Qualitative characterization of arbutus berries snacks

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Abstract

Arbutus unedo L. fruit are increasing their production in Portugal. Arbutus berries are of good quality and mostly used for alcoholic drink. Alternative uses for this fruit for consumption, as fresh or transformed, are of significant importance. The objective of this work was to develop a snack based on arbutus berries and evaluate their nutritional quality. Frozen ripe fruit were mixed with natural yogurt at a proportion of 1:1 and 3:1 in an alginate solution of 4%. Each group mixture was divided in 3 to which was added 5% stevia powder, 5 % multifloral honey or no addition (control). The final paste was poured, in baking foil, in small portions (≈2 mL) and dried at 40ºC during 48 h. After cooling, a group of snacks were used for quality analysis and the remaining were packed in sealed bags and stored at room temperature. Measurements of color (CIELab), firmness, water activity, mineral composition, lipids and microbial content were performed, as well as a taste panel. Results showed good quality for all treatments, which were preserved for at least 1 month. The addition of stevia and honey improved firmness and panelists preferred snacks with stevia followed by honey for both fruit/yogurt proportions. Arbutus berries snacks are an innovative product of good nutritional quality, which should be further studied to find the best ingredient proportions, as well as their storage ability.

Keywords: *Arbutus unedo*; berries; snacks; quality.

Introduction

Over the years, it has been an increased demand for healthier foods of rapid consumption that not only provide nutritional and wholesome benefits but also convenience and taste (Joshi et al., 2011).

The term "snack" is defined as the food consumed between the three main meals (De Graaf, 2006; Grunert et al., 2016). However, the number of snacks that are eaten per day has increased, becoming an important part of the daily life due to the change in lifestyle of consumers (De Graaf, 2006). The increase in portion sizes and changes in eating patterns, such as more frequent snacking promotes weight gain or even obesity (Bucher et al., 2016). Therefore, is essential to promote consumption of healthy products. Most snacks in the market have high content of salt, sugar and fat (De Graaf, 2006; Grunert et al., 2016). One of the healthy alternatives is the fruit-snacks. But even those can be unhealthy, containing low amount of fruit and high sugar content.

The strawberry tree (*Arbutus unedo* L.) is an evergreen shrub, belonging to the *Ericacea* family, a native Mediterranean species. Its fruits are conspicuous, globular,

orange-red, rough, usually smaller than 5 cm in diameter and are tasty when fully ripe (Guerreiro et al., 2013, Fortalezas et al., 2010, Miguel et al., 2014). The fruits can be eaten as fresh fruits, but they have other utilities, such as for the production of alcoholic beverages, jams, jellies, marmalades (Fortalezas et al., 2010, Miguel et al., 2014) and can also be incorporated into yoghurts to flavor them (Miguel et al., 2014). The incorporation of strawberry tree fruits into snacks may have great potential since was considered as a "health promoting food" (Fortalezas et al., 2010). This is suggested by the wide range of antioxidants such as phenolic compounds (e.g. anthocyanins, gallic acid derivatives and tannins), vitamin C and E and carotenoids (Fortalezas et al., 2010, Guerreiro et al., 2013; 2015).

To our knowledge, the strawberry tree fruits are not yet being used as fruit-snacks. Thus, the objective of this study was to develop a new healthy product with high fruit content using strawberry tree fruits and yoghurt at different ratios, sweetened with stevia or honey, and evaluate their nutritional parameters and sensory quality.

Material and methods

The fruits were harvested in the mountain Caldeirão, in Algarve, Portugal, in mid-November, when they were ripe, and immediately transported to the postharvest laboratory at the University of Algarve, where they were selected for uniformity of size and freedom from defects and washed in tap water. After removing the excess water with absorbent paper, fruit were left to dry at room temperature for ≈1h then, stored at -80ºC till experiments.

For snack preparation the base ingredients were arbutus berries, natural yoghurt and pectin solution. The pectin solution includes pectin (4%), ascorbic acid (1%) and distilled water (95%). Pectin solution and thawed fruit were mixed in equal portions. Then, mixture was used to create different types of snacks: 50/50 (50% strawberry tree fruit and pectin + 50% yogurt); 75/25 (75% strawberry tree fruit and pectin + 25% yogurt). Each treatment was divided in 3 portions to which was added 5% stevia, 5% honey or nothing (control). The mixture was performed using an ultra turrax during few minutes. The speed of the ultra-turrax was increased as the consistency.

The final paste was immediately poured, in baking foil, in portions (≈2 mL) and then dried at 40ºC for 48 h. After drying, the snacks were left to cool for ≈ 45 minutes and packaged in metalized bags thermally insulated and stored at room temperature ≈23ºC.

Just after the snack preparation the moisture, ash and fat content, firmness and mineral composition were determined. After preparation and after 1 month of storage the quality parameters, such as the microbiology analysis, color and water activity were measured.

The microbiological parameters determined included aerobic mesophilic microorganisms, *Enterobacteriaceae* and moulds and yeasts. The counts of aerobic mesophilic were done according to the standard Portuguese NP-4405 (2002) using Plate Count Agar medium (Biokar, Paris, France). The counts of *Enterobacteriaceae* were performed according to ISO 21528-2 (2004) using Violet Red Bile Glucose Agar (Biokar, Paris, France). The counts of moulds and yeasts were done according to the ISO 21527-2 (2008) using Dichloran Rose-Bengal Chloramphenicol Agar (Biokar, Paris, France).

The color of the snacks was measured using a Minolta Chroma meter CR-300 (EC Minolta, Japan) using the CIE Lab scale (L*, a* and b*). Hue was calculated as h° = arctan (b*/a*) and color saturation (Chroma) as $C^* = (a^{*2} + b^{*}_{2})^{0.5}$ (Mcguire, 1992).

The firmness of the snacks was determined by puncture with a Chatillon TCD200 and Digital Force Gauge DFIS 50 (Jonh Chatillon & Sons, Inc., USA) using a spherical piston of 15 mm diameter till snack breakout.

Water activity (a_W) of the snacks was measured at room temperature using Rotronic Hydrolab meter (Rotronic AG, Bassersdor, Switzeland). Moisture content of the snacks was determined by drying the samples at 105ºC until constant weight. Ash was measured by incineration for 4 h at 550ºC and cooled in a desiccator before weighing.

The fat content was determined by using the homogenization extraction technique as described in Meyer & Terry (2008). The carbohydrates content were calculated as Carbohydrates = 100 – (%Moisture + %Ash + %Fat + %Protein) and the energetic value was calculated according to CE regulation No. 1169/2011.

For the mineral analysis, snacks were dried at 60ºC for 48 h, then ashed at 500ºC for 7 h and digested in 10 ml of HCl (37%). The nutrient content was determined according to AOAC procedure. Phosphorus was measured by molecular absorption spectrometry (T80/T80+ UV-Visible Spectrophotometer, PG instruments, Luttewrworth, United Kingdom) and calcium, magnesium, sodium, iron and potassium were measured by atomic absorption spectrometry-AA with flame (PinAAcle 900T Atomic Absorption Spectrometer, PerkinElmer Inc., Waltham, MA). The nitrogen was measured by the Kjeldahl method. The percentage of protein was calculated according to the standard Portuguese NP-1612 (2006). A taste panel was performed with 12 semi-trained panelists, by evaluation of appearance, crunchiness, aroma, texture, sweetness, acidity and overall flavor on the base of a 7 point hedonic scale (1- dislike definitely; 7-like definitely). Overall liking was calculated as a mean of the sensory parameters evaluated.

The statistical software package SPSS 22.0 (SPSS Inc.) was used for data analysis. The results were evaluated by analysis of variance (ANOVA). Significant differences between results were determined by Duncan's multiple-range test ($P<0.05$).

Results and Discussion

The moisture content was significantly higher in the 75/25 formulation as compared to the 50/50 one (Table 1). This can be due to higher concentration of fruit present in the 75/25 formulation snacks. Also, the control (75/25) and the stevia (75/25) samples showed moisture content significantly lower than the honey (75/25) sample. The stevia (50/50) sample presented a slightly higher fat content and both honey samples had the lowest values. Honey sample at 50/50 showed higher energy value than the other treatments. The ash content was higher in the control 50/50 samples, which was found to be similar in the other samples, but the honey (50/50) sample had the lowest ash content (Table 1). Results showed that the control and stevia (50/50) samples had the highest protein content. The honey (50/50) sample had similar protein value to all 75/25 samples (Table 1).

The control snacks with more yogurt concentration (50/50) contained significantly higher amounts of phosphorus, calcium, magnesium and potassium when compared with all the other samples (Table 2). This can be due to the fact that the yogurt has higher quantities of these nutrients (Gahruie et al., 2015). The samples with 25% of yogurt had lower nutrients content. The addition of stevia or honey to the snacks induced a slight decrease in nutrients concentration. The exception was Fe concentration, which did not show significant differences among treatments.

There was a clear difference in color among the samples (Table 3). The color parameter lightness (L*) values were significantly lower ($P < 0.05$) in the presence of more fruit. The higher concentration of strawberry tree fruits provides a darker color to snacks due to fruit color. At the same time, a higher yogurt concentration in the 50/50

snacks contributes for a lighter color snacks. The control 50/50 sample had a slight reduction of the L* valueover 1 month storage. Guerreiro et al. (2013) who studied strawberry tree fruit showed that, over time, the L* values decreased. After 1 month storage, the lightness of 75/25 snacks with stevia or honey significantly increased and the 50/50 snacks didn't show any alteration ($P > 0.05$). This can be due to the presence of stevia and honey properties to prevent the snacks quality degradation. Criado et al. (2014) reported that stevia could be used as a preservative agent. They showed that enzymatic browning was influenced by the presence of stevia. Similar results were reported for honey (Lee, 1997).

The hue values obtained in this study showed that all samples maintained the yellow-orange color with the exception of stevia and honey samples (50/50), which showed to be more yellow snacks. Blancas-Benitez et al. (2015) showed that no changes in the color were observed by replacing the sugar for fruit concentrates and fruit by-products. The chroma value showed a similarity among the samples and was preserved over a month, with the exception of stevia (50/50) in which increased.

The a_w of the 75/25 snacks was significantly higher than the 50/50 snacks. When measured after 1 month storage, the a_w of 75/25 snacks declined significantly. The values obtained prevent the proliferation of pathogenic microorganisms, which grow with an $a_w > 0.85$, and allow the growth of fungi and yeasts at $a_w > 0.60$ (Rahman, 2007). Torres et al. (2015) reported a range of 0.54 – 0.69 for apple and quince leathers and Blancas-Benitez et al. (2015) reported a similar a_w for mango snacks as the one of our work. Nevertheless, values were inferior to the range for susceptibility to microbial spoilage.

Aerobic mesophilic bacteria and moulds and yeasts counts were lower than 2 Log_{10} (CFU/g) (Table 4) in all formulations snacks. *Enterobacteriaceae* counts were negative for all samples. These findings were expected since snacks had low water activity (Table 4). For apple and quince leathers, aerobic mesophilic bacteria, moulds and yeasts and *Enterobacteriaceae* counts were less than 10 CFU/g (1 Log_{10} CFU/g) at 30ºC (Torres et al., 2015). Mango leathers with aw = 0.62 showed for aerobic mesophilic bacteria counts less than 10 CFU/g and less than 100 CFU/g (2 Log_{10} CFU/g) of yeasts and moulds over 6 months (Azeredo et al., 2006).

The objective of sensory analysis was to evaluate the sensory attributes and overall preference for the different strawberry tree fruit snacks formulations (Fig. 1). For appearance, the highest score was given to 75/25 snacks followed by 50/50 stevia. The 50/50 control and honey were the least appreciated regarding the appearance, nevertheless with score over 4 in a scale of 1-dislike definitely to 7-like definitely. The taste panel showed that all snacks had a good appreciation of the aroma attribute (> 4). According to texture, sweetness and acidity the control snacks had the lowest scores. The overall flavor shows significant higher scores ($P < 0.05$) for the stevia snacks followed by honey. Interestingly, taste parameters were not influenced by fruit percentage, but appearance was slightly higher in 75/25 samples.

Conclusion

Strawberry tree fruit snacks presented good quality parameters and nutritional value. The addition of stevia to formulations was more appreciated by consumers. The 75/75 samples were scored with better appearance and controls were the less appreciated. All different formulations had low water activity, which remained over time and were microbiologically safe over 1 month storage at room temperature.

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Tables and Figures

Table 1 - Physicochemical analysis of different strawberry tree fruit snacks after preparation. 50/50 (50% strawberry tree fruit + 50% yogurt); 75/25 (75% strawberry tree fruit + 25% yogurt). Control (without sugar); Stevia (5%); Honey (5%). Values are mean ± standard error of three replicates.

Treatment	Moisture	Ash	Protein	Fat	Carbohydrates	Energy	Firmness
			(%)			(kcal/100 g)	(N)
Control (50/50)	5.65±0.17 c	3.67±0.09 a	12.72±0.45 a	1.11±0.10 b	76.85±0.27 c	368.26±0.29 b	1.08±0.04 c
Stevia (50/50)	2.83±0.47 d	2.32±0.19 ab	10.22±0.05 a	1.62±0.12 a	83.00±0.49 a,b	387.50±2.94 a	4.72±0.52 b
Honey (50/50)	6.66±0.88 c	1.64±1.04 b	7.26±1.18 b	0.59±0.01 c	83.85±1.30 a	369.77±5.71 b	10.04±1.82 a
Control (75/25)	8.64±0.07 b	2.95±0.02 ab	6.94±0.21 b	1.12±0.05 b	80.35±0.18 b	359.28±0.45 c,d	5.15±0.29 b
Stevia (75/25)	8.35±0.05 b	2.24±0.01 ab	7.56±1.63 b	0.80±0.12 bc	81.05±1.53 a,b	361.60±0.75 b,c	11.77±0.45 a
Honey (75/25)	10.35±0.03 a	2.49±0.07 ab	4.96±0.06 b	0.59±0.20 c	81.62±0.29 a,b	351.60±0.80 d	11.48±1.82 a

Values in the same column followed by the same letter are not significantly different by Duncan's multiple range test ($P<0.05$).

Table 2 - Mineral content of different strawberry tree fruit snacks after preparation. 50/50 (50% strawberry tree fruit + 50% yogurt); 75/25 (75% strawberry tree fruit + 25% yogurt). Control (without sugar); Stevia (5%); Honey (5%). Values are mean ± standard error of three replicates.

Treatment	P	Na	Fe	Ca	Mg	K
	g/100g DW					
Control (50/50)	3.10±0.14 a	1.05±0.10 a	0.004±0.001 a	0.45±0.05 a	0.42±0.19 a	1.18±0.07 a
Stevia (50/50)	2.21±0.19 bc	1.05±0.55 a	0.002±0.000 a	0.33±0.03 b	0.04±0.00 b	0.80±0.06 b
Honey (50/50)	2.35±0.23 b	0.63±0.08 ab	0.004±0.002 a	0.33±0.04 b	0.04±0.00 b	0.79±0.09 b
Control (75/25)	1.84±0.09 c	0.23±0.09 b	0.003±0.000 a	0.31±0.02 b	0.06±0.00 b	0.96±0.03 b
Stevia (75/25)	1.32±0.10 d	0.22±0.04 b	0.002±0.000 a	0.20±0.01 c	0.04±0.00 b	0.77±0.05 b
Honey (75/25)	1.35±0.10 d	0.22±0.04 b	0.005±.001 a	0.20±0.01 c	0.04±0.00 b	0.79±0.05 b

Values in the same column followed by the same letter are not significantly different by Duncan's multiple range test (P<0.05).

Table 3 - Color parameters of different strawberry tree fruit snacks after preparation and after 1 month storage. 50/50 (50% strawberry tree fruit + 50% yogurt); 75/25 (75% strawberry tree fruit + 25% yogurt). Control (without sugar); Stevia (5%); Honey (5%). Values are mean ± standard error of five replicates.

Treatment	L*		H*		Chroma	
	0 months	1 month	0 months	1 month	0 months	1 month
Control (50/50)	61.03±0.38 a*	58.95±0.43 b	70.10±0.44 bc*	68.32±0.37 c	27.86±0.23 c^{NS}	28.97±0.45 b
Stevia (50/50)	62.04±0.77 a^{NS}	61.60±0.03 a	73.85±0.85 a^{NS}	73.53±0.22 a	29.45±0.48 ab*	31.17±0.07 a
Honey (50/50)	61.50±0.72 a^{NS}	59.45±0.49 ab	74.12±0.27 a^{NS}	72.33±0.76 ab	27.76±0.54 c^{NS}	27.99±0.40 b
Control (75/25)	58.63±0.29 b^{NS}	59.98±1.34 ab	69.72±0.22 c^{NS}	71.26±0.92 b	30.73±0.16 a^{NS}	31.49±0.84 a
Stevia (75/25)	58.27±0.45 b*	60.52±0.54 ab	71.58±0.49 b^{NS}	73.07±0.30 a	30.42±0.55 a^{NS}	31.12±0.55 a
Honey (75/25)	56.25±0.35 c*	59.31±0.51 ab	70.11±0.47 bc^{NS}	71.09±0.13 b	28.41±0.63 bc^{NS}	29.31±0.34 b

Values in the same column followed by the same letter are not significantly different by Duncan's multiple range test (P<0.05).
*Values with significant differences and ^{NS}Not significant difference (P<0.05) between 0 month and 1 month for each parameter.

Table 4 - Microbiological parameters of different strawberry tree fruit snacks after preparation and after 1 month storage. 50/50 (50% strawberry tree fruit + 50% yogurt); 75/25 (75% strawberry tree fruit + 25% yogurt). Control (without sugar); Stevia (5%); Honey (5%). Values are mean ± standard error of three replicates.

Treatment	Aerobic Mesophilic Bacteria Log_{10}(CFU/g)		Moulds and Yeasts Log_{10}(CFU/g)		Water activity	
	0 months	1 month	0 months	1 month	0 months	1 month
Control (50/50)	1.49±0.06 abc^{NS}	1.44±0.06 a	1.05±0.05 a^{NS}	1.00±0.00 a	0.51±0.02 ab^{NS}	0.50±0.00 b
Stevia (50/50)	1.34±0.10 abc^{NS}	1.23±0.16 ab	1.27±0.20 a^{NS}	1.08±0.06 a	0.49±0.02 b^{NS}	0.50±0.00 ab
Honey (50/50)	1.67±0.30 ab^{NS}	1.20±0.13 ab	1.20±0.10 a^{NS}	1.30±0.25 a	0.49±0.01 b^{NS}	0.51±0.00 a
Control (75/25)	1.25±0.05 bc^{NS}	1.00±0.00 b	1.26±0.11 a^{NS}	1.20±0.10 a	0.55±0.00 a*	0.44±0.00 c
Stevia (75/25)	1.74±0.03 a*	1.00±0.00 b	1.43±0.04 a^{NS}	1.30±0.25 a	0.54±0.00 a*	0.44±0.00 c
Honey (75/25)	1.16±0.08 c^{NS}	1.35±0.04 ab	1.21±0.11 a^{NS}	1.15±0.12 a	0.54±0.00 a*	0.44±0.00 c

Values in the same column followed by the same letter are not significantly different by Duncan's multiple range test (P<0.05).

*Values with significant differences and NSNot significant difference (P<0.05) between 0 month and 1 month for each parameter.

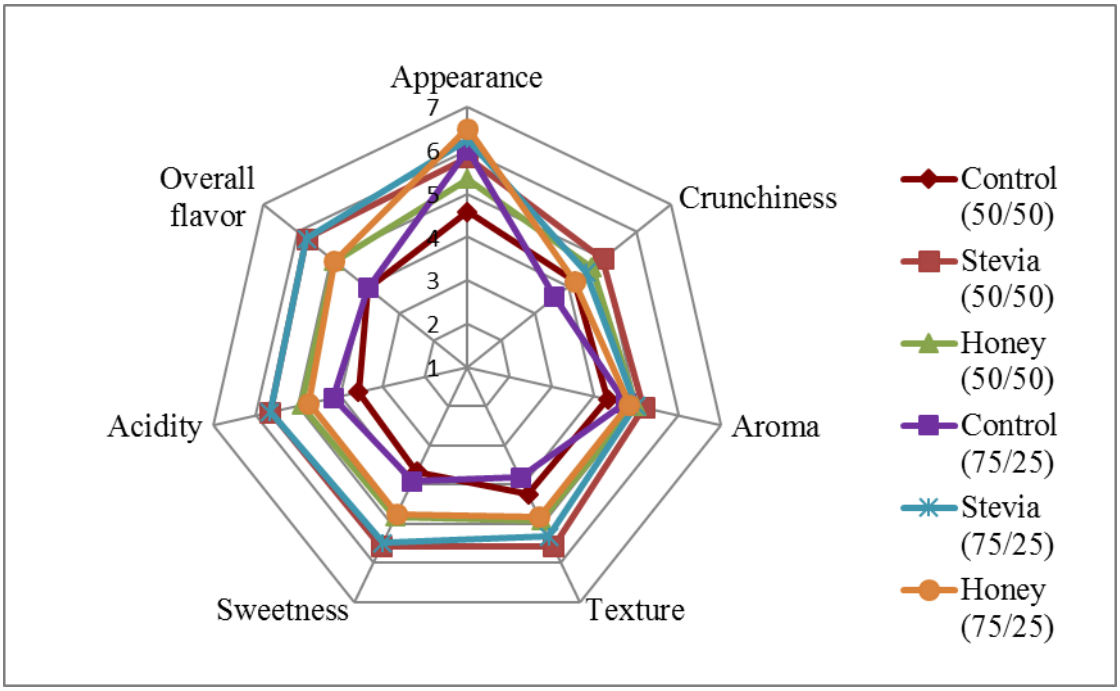

Figure 1 - Sensorial attributes of different strawberry tree fruit snacks after preparation. 50/50 (50% strawberry tree fruit and pectin + 50% yogurt); 75/25 (75% strawberry tree fruit and yogurt + 25% yogurt). Control (without sugar); Stevia (5%); Honey (5%).