green (when negative a*),and b* indicates the colors yellow (when positive b*) and blue (negative b*). The difference between e two colors is calculated according to the following formula: $\sqrt{(L_i - L_j)^2 + (a_i - a_j)^2 + (b_i - b_j)^2}$

According to Mokrzycki & Tatol (2011), a standard observer sees the color difference as follows:

- 0 <ΔE <1: observer does not notice the difference
- 1 <ΔE <2: only an experienced observer can notice the difference
- 2 <ΔE < 3.5: unexperienced observer also notices the difference
- 3.5<ΔE < 5: clear difference in color is noticed
- ΔE >5: observer notices two different colors.

All analyses were performed in triplicate.

Textural profile analysis

Textural analyses of candies were carried out by the TA.XT2i Plus Texture Analyser® (Stable Micro System, Godalming, UK) equipped with a 25-kg load cell according to the method described by Bertolino et al. (2011), with slight modifications. For the acquisition of the force-time curve, the Texture Expert Exceed software 2.54 (Stable Micro System, Godalming, UK) was used. For each matrix, six samples were analyzed. The candy has a trapezoidal shape (Two parallel sides and a line of symmetry) with a height of 25 mm and bases of 40/20 mm and 30/10 mm (length/width).

Candy hardness (N), cohesiveness (adimensional), adhesiveness (mJ), gumminess (N), springiness (mm), chewiness (mJ), and resilience (adimensional) parameters were measured using an SMS P/100 probe (Stable Micro System, Godalming, UK). The texture analyzer setting was as follows: pre-test speed of 1 mm/s, test speed of 1 mm/s, post-test speed of 1 mm/s, a distance of 20%, and a trigger force of 10 g.

Extractions of polyphenols

The extraction of polyphenols was carried out according to the method described by Alahyane et al. (2019) with slight modifications. Briefly, 3 g of the studied powder (or candy) was mixed with 30 mL of ethanol/water solution (80/20, v/v), and the extraction was carried out at 25 °C for 2 h with a VDRL 711 orbital shaker (Asal S.r.l., Milan, Italy) under constant rotatory agitation at 60 rpm. All extracts were centrifuged at 2,800 × g for 10 min at 4°C, and the supernatants were then collected and filtered through a 0.45-µm nylon membrane filter. The samples were kept in amber vials at –18°C. All extractions were performed in triplicate.

Total phenolics content

The total phenolic content (TPC) of the extract was determined based on the Folin–Ciocalteu colorimetric method adapted to a 96-well microplate (Barbosa-Pereira et al., 2018). An aliquot (20 µL) of the sample extract was mixed with 100 µL of Folin-Ciocalteu aqueous reagent (10% v/v) in the wells of a 96-well microplate. After 3 min, 75 µL of a 7.5% sodium carbonate anhydrous solution was added, and the obtained solution was mixed. The solution was allowed to stand for 2 h at 25 °C, and the absorbance was measured at 740 nm against a blank in a BioTek Synergy HT spectrophotometric multi-detection microplate reader (BioTek Instruments, Milan, Italy). All determinations were performed in triplicate. A calibration curve of gallic acid (20–100 mg/L) was constructed to determine the concentration which was expressed in milligrams of gallic acid equivalents per gram of dry weight (mg GAE/g).

Antioxidant capacity

The antioxidant capacity of the extracts was evaluated by the 2,2-diphenyl-1-picrylhydrazyl radical (DPPH*) radical scavenging method described by Barbosa-Pereira et al. (2018).

All the assays were performed in triplicate in 96-well microplates with the BioTek Synergy HT spectrophotometric multi-detection microplate reader (BioTek Instruments, Milan, Italy). Antioxidant capacity was calculated as the inhibition percentage (IP) of DPPH radical as follows:

$$IP\ (\%) = ((A0 - A30)/A0) \times 100$$

where A0 is the absorbance of the blank and A30 is the absorbance at 30 min.

A standard curve of Trolox was constructed (12.5–300 μM) for the evaluation of the radical-scavenging activity values which were expressed as micromoles of Trolox equivalent per gram of dry weight (μmol TE/g).

Liking test

The sensory test was carried out with 25 adult subjects (females=80%; age range: 18–59 years) who were joined up among the staff and students of the University of Turin. Participants received individual trays with four candy samples and rinsed their mouths with noncarbonated water before beginning the evaluation. Participants tasted the samples according to the tray presentation order, blind, without any information about the innovativeness of the candies to avoid a probable effect of the information on liking scores. Participants rated their liking for appearance, odor, taste, flavor, texture, and overall liking using a 9-point hedonic scale (1 = extremely dislike, 9 = extremely like) according to Lim, (2011). Purchase interest (“Will you buy this candy?”) was also rated on a 7-point scale (1 = absolutely no, 7 = absolutely yes). Candies were distributed in a randomized and balanced order. Participants were asked to rinse their mouths with still water for about 1 min between samples. Each consumer test lasted 10 to 15 min.

Statistical analysis

Physico-chemical data were submitted to a one-way analysis of variance (ANOVA) with Duncan’s post hoc test at a 95% confidence level, while the Kruskal-Wallis test was applied for the statistical analysis of the liking test results. Correlation analysis is performed using Pearson's coefficient. Data analyses were conducted using the Statistica 13.3 software (StatSoft, Inc., Tulsa, OK, USA).

Results and Discussion

The moisture content and water activity of different candies are shown in table 2. The substitution of apple puree with various percentages of powders reduced significantly the moisture content of candies ($p<0.05$). At the same level of substitution, the candies contained almost the same water content ($p>0.01$). All the water activity values were near 0.955. This similarity was due to the adoption of the same cooking conditions. These values were inferior to those reported by Ventura et al. (2013) who obtained water activity values of about 0.984 for reduced-sugar pomegranate juice jelly prepared using an aqueous extract of pomegranate peels.

The pH values varied depending on powder percentage (Table 2). Except for Pinot noir, the substitution of a percentage of apple puree with grapes marc powder increased the acidity of candies. However, canary date, CBS, and coffee silverskin made the apple candies less acid. In general, the most acid candies are ones prepared with Barbera, Moscato, and Chardonnay.

Regarding the color of obtained candies, it was observed that the different powders affected the color parameters compared to the control sample. This effect increased with the used amount of studied functional ingredients (Table 2). The brightness values (L*) of the candies varied between 11.69 for the barbera candy and 43.64 for the date candy, the b* parameter (yellowness) varied from 0.24 for the barbera candy to 38.63 for the date candy, whereas the* parameter (redness) varied from 2.78 for the control candy to 13.50 for the CBS candy. By fixing the percentage of substitution, all the candies produced with different studied powders showed significant differences in terms of color ($p<0.05$) which is supported by the high values of ΔE ($\Delta E>2$; data not shown). Then, color differences can be detected with eyes between all different candies at the same substitution level.

Table 2. Physico-chemical characteristics of the candies produced with different percentages of studied functional ingredients

Para-meter	Samples	C. Moscato	C. Chardonnay	C. Barbera	C. Pinot noir	C. CBS	C. Silverskin	C. Canary date	Significance
Humidity (%)	**0%**	56.91 ±0.75^{b}	56.91 ±0.75^{c}	56.91 ±0.75^{c}	56.91 ±0.75^{b}	56.91 ±0.75^{c}	56.91 ±0.75^{c}	56.91 ±0.75^{bc}	-
	2%	55.60 ±0.64^{bBC}	53.77 ±0.44^{bA}	55.90 ±0.34^{bcBC}	55.72 ±0.47^{bBC}	55.00 ±0.44^{cAB}	55.02 ±0.45^{bcAB}	57.15 ±0.22^{cC}	*
	4%	53.99 ±1.52^{abA}	51.54 ±0.70^{abA}	53.07 ±0.56^{bA}	52.66 ±0.56^{aA}	52.62 ±0.53^{bA}	53.33 ±0.53^{bA}	54.37 ±0.24^{abA}	ns
	6%	51.22 ±0.61^{aABC}	49.70 ±0.59^{aAB}	49.18 ±1.15^{aA}	52.46 ±0.48^{aC}	48.63 ±0.44^{aA}	48.99 ±0.55^{aA}	52.21 ±1.06^{aBC}	*
	Significance	ns	**	**	*	**	**	*	
Water activity	**0%**	0.96 ±0.00^{b}	0.96 ±0.00^{a}	0.96 ±0.00^{b}	0.96 ±0.00^{a}	0.96 ±0.00^{a}	0.96 ±0.00^{a}	0.96 ±0.00^{bc}	-
	2%	0.95 ±0.00^{abA}	0.95 ±0.00^{aA}	0.96 ±0.00^{bAB}	0.96 ±0.00^{bBC}	0.96 ±0.00^{bBC}	0.96 ±0.00^{aBC}	0.96 ±0.00^{cC}	**
	4%	0.95 ±0.00^{abAB}	0.95 ±0.01^{aA}	0.95 ±0.00^{abABC}	0.96 ±0.00^{abD}	0.96 ±0.00^{abCD}	0.96 ±0.00^{aBCD}	0.95 ±0.00^{bABC}	**
	6%	0.95 ±0.00^{aA}	0.95 ±0.00^{aA}	0.95 ±0.00^{aAB}	0.96 ±0.00^{abBC}	0.96 ±0.00^{aBC}	0.96 ±0.00^{aC}	0.95 ±0.00^{aA}	***
	Significance	*	ns	ns	ns	ns	ns	**	
°Brix	**0%**	37.63 ±0.03^{a}	37.63 ±0.03^{a}	37.63 ±0.03^{a}	37.63 ±0.03^{a}	37.63 ±0.03^{a}	37.63 ±0.03^{a}	37.63 ±0.03^{a}	-
	2%	38.00 ±0.40^{aA}	37.60 ±0.40^{aA}	38.17 ±0.32^{aA}	37.23 ±0.35^{aA}	37.73 ±0.07^{aA}	37.53 ±0.13^{aA}	37.13 ±0.73^{aA}	ns
	4%	37.17 ±0.35^{aA}	37.67 ±0.58^{aA}	38.37 ±0.35^{aA}	37.33 ±0.18^{aA}	37.43 ±0.20^{aA}	37.37 ±0.58^{aA}	37.30 ±1.60^{aA}	ns
	6%	37.93 ±0.19^{aA}	37.63 ±0.27^{aA}	38.37 ±0.37^{aA}	37.70 ±0.50^{aA}	37.87 ±0.18^{aA}	37.63 ±0.19^{aA}	37.90 ±2.30^{aA}	ns
	Significance	ns	ns	ns	ns	ns	ns	ns	
pH	**0%**	4.10 ±0.01^{c}	4.10 ±0.01^{c}	4.10 ±0.01^{d}	4.10 ±0.01^{a}	4.10 ±0.01^{a}	4.10 ±0.01^{a}	4.10 ±0.01^{a}	-
	2%	3.99 ±0.02^{bB}	4.00 ±0.01^{bB}	3.93 ±0.01^{cA}	4.09 ±0.03^{aC}	4.55 ±0.01^{bE}	4.33 ±0.02^{bD}	4.37 ±0.01^{bD}	***
	4%	3.96 ±0.02^{abB}	3.95 ±0.01^{aB}	3.89 ±0.02^{bA}	4.15 ±0.01^{bC}	4.76 ±0.01^{cF}	4.49 ±0.01^{cD}	4.57 ±0.02^{cE}	***
	6%	3.93 ±0.03^{aB}	3.94 ±0.01^{aB}	3.82 ±0.01^{aA}	4.17 ±0.01^{bC}	4.95 ±0.02^{dF}	4.62 ±0.02^{dD}	4.70 ±0.01^{dE}	***
	Significance	***	***	***	**	***	***	***	

L*	**0%**	37.87 ±0.91^{b}	37.87 ±0.91^{b}	37.87 ±0.91^{b}	37.87 ±0.91^{b}	37.87 ±0.91^{c}	37.87 ±0.91^{c}	37.87 ±0.91^{a}	-
	2%	28.21 ±0.40^{aE}	27.47 ±0.47^{aE}	13.12 ±0.56^{aA}	22.61 ±0.27^{aD}	21.05 ±0.37^{bC}	17.29 ±0.43^{bB}	43.42 ±0.35^{bF}	***
	4%	27.69 ±0.66^{aE}	26.30 ±0.47^{aE}	11.69 ±0.54^{aA}	21.55 ±0.64^{aD}	19.62 ±0.48^{abC}	16.60 ±0.46^{abB}	43.64 ±0.21^{bF}	***
	6%	26.97 ±0.31^{aE}	26.81 ±0.23^{aE}	11.73 ±0.57^{aA}	20.91 ±0.57^{aD}	18.69 ±0.21^{aC}	14.98 ±0.36^{aB}	42.78 ±0.42^{bF}	***
	Significance	***	***	***	***	***	***	***	
a*	**0%**	2.78 ±0.38^{a}	2.78 ±0.38^{a}	2.78 ±0.38^{a}	2.78 ±0.38^{a}	2.78 ±0.38^{a}	2.78 ±0.38^{a}	2.78 ±0.38^{a}	-
	2%	9.29 ±0.20^{bC}	8.22 ±0.20^{bB}	10.64 ±0.38^{cE}	10.43 ±0.13^{bDE}	13.50 ±0.18^{cF}	4.76 ±0.09^{cA}	9.93 ±0.07^{bD}	***
	4%	9.49 ±0.23^{bC}	8.55 ±0.09^{bB}	9.81 ±0.42^{bcCD}	9.87 ±0.31^{bCD}	12.48 ±0.32^{bE}	4.00 ±0.18^{bA}	10.50 ±0.12^{cD}	***
	6%	9.84 ±0.12^{bC}	8.92 ±0.17^{bB}	9.03 ±0.45^{bB}	10.28 ±0.35^{bC}	12.47 ±0.17^{bD}	4.26 ±0.09^{bcA}	12.97 ±0.14^{dD}	***
	Significance	***	***	***	***	***	***	***	
b*	**0%**	22.97 ±1.34^{b}	22.97 ±1.34^{b}	22.97 ±1.34^{b}	22.97 ±1.34^{b}	22.97 ±1.34^{b}	22.97 ±1.34^{b}	22.97 ±1.34^{a}	-
	2%	16.35 ±0.86^{aD}	14.59 ±0.45^{aC}	1.27 ±0.15^{aA}	10.17 ±0.24^{aB}	14.88 ±0.35^{aC}	10.19 ±0.29^{aB}	38.63 ±0.58^{cE}	***
	4%	16.96 ±0.60^{aE}	15.04 ±0.38^{aD}	0.34 ±0.36^{aA}	9.06 ±0.41^{aB}	13.06 ±0.59^{aC}	7.91 ±0.60^{aB}	32.31 ±0.77^{bF}	***
	6%	17.75 ±0.49^{aE}	16.27 ±0.47^{aD}	0.24 ±0.21^{aA}	9.49 ±0.39^{aB}	13.14 ±0.39^{aC}	8.97 ±0.30^{aB}	33.37 ±0.67^{bF}	***
	Significance	***	***	***	***	***	***	***	

C.: Candy; CBS: Cocoa bean shell; Data are mean values ± standard error; ns: not significant; *p<0.05; **p<0.01; ***p<0.001. Data within the same line having different capital letters were significantly different at p<0.05. Data within the same column having different lowercase letters were significantly different at p<0.05.

Texture evaluation showed that generally the hardness of different candies increased significantly as the percentage of canary date or by-product powder added increased (Table 3; $p<0.05$). The highest results in terms of hardness were recorded for candies prepared with grape pomace, particularly Barbera powder. However, the hardness of grape by-products, with the exception of Barbera, decreased at the 6% substitution level. Only the candies developed with CBS showed lower hardness values than the control candy obtained only from the apple puree base. This decrease was also observed on biscuits fortified with CBS powder (Rojo-Poveda et al., 2020). The lower fiber content of the CBS by-product (Table 4) compared to the other powders may explain this difference. Moisture content, pH optimization, and gelling agent dosage and strength help to adjust the texture of soft candies (Altınok et al., 2020).

The adhesiveness of candies was positively correlated with the hardness ($r=0.93$; with 4% substitution). The candies produced with the canary date and CBS powders were characterized by the lowest insoluble fiber content and showed the highest adhesiveness (-0.42 and -0.36 respectively). This result shows a strong correlation between insoluble fiber and adhesiveness ($r=0.82$). This increase could affect the candy quality in the stage of production and consumption (Altınok et al., 2020). Contrary to the hardness results, the CBS candy displayed the highest cohesiveness values, while the cohesion of the other candies decreased by gradually adding a canary date or different by-products. The chewiest candy was the one prepared with silverskin, the richest powder in fiber (Table 4). Ateş & Elmacı (2018) has also recorded an increase in chewiness after preparing cakes with coffee silverskin. The resilience of the candies generally decreased as the percentage of studied powder increased. However, the powder substitution did not affect the candy springiness. Except for springiness and cohesiveness, significant differences in all texture parameters of candies produced with grape by-products were observed by Altınok et al. (2020). The canary date substitution affected the candy’s textural properties, especially on hardness, cohesiveness, and adhesiveness. This impact was also recorded after the biscuit dough substitution by canary date powder (Turki et al., 2020). Indeed, several authors have mentioned that fiber addition has an interesting effect on the micro- and macrostructure of jelly candies (Altınok et al., 2020; Cappa et al., 2015).

Table 3. Mean values of texture parameter evaluated on candies prepared with different percentages of studied functional ingredient

Para-meter	Samples	C. Moscato	C. Chardonnay	C. Barbera	C. Pinot noir	C. CBS	C. Silverskin	C. Canary date	Significance
Hardness (N)	0%	5.81 ±0.14^{a}	5.81 ±0.14^{a}	5.81 ±0.14^{a}	5.81 ±0.14^{a}	5.81 ±0.14^{b}	5.81 ±0.14^{a}	5.81 ±0.14^{a}	-
	2%	7.08 ±0.18^{cD}	7.14 ±0.10^{bDE}	7.51 ±0.07^{bE}	7.27 ±0.13^{cDE}	5.44 ±0.09^{aA}	6.32 ±0.10^{bC}	5.84 ±0.14^{aB}	***
	4%	7.10 ±0.07^{cD}	7.34 ±0.20^{bDE}	7.39 ±0.15^{bDE}	7.61 ±0.13^{cE}	5.80 ±0.06^{bA}	6.62 ±0.07^{cC}	6.22 ±0.07^{abB}	***
	6%	6.36 ±0.10^{bB}	6.05 ±0.14^{aA}	7.75 ±0.13^{bD}	6.53 ±0.10^{bBC}	5.86 ±0.10^{bA}	6.86 ±0.05^{cC}	6.64± 0.06^{bBC}	***
	Significance	***	***	***	***	*	***	**	
Cohesiveness (-)	0%	0.63 ±0.01^{c}	0.63 ±0.01^{c}	0.63 ±0.01^{c}	0.63 ±0.01^{c}	0.63 ±0.01^{a}	0.63 ±0.01^{b}	0.63 ±0.01^{b}	-
	2%	0.58 ±0.01^{bB}	0.58 ±0.01^{bB}	0.55 ±0.00^{bA}	0.57 ±0.00^{bB}	0.65 ±0.00^{bC}	0.59 ±0.00^{aB}	0.54 ±0.01^{aA}	***
	4%	0.56 ±0.00^{aC}	0.57 ±0.01^{bC}	0.49 ±0.00^{aA}	0.57 ±0.00^{bC}	0.66 ±0.00^{bcE}	0.58 ±0.00^{aD}	0.54 ±0.01^{aB}	***
	6%	0.55 ±0.00^{aC}	0.54 ±0.01^{aBC}	0.50 ±0.00^{aA}	0.55 ±0.00^{aC}	0.67 ±0.00^{cE}	0.62 ±0.00^{bD}	0.54± 0.01^{aB}	***
	Significance	***	***	***	***	***	***	***	
Adhesiveness (mJ)	0%	-0.23 ±0.03^{b}	-0.23 ±0.03^{bc}	-0.23 ±0.03^{a}	-0.23 ±0.03^{ab}	-0.23 ±0.03^{b}	-0.23 ±0.03^{a}	-0.23 ±0.03^{c}	-
	2%	-0.18 ±0.01^{bD}	-0.18 ±0.01^{cD}	-0.27 ±0.02^{aAB}	-0.2 ±0.02^{bCD}	-0.3 ±0.01^{aA}	-0.23 ±0.02^{aBC}	-0.28 ±0.02^{bcAB}	***
	4%	-0.29 ±0.02^{aBC}	-0.28 ±0.02^{abBC}	-0.27 ±0.02^{aC}	-0.28 ±0.02^{aBC}	-0.36 ±0.02^{aA}	-0.29 ±0.02^{aBC}	-0.31 ±0.01^{abAB}	*
	6%	-0.31 ±0.01^{aB}	-0.31 ±0.01^{aB}	-0.27 ±0.02^{aBC}	-0.25 ±0.01^{abC}	-0.32 ±0.01^{aB}	-0.29 ±0.02^{aBC}	-0.42± 0.02^{aA}	***
	Significance	***	**	ns	ns	**	ns	**	
Gumminess (N)	0%	3.64 ±0.09^{a}	3.64 ±0.09^{b}	3.64 ±0.09^{a}	3.64 ±0.09^{a}	3.64 ±0.09^{ab}	3.64 ±0.09^{a}	3.64 ±0.09^{c}	-
	2%	4.09 ±0.15^{bC}	4.13 ±0.07^{cC}	4.16 ±0.04^{cC}	4.16 ±0.08^{bC}	3.54 ±0.06^{aB}	3.70 ±0.06^{abB}	3.16 ±0.04^{aA}	***
	4%	3.97 ±0.04^{bCD}	4.19 ±0.18^{cDE}	3.65 ±0.10^{aB}	4.32 ±0.08^{bE}	3.82 ±0.04^{bcBC}	3.87 ±0.05^{bBC}	3.34 ±0.04^{abA}	***
	6%	0.06± 3.50^{aAB}	3.29 ±0.12^{aA}	3.90 ±0.06^{bC}	3.61 ±0.07^{aB}	3.92 ±0.07^{cC}	4.24 ±0.03^{cD}	3.55± 0.09^{bcB}	***
	Significance	***	***	***	***	**	***	**	
Chewiness (mJ)	0%	13.84 ±0.48^{a}	13.84 ±0.48^{b}	13.84 ±0.48^{a}	13.84 ±0.48^{a}	13.84 ±0.48^{a}	13.84 ±0.48^{a}	13.84 ±0.48^{b}	-
	2%	14.38 ±1.62^{aBC}	15.44 ±0.33^{cBC}	16.67 ±0.21^{cC}	16.00 ±0.31^{bBC}	14.07 ±0.22^{aAB}	14.27 ±0.26^{abABC}	12.02± 0.31^{aA}	**

	4%	14.25 ±1.23^{aAB}	15.88 ±0.51^{cBC}	14.49 ±0.35^{aAB}	16.91 ±0.36^{bC}	15.18 ±0.16^{bBC}	15.09 ±0.26^{bBC}	13.07± 0.15^{abA}	**
	6%	12.10 ±1.52^{aA}	12.46 ±0.45^{aA}	15.61 ±0.29^{bBC}	13.80 ±0.20^{aAB}	15.86 ±0.20^{bBC}	16.82 ±0.15^{cC}	13.96± 0.42^{bAB}	***
	Significance	ns	***	***	***	***	***	*	
Springiness (mJ)	0%	3.80 ±0.07^{a}	3.80 ±0.07^{a}	3.80 ±0.07^{a}	3.80 ±0.07^{a}	3.80 ±0.07^{a}	3.80 ±0.07^{a}	3.80 ±0.07^{a}	-
	2%	3.45 ±0.35^{aA}	3.74 ±0.06^{aAB}	4.00 ±0.03^{bB}	3.84 ±0.03^{aAB}	3.98 ±0.08^{bB}	3.86 ±0.04^{abAB}	3.80± 0.08^{aAB}	ns
	4%	3.60 ±0.31^{aA}	3.81 ±0.06^{aA}	3.98 ±0.02^{bA}	3.91 ±0.02^{aA}	4.02 ±0.01^{bA}	3.9 ±0.02^{abA}	3.91± 0.01^{aA}	ns
	6%	3.48 ±0.43^{aA}	3.79 ±0.04^{aA}	4.00 ±0.04^{bA}	3.83 ±0.04^{aA}	4.06 ±0.04^{bA}	3.97 ±0.03^{bA}	3.93± 0.07^{aA}	ns
	Significance	ns	ns	**	ns	*	ns	ns	
Resilience (-)	0%	0.32 ±0.00^{c}	0.32 ±0.00^{b}	0.32 ±0.00^{ab}	0.32 ±0.00^{c}	0.32 ±0.00^{b}	0.32 ±0.00^{c}	0.32 ±0.00^{c}	-
	2%	0.28 ±0.00^{bA}	0.28 ±0.00^{aA}	0.29 ±0.00^{aA}	0.28 ±0.00^{bA}	0.31 ±0.00^{aB}	0.28 ±0.00^{aA}	0.31± 0.00^{cB}	***
	4%	0.28 ±0.00^{bA}	0.28 ±0.01^{aA}	0.38 ±0.02^{cC}	0.27 ±0.00^{abA}	0.31 ±0.00^{abB}	0.28 ±0.00^{aA}	0.29± 0.00^{bAB}	***
	6%	0.27 ±0.00^{aA}	0.27 ±0.00^{aA}	0.34 ±0.02^{bcC}	0.27 ±0.00^{aA}	0.33 ±0.00^{cC}	0.30 ±0.00^{bB}	0.27± 0.00^{aA}	***
	Significance	***	***	**	***	***	***	***	

C. : Candy; CBS: Cocoa bean shell; Data are mean values ± standard error; ns: not significant; *$p<0.05$; **$p<0.01$; ***$p<0.001$. Data within the same line having different capital letters were significantly different at $p<0.05$. Data within the same column having different lowercase letters were significantly different at $p<0.05$.

The total phenolic content (TPC) and the free radical scavenging activity (RSA) of the different candies are shown in table 5. The candies produced with the canary date and Pinot noir showed the highest values of RSA and TPC, however, the replacement of apple puree with coffee silverskin reduced the values of RSA and TPC in comparison with the candy control. This result could be explained by the values of RSA and TPC of different powders (Table 4). A strong correlation is determined between the different values of powders and candies in terms of RSA and TPC (r= 0.91 and 0.97 respectively; with 4% substitution). There was no significant difference between candies prepared with CBS, Muscat, and Chardonnay in terms of RSA and TPC ($p>0.05$).

The substitution of wheat flour with 4% and 6% of grapes pomace powder (Muscat Hamburg variety) increased the TPC of cakes by 2 - 3 times, respectively (Nakov et al., 2020), as well as the enrichment with 4% and 6% of Moscato by-products at the expense of apple puree increased the TPC of candies by the same percentage (Table 5). Similarly to grape marc, the substitution with canary date powder increased the health benefits of candies as shown with biscuits (Turki et al., 2020). The TPC and RSA of candy produced with a canary date were comparable to the values determined by Rivero et al. (2021) for two gelatin candies developed with raspberry powder and orange juice (491.9- 550.8 mg GAE/100 g; 1.60 and 1.82 mmol Trolox/100 g for TPC and RSA, respectively).

Table 4. Fiber and total phenolic (TPC; mg GAE/g dry weight) content and radical scavenging activity (RSA; µmol eq. Trolox/g dry weight) of powder of the different studied functional ingredients

Powders	Total fiber	Soluble fiber	Insoluble fiber	RSA (µmol TE/g DW)	TPC (mg GAE/gDW)
Moscato	44.3 ± 4.21^{bc}	3.8 ±0.33^{a}	40.5 ±3.81^{b}	216.16 ±18.08^{bc}	38.84 ±3.88^{c}
Chardonnay	44.1 ±4^{bc}	3.3 ±0.28^{a}	40.8 ±3.89^{b}	193.88 ±24.49^{b}	33.99 ±3.92^{bc}
Barbera	44.0 ±3.82^{bc}	4.1 ±0.36^{a}	39.9 ±3.72^{b}	64.04 ±0.61^{a}	17.69 ±0.25^{ab}
Pinot noir	53.7 ±5.23^{cd}	4 ±0.35^{a}	49.7 ±2.71^{c}	312.99 ±27.30^{c}	67.07 ±6.90^{d}
CBS	31.2 ±2.91^{a}	4.2 ±0.34^{a}	27 ±2.48^{a}	117.53 ±17.97^{ab}	29.95 ±4.83^{bc}
Silverskin	61.9 ±5.92^{d}	13.1 ±0.79^{c}	48.8 ±1.59^{c}	19.74 ±2.56^{a}	3.11 ±0.10^{a}
Canary date	36.88 ±3.5^{ab}	8.91 ±0.84^{b}	27.97 ±2.6^{a}	1211.84 ±49.62^{d}	202.09 ±6.23^{e}
Significance	***	***	***	***	***

Data are mean values ± standard error; ***$p<0.001$; data, in the same column, with different letters were significantly different at $p<0.05$

Table 5. Total phenolic content (TPC; mg GAE/g dry weight) and radical scavenging activity (RSA; μmol eq. Trolox/g dry weight) of candies produced with different percentages of studied functional ingredients

Parameter	Samples	C. Moscato	C. Chardonnay	C. Barbera	C. Pinot noir	C. CBS	C. Silverskin	C. Canary date	Significance
RSA (μmol TE/g DW)	0%	3.36 ± 0.33^{a}	3.36 ± 0.33^{a}	3.36 ± 0.33^{a}	3.36 ± 0.33^{a}	3.36 ± 0.33^{a}	3.36 ± 0.33^{a}	3.36 ± 0.33^{a}	-
	2%	5.13 ± 0.35^{bB}	5.43 ± 0.08^{aB}	4.49 ± 0.24^{aB}	7.71 ± 0.61^{bC}	6.65 ± 0.20^{bC}	2.37 ± 0.20^{aA}	11.16 ± 0.49^{bD}	***
	4%	8.08 ± 0.41^{cBC}	7.93 ± 0.57^{bBC}	6.55 ± 0.26^{bB}	14.9 ± 0.82^{cD}	8.61 ± 0.07^{cC}	2.95 ± 0.36^{aA}	20.91 ± 0.19^{cE}	***
	6%	12.05 ± 0.04^{dBC}	13.79 ± 0.92^{cC}	10.13 ± 0.64^{cB}	24.04 ± 1.57^{dD}	14.35 ± 0.16^{dC}	2.54 ± 0.02^{aA}	26.54 ± 1.22^{dD}	***
	Significance	***	**	**	***	***	ns	***	
TPC (mg GAE/gDW)	0%	0.94 ± 0.08^{a}	0.94 ± 0.08^{a}	0.94 ± 0.08^{a}	0.94 ± 0.08^{a}	0.94 ± 0.08^{a}	0.94 ± 0.08^{b}	0.94 ± 0.08^{a}	-
	2%	1.53 ± 0.18^{bBC}	1.62 ± 0.01^{abBCD}	1.30 ± 0.03^{bB}	1.95 ± 0.11^{bCD}	2.00 ± 0.23^{bD}	0.72 ± 0.10^{abA}	3.41 ± 0.12^{bE}	***
	4%	2.10 ± 0.11^{cC}	2.18 ± 0.20^{bC}	1.72 ± 0.07^{cB}	3.49 ± 0.14^{cD}	2.18 ± 0.01^{bcC}	0.82 ± 0.05^{abA}	5.49 ± 0.10^{cE}	***
	6%	2.87 ± 0.04^{dB}	3.17 ± 0.31^{cB}	2.47 ± 0.14^{dB}	4.54 ± 0.22^{dC}	3.07 ± 0.43^{cB}	0.63 ± 0.01^{aA}	6.18 ± 0.30^{dD}	***
	Significance	**	**	**	***	*	ns	***	

C. : Candy; CBS: Cocoa bean shell; Data are mean values ± standard error; ns: not significant; *$p<0.05$; **$p<0.01$; ***$p<0.001$. Data within the same line having different capital letters were significantly different at $p<0.05$. Data within the same column having different lowercase letters were significantly different at p<0.0

The sensory effect of functional ingredient powders on candies was assessed with an overall consumer liking and purchase interest (Table 6). No significant difference was observed in liking among samples at 2 and 4% for all the examined parameters (smell, taste, flavor, texture, overall liking, and purchase interest) except the appearance. The candy prepared with Barbera was the most appreciated in terms of appearance, thanks to its characteristic red color. At 6% of substitution, silverskin and canary date candies exhibited the lowest scores for taste, flavor, overall liking, and purchase interest. They were the least appreciated candies due to the bitterness of these powders. This also could be correlated to the high chewiness of silverskin candy, which implies more time and effort required to masticate it (Altınok et al., 2020). The silverskin candy also showed low values for TPC and RSA.

Candies produced with canary date powder showed the best results in terms of total phenolic compounds and antioxidant capacity. It could be valorized using the percentage of substitution accepted by the tasters (4%).

Table 6. Sum of the ranks for each sensory parameter of candies prepared with different percentages of studied functional ingredients and results of the Kruskall-Wallis test

	Samples	Appearance	Odor	Taste	Flavor	Texture	Overall Satisfaction	Purchase
2%	**C. Moscato**	1284.0^{abc}	1243.5^{a}	1452.0^{a}	1401.5^{a}	1491.0^{a}	1364.0^{a}	1369.0^{a}
	C. Chardonnay	1308.5^{abc}	1178.5^{a}	1561.5^{a}	1443.5^{a}	1293.0^{a}	1491.0^{a}	1390.0^{a}
	C. Barbera	1759.5^{c}	1668.0^{a}	1640.5^{a}	1513.5^{a}	1280.0^{a}	1429.5^{a}	1429.0^{a}
	C. Pinot noir	1212.0^{abc}	1287.0^{a}	1130.5^{a}	1101.5^{a}	1303.0^{a}	1242.5^{a}	1154.5^{a}
	C. CBS	993.5^{ab}	1240.5^{a}	957.0^{a}	1014.5^{a}	1331.0^{a}	1156.5^{a}	1234.0^{a}
	C. Silverskin	777.5^{a}	955.0^{a}	930.0^{a}	1081.5^{a}	882.0^{a}	905.0^{a}	984.0^{a}
	C. Canary date	1576.0^{bc}	1338.5^{a}	1239.5^{a}	1355.0^{a}	1331.0^{a}	1322.5^{a}	1350.5^{a}
	Significance	***	ns	**	ns	ns	ns	ns
4%	**C. Moscato**	1257.0^{ab}	1415.5^{a}	1416.5^{a}	1409.5^{a}	1395.5^{a}	1479.0^{a}	1361.0^{a}
	C. Chardonnay	1058.5^{ab}	1118.5^{a}	1275.5^{a}	1323.5^{a}	1291.0^{a}	1185.0^{a}	1105.5^{a}
	C. Barbera	1680.0^{b}	1257.5^{a}	1570.0^{a}	1477.0^{a}	1313.0^{a}	1491.5^{a}	1522.0^{a}
	C. Pinot noir	1485.5^{ab}	1367.0^{a}	1520.0^{a}	1509.5^{a}	1349.0^{a}	1439.5^{a}	1583.0^{a}
	C. CBS	1323.5^{ab}	1419.5^{a}	1233.5^{a}	1280.5^{a}	1408.5^{a}	1350.5^{a}	1327.0^{a}
	C. Silverskin	1192.0^{ab}	1135.5^{a}	812.0^{a}	969.5^{a}	1169.0^{a}	999.5^{a}	1081.0^{a}
	C. Canary date	914.5^{a}	1197.5^{a}	1083.5^{a}	941.5^{a}	985.0^{a}	966.0^{a}	931.5^{a}
	Significance	*	ns	*	ns	ns	ns	*
6%	**C. Moscato**	1155.5^{ab}	1242.0^{a}	1540.0^{b}	1687.5^{c}	1310.5^{ab}	1557.0^{a}	1502.5^{ab}

C. Chardonnay	1001.5^{ab}	984.0^{a}	1243.5^{ab}	1259.5^{abc}	1242.0^{ab}	1259.0^{a}	1109.5^{ab}
C. Barbera	1687.5^{b}	1378.0^{a}	1467.0^{b}	1475.5^{abc}	1283.5^{ab}	1458.5^{a}	1388.5^{ab}
C. Pinot noir	1351.0^{ab}	1300.5^{a}	1586.5^{b}	1586.0^{bc}	1285.5^{ab}	1537.5^{a}	1577.0^{b}
C. CBS	1378.0^{ab}	1629.5^{a}	1471.0^{b}	1185.5^{abc}	1537.0^{b}	1391.5^{a}	1457.0^{ab}
C. Silverskin	1534.0^{b}	1220.5^{a}	712.0^{a}	798.5^{a}	697.0^{a}	866.0^{a}	1034.0^{ab}
C. Canary date	803.5^{a}	1156.5^{a}	891.0^{ab}	918.5^{ab}	1555.5^{b}	841.5^{a}	842.5^{a}
Significance	**	ns	***	***	**	**	**

C. : Candy; CBS: Cocoa bean shell; ns: not significant; *p<0.05; **p<0.01; ***p<0.001. Sums of ranks within the same column having different letters were significantly different at p<0.05.

Conclusion

In this way, it would be possible to re-evaluate a by-product and have a greater economic gain for companies as well as obtain products with sources of functional compounds (polyphenols, fibers) with important biological activities while providing the consumer with a pleasant product as it turns out it is candy but healthier. Jelly candies with percentages of apple puree substituted with canary date powder exhibited the best results in terms of antioxidant capacity and total phenolic compounds. The valorization of these candies should be done using the percentage of substitution appreciated by the consumers (4%). It will be interesting to study the nutritional effects of candies developed with these functional ingredients.

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Conflict-of-Interest Statement

Declarations of interest: none.

Informed Consent Statement

Informed consent was obtained from all individual participants included in the study.

Human and Animal Rights Statement

Ethical approval: “All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.”

References

Alahyane, A., Harrak, H., Ayour, J., Elateri, I., Ait-Oubahou, A., & Benichou, M. (2019). Bioactive compounds and antioxidant activity of seventeen Moroccan date varieties and clones (*Phoenix dactylifera* L.). South African Journal of Botany, 121, 402-409.

Altınok, E., Palabiyik, I., Gunes, R., Toker, O. S., Konar, N., & Kurultay, S. (2020). Valorization of grape by-products as a bulking agent in soft candies: Effect of particle size. LWT - Food Science and Technology, 118, 1-7.

Ateş, G., & Elmacı, Y. (2018). Coffee silverskin as a fat replacer in cake formulations and its effect on physical, chemical, and sensory attributes of cakes. Lwt - Food Science and Technology, 90, 519-525.

Barbero-López, A., Monzó-Beltrán, J., Virjamo, V., Akkanen, J., & Haapala, A. (2020). Revalorization of coffee silverskin as a potential feedstock for antifungal chemicals in wood preservation. International Biodeterioration and Biodegradation, 152, 1-7.

Barbosa-Pereira, L., Guglielmetti, A., & Zeppa, G. (2018). Pulsed Electric Field Assisted Extraction of Bioactive Compounds from Cocoa Bean Shell and Coffee Silverskin. Food and Bioprocess Technology, 11, 818-835.

Bertolino, M., Dolci, P., Giordano, M., Rolle, L., & Zeppa, G. (2011). Evolution of chemical-physical characteristics during manufacture and ripening of Castelmagno PDO cheese in wintertime. Food Chemistry, 129, 1001-1011.

Cappa, C., Lavelli, V., & Mariotti, M. (2015). Fruit candies enriched with grape skin powders: physicochemical properties. LWT - Food Science and Technology, 62, 569-575.

Coderoni, S., & Perito, M. A. (2020). Sustainable consumption in the circular economy. An analysis of consumers' purchase intentions for waste-to-value food. Journal of Cleaner Production, 252, 1-11.

Gocmen, D., Sahan, Y., Yildiz, E., Coskun, M., & Aroufai, I. A. (2019). Use of coffee silverskin to improve the functional properties of cookies. Journal of Food Science and Technology, 56, 2979-2988.

Gouvinhas, I., Queiroz, M., Rodrigues, M., & Barros, A. I. R. N. A. (2019). Chapter 23 - Evaluation of the Phytochemistry and Biological Activity of Grape (*Vitis vinifera* L.) Stems: Toward a Sustainable Winery Industry. In Polyphenols in Plants (2nd ed., pp. 381-394). Academic press.

Grillo, G., Boffa, L., Binello, A., Mantegna, S., Cravotto, G., Chemat, F., Dizhbite T., Lauberte L., & Telysheva, G. (2019). Cocoa bean shell waste valorization; extraction from lab to pilot-scale cavitational reactors. Food Research International, 115, 200-208.

Lim, J. (2011). Hedonic scaling: A review of methods and theory. Food Quality and Preference, 22, 733-747.

Maier, T., Fromm, M., Schieber, A., Kammerer, D. R., & Carle, R. (2009). Process and storage stability of anthocyanins and non-anthocyanin phenolics in pectin and gelatin gels enriched with grape pomace extracts. European Food Research and Technology, 229, 949-960.

Mateos-Aparicio, I., De la Pena Armada, R., Pérez-Cozar, M. L., Rupérez, P., Redondo-Cuenca, A., & Villanueva-Suarez, M. J. (2020). Apple by-product dietary fiber exhibits potential prebiotic and hypolipidemic effectsin high-fat-fed Wistar rats. Bioactive Carbohydrates and Dietary Fibre, 23, 1-6.

Mokrzycki, W. S., & Tatol, M. (2011). Color difference Delta E - A survey. Machine Graphics and Vision, 20, 383-411.

Nakov, G., Brandolini, A., Hidalgo, A., Ivanova, N., Stamatovska, V., & Dimov, I. (2020). Effect of grape pomace powder addition on chemical, nutritional and technological properties of cakes. LWT - Food Science and Technology, 134, 1-8.

OIV. (2019). International Organisation of Vine and Wine, Statistical Report on World Vitiviniculture. Available online at: https://www.oiv.int/public/medias/6782/oiv-2019-statistical-report-on-world-vitiviniculture.pdf (consulted on 10 March 2021)

Rivero, R., Archaina, D., Sosa, N., & Schebor, C. (2021). Development and characterization of two gelatin candies with alternative sweeteners and fruit bioactive compounds. LWT - Food Science and Technology, 141, 1-7.

Rojo-Poveda, O., Barbosa-Pereira, L., Mateus-Reguengo, L., Bertolino, M., Stévigny, C., & Zeppa, G. (2019). Effects of particle size and extraction methods on cocoa bean shell functional beverage. Nutrients, 11, 867.

Rojo-Poveda, O., Barbosa-Pereira, L., Orden, D., Stévigny, C., Zeppa, G., & Bertolino, M. (2020). Physical properties and consumer evaluation of cocoa bean shell-functionalized biscuits adapted for diabetic consumers by the replacement of sucrose with tagatose. Foods, 9, 814.

Turki, M., Barbosa-Pereira, L., Bertolino, M., Essaidi, I., Ghirardello, D., Torri, L., Bouzouita, N., & Zeppa, G. (2020). Physico-chemical characterization of Tunisian canary palm (*Phoenix canariensis* Hort. Ex Chabaud) dates and evaluation of their addition in biscuits. Foods, **9**, 695.

Ventura, J., Alarcón-Aguilar, F., Roman-Ramos, R., Campos-Sepulveda, E., Reyes-Vega, M. L., Boone-Villa, V. D., Jasso-Villagómez E. I., & Aguilar, C. N. (2013). Quality and antioxidant properties of a reduced-sugar pomegranate juice jelly with an aqueous extract of pomegranate peels. Food Chemistry, 136, 109-115.