Research Article

Edite Teixeira-Lemos*, Ana Rita Almeida, Beatriz Vouga, Cátia Morais, Inês Correia, Pedro Pereira, Raquel P. F. Guiné

Development and characterization of healthy gummy jellies containing natural fruits

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Abstract: The reduction of sugar and the addition of healthier ingredients in gummy jellies brings some improved health characteristics to a product that usually is devoid of nutrition. Therefore, the aim of this study is to develop gummy jellies using natural ingredients, without added sugars or additives, in two varieties: one including orange juice and slightly sweetened with honey (ORH) and the other including puree made from a mixture of berries (BEM). These were submitted to physicochemical, microbiological, and sensorial analyses. Results of microbiological analyses showed that both gummies were suitable for consumption accordingly to EU legislation. The physicochemical analyses allowed making a nutritional evaluation, so that ORH and BEM presented 73.8 kcal/100 g and 39.8 kcal/100 g, respectively, five and nine times lower than similar commercial products. The contribution of macronutrients of ORH and BEM was as follows: 78.0 and 67% from carbohydrates, 21.7 and 33% from proteins, respectively. Regarding the potential functional properties, the antioxidant capacity was 50.4 ± 4.5 mg/L TE for ORH and 83.7 ± 7.6 mg/L for BEM. Sensorial evaluation showed that although the developed gummy jellies were slightly less appreciated than a commercial counterpart, still they were appreciated by members of a panel and particularly the ORH, which was rated with scores almost equal to those of the commercial sample. In addition, the developed gummies showed lower caloric values and higher antioxidant capacity than similar commercial candies. Overall, ORH and BEM gummy jellies could represent an opportunity to provide consumers with a healthier alternative to the common jelly candies available in the market.

Keywords: antioxidant activity, nutritional evaluation, color, texture, microbiological safety

1 Introduction

Confectionery products are widely consumed by both children and adults. In Portugal, 86.8% of children between 6 and 8 years consume these products at least three times a week [1]. Jellies and gummies are particularly popular in the age group under 17 years due to their organic and chewy nature [2]. These products have a gel-like structure, containing fruits (a minimum of 45 g/100 g) and sugars (in the form of sucrose syrup and/or glucose, in concentrations of about 55 g/100 g), combined with gelling agents, acids, aromas, and food colorants [3,4]. However, excessive and widespread consumption of jellies and gummies is thought to negatively impact public health due to their high contents in sugar and food additives, as well as the presence of nondesirable compounds generated by the heat treatment such as hydroxymethyl-2-furaldehyde or acrylamide. Indeed, these products have been associated with a high incidence of obesity, tooth decay, and hyperglycemia [5,6]. Their low nutritional values have also been questioned, and industries are increasingly pressured to reduce sugar in these products to respond to consumer demands for healthier formulations.

Reducing or even replacing sugars with other sweetening products such as honey might represent healthier alternatives for gummies and jellies [7]. For instance, Jacques et al. [8] found that honey-fed rats showed significantly less anxiety than those fed with sucrose. However, reducing the sugar content of foods generally leads to an increase in the moisture content, potentially increasing microbiological risks. In the case of gummies and jellies, this is unlikely to happen, as the changes in the water

* **Corresponding author: Edite Teixeira-Lemos,** CERNAS Research Centre, Polytechnic Institute of Viseu, 3504-510 Viseu, Portugal; Department of Food Industry, Agrarian School of Viseu, 3500-606 Viseu, Portugal, e-mail: etlemos3@gmail.com, tel: +351-232-446-600, fax: +351-232-426-536
Ana Rita Almeida, Beatriz Vouga, Cátia Morais, Inês Correia, Pedro Pereira: Department of Food Industry, Agrarian School of Viseu, 3500-606 Viseu, Portugal
Raquel P. F. Guiné: CERNAS Research Centre, Polytechnic Institute of Viseu, 3504-510 Viseu, Portugal; Department of Food Industry, Agrarian School of Viseu, 3500-606 Viseu, Portugal

content caused by the reduction of sugar levels are not high enough to favor microbiological proliferation. Nevertheless, to protect the health of consumers, any changes in product formulations should be evaluated in accordance with the principles of HACCP.

The use of natural juices or purees of orange, strawberry, and other red fruits or even fruit by-products has been considered for the manufacturing of jellies [4,9]. These can not only improve the organoleptic properties (color, flavor, and texture) of gummies and jellies but also produce healthier formulations with antioxidant properties [10]. Recent works have shown that the use of anthocyanin extracts, when added into gelatin and pectin gels, can not only provide an alternative to synthetic colorants but also have additional beneficial health effects for those who consumed the products in moderate amounts [11–13].

Considering the demand for jellies or gummies with improved nutritional characteristics, while also maintaining their traditional textural characteristics, our research group developed several alternative formulations. In the previous study, Guiné et al. [14] tested different combinations based on fruits and herbs in an attempt to introduce flavor derived from these ingredients as well as color derived from natural colorants. The berry fruits used in the formulations, which included strawberries, raspberries, and blueberries, contain high amounts of anthocyanins and other phenolic compounds with antioxidant activity [15–17]. Moreover, anise and mint, which were also used in these formulations, are natural flavor enhancers containing beneficial components with bioactive activity [18].

Taking this into account, the aim of this study is to develop healthy and palatable gummy jellies containing only natural ingredients such as orange juice and red fruits puree, without added sugar or artificial food additives. This is a preliminary approach to the problem, and in this stage, we have also evaluated these gummy jellies in terms of color, texture, antioxidant activity, microbiologic safety, nutritional composition, and sensorial evaluation to demonstrate their health benefits while also preserving most of the desirable organoleptic properties of traditional gummies and jellies. In addition, the nutritional value of the produced gummy jellies was compared with commercial formulations.

2 Materials and methods

2.1 Gummy jellies preparation

In this study, some recipes were tested with different combinations of fruits (including apple, orange, strawberry, and a mix of berries) with other ingredients, but after initial screening, some of the formulations were not considered satisfactory either in terms of texture, appearance, consistency, or taste (basic qualitative evaluation made only by the developers). Hence, the two formulations considered with the best characteristics were produced for the following evaluation, and their formulations are presented in Table 1: a gummy jelly with orange juice and honey (ORH) and one with a puree made from a mixture of berries (BEM).

We used multifloral honey produced by the Agrarian School of Viseu. All other raw materials used in these experiments were purchased from local supermarkets. The orange juice used in the formulation was freshly squeezed, and the red fruit puree was obtained from a mix of frozen berries (cultivated blackberries [22%]; raspberries [22%]; strawberries [25%]; cassis [14%]; wild blueberries [16%]). Experiments included two kinds of gummy jellies, with the use of agar (NATALI Biologique) and pork gelatin (ROYAL, Portugal) as thickening agents. Figure 1 shows the procedure for the gum preparation, which is summarized as follows: thickeners were dissolved slowly in hot liquids. The formulation remained in a water bath, reaching a temperature of 70–75°C, long enough for the complete dissolution of the ingredients. After complete homogenization, the formulation was transferred to heart-shaped tray molds, resulting in gums of approximately 5 g. These trays remained at room temperature for about 30 min until cooling to achieve an equilibrium with the kitchen temperature. Then, they were placed in the refrigerator (+4°C) for 24 h. After 24 h, they were removed from the molds and stored in a closed container that was kept in the refrigerator until further analysis. No overall appearance changes have been noticed for 1 week.

Table 1: Formulations of the two gummy jellies

Ingredients	Orange (ORH)		Berries mix (BEM)	
	g	%	g	%
Orange juice	250	86.2	—	
Honey	25	8.6		
Neutral gelatin	10	3.4	10	2.7
Agar-agar	5	1.7	5	1.4
Water			150	41
Red fruit puree			200	54.5
Lemon juice			2	0.5
Total (g)	**290**	**100**	**367**	**100**

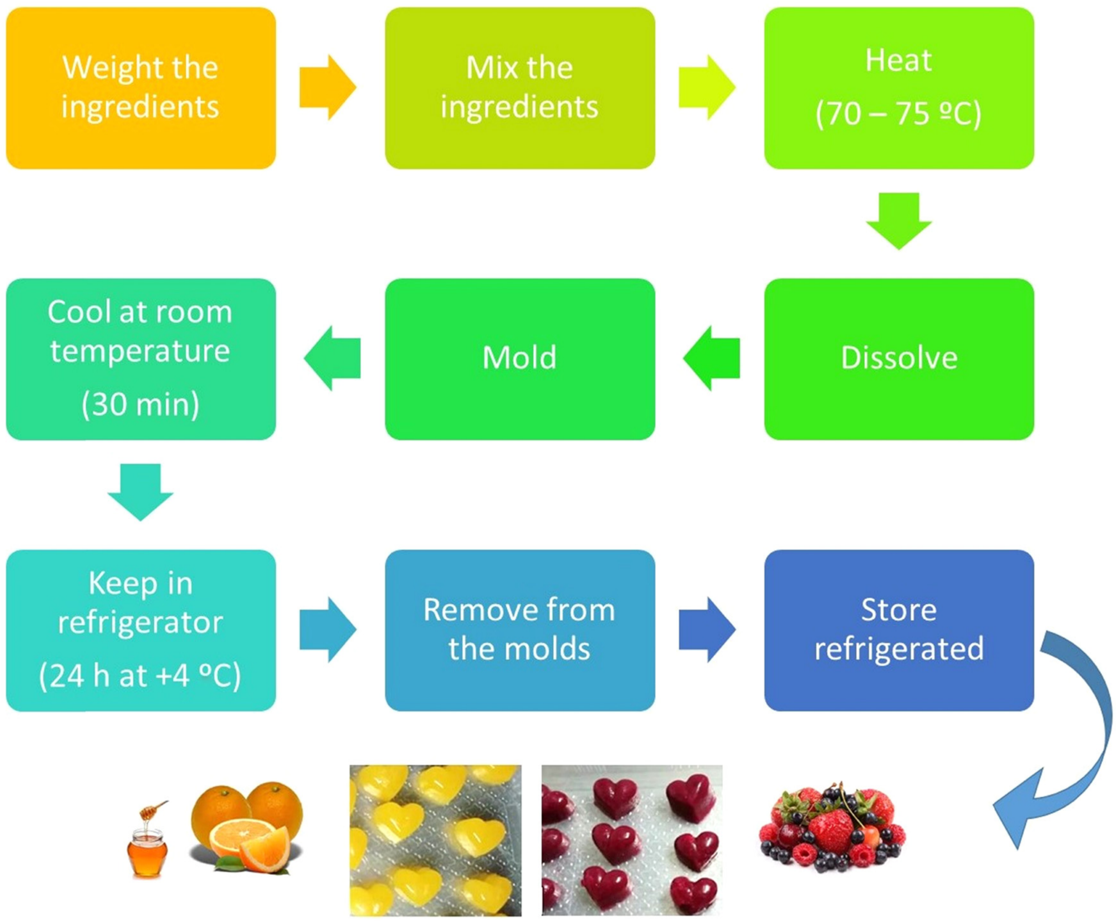

Figure 1: Flow diagram of the preparation of gummy jellies and their final aspect: Orange gummy jelly (ORH) and berries mix gummy jelly (BEM).

2.2 Analytical determinations

The moisture content, antioxidant capacity, optical and mechanical properties (color and texture), and microbiological analyses were performed for each formulation of gummy jellies in triplicates, except for color and texture for which 15 replicates were performed in each sample.

2.2.1 Moisture content

The moisture content was determined by drying finely grounded samples (10 g) in an air oven at 105°C overnight until a constant weight was achieved [19].

2.2.2 Antioxidant capacity

Briefly, two successive extractions with acetone solution (60% v/v) were performed. For each of the two extractions performed, the sample was left under an ultrasonic bath for 60 min at room temperature. This procedure resulted in two ethanol extracts (EtOH-E), which were later used to evaluate the total antioxidant activity. The antioxidant activity of both formulations of gummy jellies was determined by the method described by Gonçalves et al. [20], which is based on the scavenging activity of the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical and measuring the absorbance change of samples at a wavelength of 515 nm using a spectrophotometer. The results were represented as the percentage of inhibition of each sample, by comparing it with Trolox, a standard antioxidant, using a dose–response curve. Results were expressed as milligrams of Trolox equivalents (TE) per 100 g of gummy jelly. Calibration curves in the range 0.5–5.0 mmol Trolox/L were used for the quantification of the antioxidant activity showing good linearity ($R^2 \geq 0.998$).

2.2.3 Microbiological analyses

The mesophilic aerobic population was assessed according to the ISO 4833-1:2013 standard, which was previously described by Rubio-Arraez et al. [21]. A total of 10 g of each of the gummy jellies was homogenized into 90 mL of peptone water solvent, and decimal dilutions were then performed. The two samples were then inoculated on a plate count agar (PCA) and incubated at 30°C for 48 h. Microbial counts were expressed as colony-forming units per gram (CFU/g).

2.2.4 Optical properties

The color was evaluated using a colorimeter CR-400 from Konica Minolta (Tokyo, Japan) in the Cartesian coordinates CIELab, with L^* standing for lightness (varying from 0 – black to 100 – white), and a^* and b^* representing the opposed color coordinates, varying from −60 to +60, with negative a^* being green and positive a^* being red, while negative b^* is blue and positive b^* is yellow. The measurements were made on both faces (top and bottom) in 15 gummy jellies for each formulation.

2.2.5 Mechanical properties

The texture was analyzed with a texturometer TA.XT.Plus from Stable Micro Systems (Godalming, United Kingdom). The evaluation of texture comprised two different types of tests: a texture profile analysis (TPA) test with a flat cylindrical probe P/75 and a perforation test with a 2 mm diameter probe P2 (Figure 2). The tests were performed by measuring force on compression, using a 50 kg load cell and a trigger force of 0.05 N. For the perforation test, the perforation distance was 3 mm, the pretest speed was 2.0 mm/s, the test speed was 1.0 mm/s, and the posttest speed was also 1.0 mm/s. For the TPA test, the compression distance was 5 mm, and the pretest, test, and posttest speeds were all equal to 0.5 mm/s. Two compression cycles were performed with a 5 s interval between them. The properties evaluated through the TPA were hardness, adhesiveness, resilience, cohesiveness, springiness, gumminess, and chewiness, and the perforation test allowed determining the external firmness, inner firmness, stickiness, and adhesiveness. All textural measurements were performed on 15 gummy jellies of each type on two sides (top and bottom). The tests were performed at room temperature ranging from 15 to 20°C, but the samples were stored before the analyses on a refrigerator at a temperature of 4–8°C, and they were removed immediately before conducting the textural measurements.

2.3 Nutritional labeling

Nutritional composition of the two formulations and comparison with commercially available gummies with the same flavors was also performed. Next the methodologies followed for each determination are described. The nutritional content of the final products was determined using the Portuguese food composition program available online [22]. The ingredients of each formulation

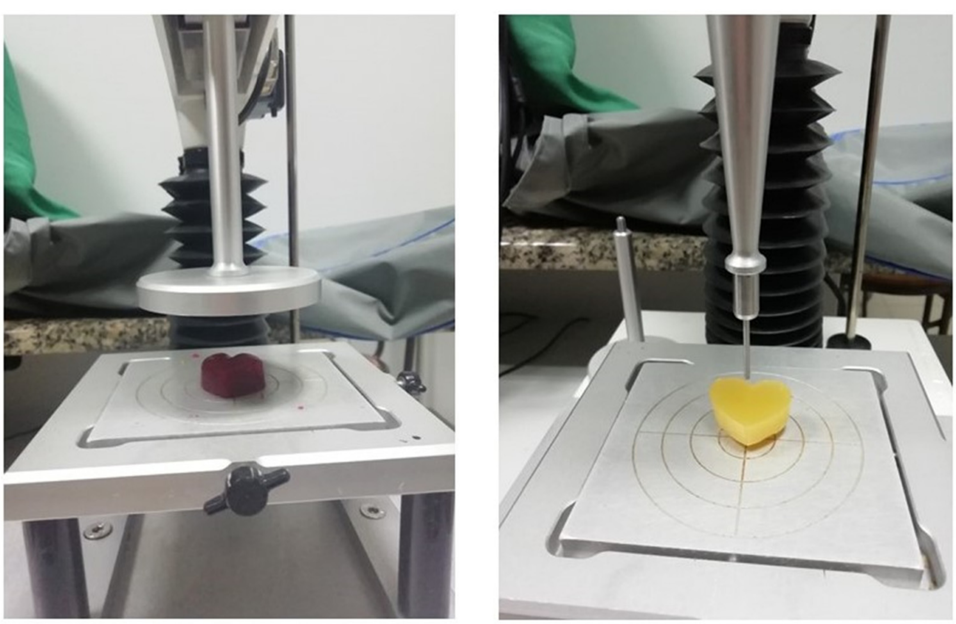

Figure 2: Texture analysis: TPA compression test (left) and perforation test (right).

were entered into the database, and the moisture content of each sample was used to adjust for any moisture loss during production. The nutritional analysis was used to determine allowable claims for the products. The serving size was determined as reported by the Portuguese Guide for Establishment of Portions for Nutritional Labelling [23].

The energy content of each type of gummy jellies was calculated by summing the multiplication of protein, carbohydrate, and fat by Atwater factors of 4, 4, and 9, respectively. The value is expressed in kilocalories and kilojoules, which is obtained by multiplying the energy values in kcal by 4.184.

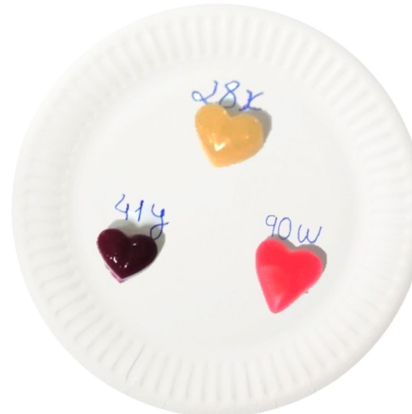

Figure 3: Samples for sensory evaluation (gummy jellies codes: 28*x* = orange and honey, 41*y* = berries mix, and 90*w* = commercial sample).

2.4 Sensory evaluation

Sensory evaluation was made using a nontrained panel of 37 members and included two tests: a descriptive test to assess the sensorial profile of the gummy jellies and an ordering test to detect preferences. The panelists had to evaluate three gummy jellies (the two formulations developed plus a commercial gummy jelly), which were presented coded so as not to influence their judgment (Figure 3). In the descriptive test, the panelists were asked to rate the samples for a number of attributes on a Likert scale from 1 to 5, where 1 was the least intense and 5 the most intense of the attribute characteristics. In this test, the following parameters were evaluated: appearance, color, global visual appreciation, taste (salty, acid, sweet, bitter, astringent, and global appreciation of taste), aroma (fruity, spicy, acid, floral, sweet, and global appreciation of aroma), texture (firmness, granules, softness, juiciness, elasticity, and global appreciation of texture), and overall appreciation. Also, the buying intention was assessed on the same five-point scale, where 1 was certainly would not buy and 5 most certainly would buy. The preferences test included the rating of the three samples from 1 (least preferred) to 3 (most preferred) according to certain attributes, namely, appearance, texture, taste, and global preference.

3 Results and discussion

3.1 Moisture, antioxidant activity, and microbiology

Table 2 summarizes the results obtained for moisture content, total antioxidant activity, and microbiological analyses for the two gummy formulations, one with orange juice and honey and the other with a mix of berries. Both formulations showed moisture content values lower than recommended (24%) for this type of product [24], thus ensuring that the moisture content and water activity are low and enable possibly good conservation. Our results showed the moisture content in the range 18–21%, being in accordance with previous studies, which reported a water content of 18–22% in jelly candies [4,25,26].

The results in Table 2 further show that both formulations possessed antioxidant capacity, but the berries mix gummy jelly had the highest antioxidant activity of the two products developed (83.7 ± 7.6 mg TE/100 g for the berries mix formulation against 50.4 ± 4.5 mg TE/100 g of the orange and honey). Rubio-Arraez et al. [27] reported values of antioxidant activity varying from 8.3 to 9.9 mg TE/100 g for watermelon jellies in which sucrose was replaced by sweeteners. Hence, the products developed in this study have considerably higher antioxidant activity. Berries are known for their high content in phenolic compounds, and particularly anthocyanins, with a high antioxidant capacity [17,20]. Nevertheless, the antioxidant activity of the orange juice and honey gummies was similar to that of a jelly formulated with citrus juice and sweeteners with a low glycemic index by Rubio-Arraez et al. [28]. Despite not being as rich in antioxidants as berry juice (namely, formulations including chokeberry, elderberry, and blueberry) [29,30], orange juice can still be considered a good source of polyphenol intake as a part of the Mediterranean diet [31].

A review published by Khoo et al. [32] examined the potential health benefits of bioactive compounds, namely, their antiangiogenic, anticancer, antidiabetic, antiobesity, antimicrobial, and neuroprotective effects, as well as their possible role in the prevention of cardiovascular diseases

Table 2: Moisture content, total antioxidant activity, and mesophilic aerobic populations of the developed gummy jellies

Determinations	Orange and honey (ORH)	Berries mix (BEM)
Moisture content[a] (g water/g sample)	18.2 ± 0.08	20.82 ± 0.88
Total antioxidant activity[a] (mg TE/100 g jelly gum)	50.4 ± 4.5	83.7 ± 7.6
Mesophilic aerobic populations (CFU/g)	1.0×10^2	1.3×10^2

[a] Results expressed as the mean value of three measurements ± standard deviation.

and in improving visual health. Dietary antioxidants can also help in the maintenance of oral health and might influence periodontal disease management, potentially improving clinical outcomes [33].

Even though both gummy formulations presented low sugar levels, they also exhibited low moisture contents (Table 2). Yeasts and molds are the main agents responsible for the spoilage of foods with low humidity and low a_w such as jelly gums. However, we did not evaluate their presence in our formulations, as microbiological stability was not part of the objectives of the study. The fact that our samples were analyzed on day 1 and the conditions how they were stored (airtight containers at 4–8°C) would also render such analysis irrelevant, as mold and yeast growth would be severely limited.

Mesophilic aerobic microorganisms, which include not only aerobic bacteria but also yeasts and other aerobic fungi, are a common cause of contamination of food products. This may occur due to the use of contaminated raw materials, inefficient treatments, or inadequate storage conditions [34]. In this study, both jelly candies presented mesophilic aerobic populations below the limits established in Portuguese and EU legislation (<10^3 CFU/g) [35,36] and those established by Anderson and Calderón-Pascual [37] (5×10^2 CFU/g), thus ensuring suitability for human consumption from a bacteriological standpoint. The observed inhibition of microorganisms in these formulations may be attributed to their contents in antioxidant compounds. Nohynek et al. [38] have studied the antimicrobial activity of berries against selected human pathogens and observed that their growth was only inhibited by phenolic extracts rich in ellagitannins. The results found in this preliminary study are encouraging; however, in future studies, a detailed microbiological analysis should be performed to know the shelf-life of both jelly candies.

3.2 Color and texture

Figure 4 shows the color coordinates of the developed gummy jellies (orange with honey and berries mix) on both sides analyzed, top and bottom. In general, the results are very similar on both sides of the samples evaluated, but they differ according to the formulation. The orange and honey gummy jellies were lighter than the berries mix gummies because the values of L^* were higher (41.6 and 36.1 for the top and bottom sides of the orange and honey gummy jellies compared with 29.4 and 27.3 for the top and bottom sides of the berries mix gummies).

Regarding the color coordinate a^*, it showed negative values for the orange gummy jellies, although the intensity of the green coloration was low (values of −2.6 and −1.6 on the top and bottom, respectively). In contrast, the samples made with berries showed an intense red coloration, as expected (values of 22.6 and 21.8, respectively, for the top and bottom sides).

The color coordinate b^* showed positive values for both sample formulations, but the values were considerably higher in the orange gummy jellies, corresponding to an intense yellow coloration (14.8 and 15.8 for the top and bottom sides, respectively).

In global, the results of the color evaluation confirmed that the orange and honey gummy jellies were clearer, more yellow, and with a slight tone of green, while those made with the mix of berries were darker, with a more intense red color and less yellow. The variability between sides was low, indicating that the gummy jellies produced were uniform. The previous results obtained for other types of gummy jellies, made with herbs and fruits, have also shown a good uniformity between two sides of the product, indicative of uniformity [14].

Table 3 presents the results obtained for the textural properties when using the two types of tests (TPA and perforation) and again evaluated on both sides (top and bottom). Similar to what had been observed for color, the results on both faces are very similar, indicating uniform textural properties. In a related work by Guiné et al. [39], some important differences had been noticed between the textural characteristics of gummies made with aromatic plants depending on the side where they were determined (top or bottom).

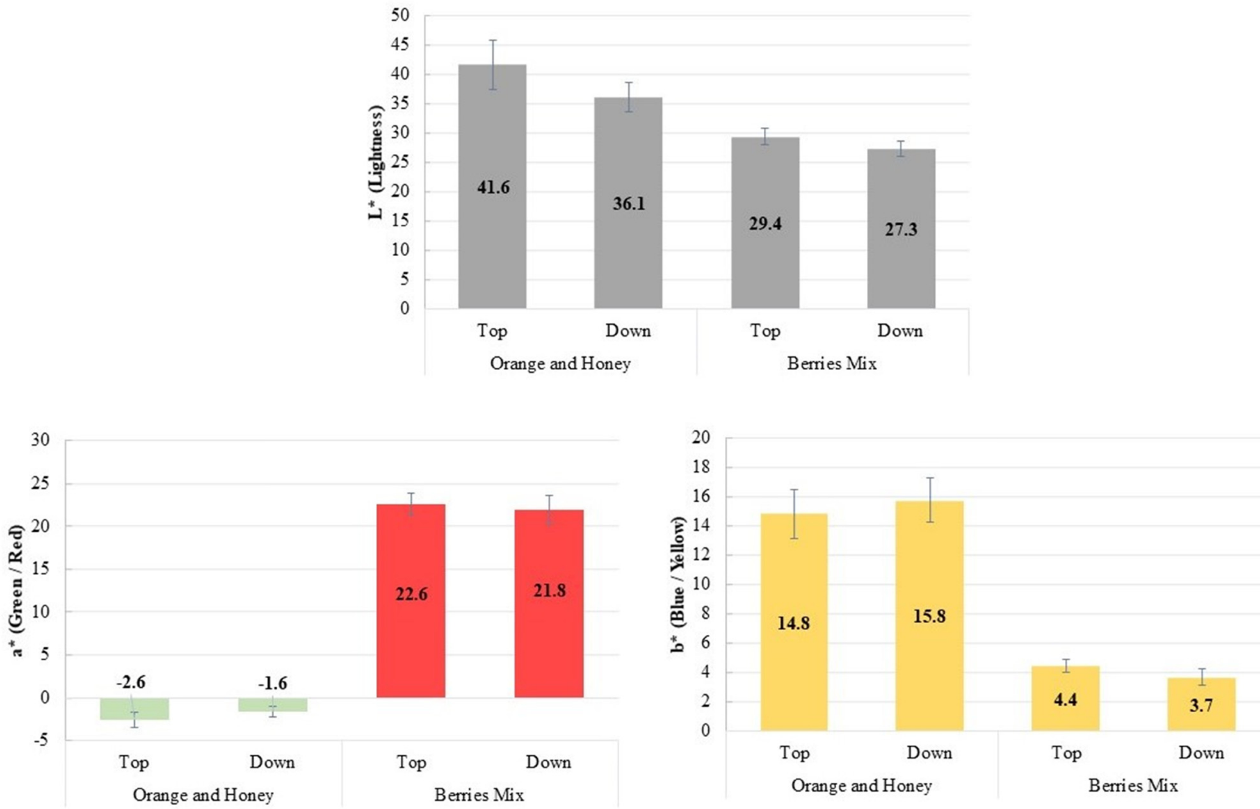

Figure 4: Color coordinates measured on both sides of the gummy jellies developed.

The results for the compression test in Table 3 further show that the orange and honey gummy jellies are softer (3.66–4.77 N), more resilient (63.95–67.07%), and more cohesive (89.08–91.34%), but less elastic (69.57–79.38%), less gummy (3.37–4.22 N), and with lower chewiness (2.42–3.40 N), when compared with the berries mix product. The results of the perforation test were very similar for both formulations and on both sides of the samples. The adhesiveness was close to zero regardless of the type of test performed.

Since there was a uniform textural profile, the results obtained for both sides were combined to determine the textural properties of the samples as a whole, and they are shown in Figure 5. These results allow easier

Table 3: Textural properties measured on both sides of the gummy jellies developed

Textural attributes	Orange and honey (ORH)		Berries mix (BEM)	
	Top	Down	Top	Down
TPA – compression test				
Hardness (N)	4.77 ± 1.75	3.66 ± 1.75	7.10 ± 2.81	5.93 ± 2.48
Adhesiveness (N s)	0.00 ± 0.00	−0.32 ± 0.20	−0.06 ± 0.23	−0.42 ± 0.09
Resilience (%)	63.95 ± 7.73	67.07 ± 5.90	48.51 ± 5.42	51.43 ± 6.46
Cohesiveness (%)	89.08 ± 1.81	91.34 ± 1.89	81.70 ± 4.74	86.55 ± 5.25
Springiness (%)	79.38 ± 4.19	69.57 ± 9.67	81.69 ± 2.48	75.55 ± 6.06
Gumminess (N)	4.22 ± 1.76	3.37 ± 1.65	5.73 ± 2.08	5.08 ± 1.95
Chewiness (N)	3.40 ± 1.57	2.42 ± 1.35	4.68 ± 1.72	3.90 ± 1.68
Perforation test				
External firmness (N)	0.39 ± 0.15	0.25 ± 0.03	0.33 ± 0.14	0.25 ± 0.08
Inner firmness (N)	0.22 ± 0.09	0.14 ± 0.03	0.19 ± 0.09	0.18 ± 0.07
Stickiness (N)	−0.05 ± 0.01	−0.06 ± 0.01	−0.07 ± 0.01	−0.09 ± 0.08
Adhesiveness (N s)	−0.02 ± 0.03	−0.02 ± 0.02	−0.03 ± 0.02	−0.04 ± 0.04

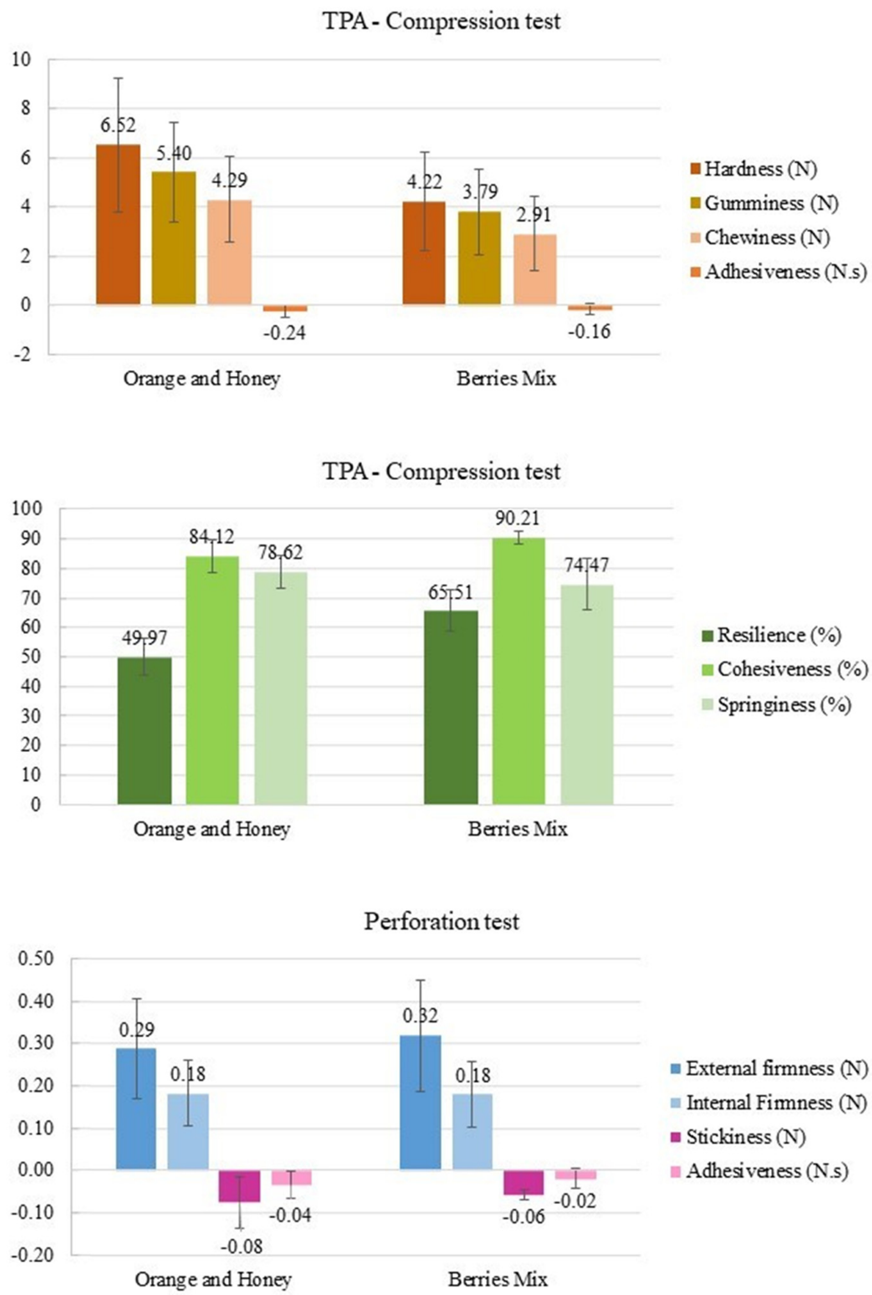

Figure 5: Textural properties of the gummy jellies combining the measurements of both sides.

comparison between both formulations developed and highlight a higher average hardness in the orange and honey sample (6.52 N) compared with the berries mix sample (4.22 N). Although the amounts of gelatin and agar-agar were equal in both formulations, the concentrations were higher in the orange gummy jelly, and the effect of these thickening agents might impact the texture. In addition, the ORH gummies had a lower moisture content when compared with BEM, also contributing possibly to a denser structure and harder texture. Finally, the orange gummy jelly had honey, which has particular rheological properties [40–42] that might also influence the product texture. It has been reported that honey had an impact on the mechanical properties of bread [43], and it has been shown that the structural properties of honey when in systems that contain gelatin, like in our case, will influence the matrix structure [44].

The orange and honey gummy jelly has lower resilience (49.97%) than the berries mix gummies (65.51%), which might also be related to the composition of the different products. Guiné et al. [39] reported values of resilience much lower (in the range of 35–45%) for similar products containing aromatic herbs.

Springiness was higher for the orange formulation (78.62%) than the berries formulation (74.47%), so the orange gummy jellies were more elastic. In the study by Guiné et al. [39], the reported values of elasticity were around 90% for gummies containing fruits and herbs.

As for the textural properties determined by the perforation test, they were practically unchangeable for the two formulations, which indicates that the internal structure of both products is much more similar than the external layer and its relation with the surface producing the force (the probe in case of the instrumental texture measurements and mouth in the case of eating).

3.3 Nutritional value

Traditional jelly candies are considered as having minimal nutritional value, with high energetic density due to their high sugar contents. However, new trends to obtain healthier products have been gaining importance [4,10,45]. In this line of work, the developed formulations showed a lower energetic value when compared to the commercially available formulations (39.8–73.8 kcal/100 g vs 351 kcal/100 g; Table 4). As expected, the orange gummy jelly, which contained 8.6% of honey, provided more energy than the berries mix formulation with no added sugars. Sugars on food labeling refer to simple sugars, such as dextrose or glucose, sugars from syrups and honey, or sugars from concentrated fruit and vegetable juices. It was aimed to have a lower sugar content in the developed formulations, in contrast with the commercially available confectionaries that consumers are used to and that have high sugar contents. The berries mix gummies contained less than 5 g of simple sugars per 100 g, with the orange formulation containing almost twice as much, again due to the addition of honey to counteract the acidity of the juice. The use of honey as a sweetener has beneficial effects unlike added sugars such as sucrose, since the bioactive compounds present in honey have antioxidant properties, either by themselves or by interacting with other substances [46]. A study by Atwa et al. [47] showed that topical application/chewing of honey might help prevent gingivitis and caries in patients undergoing orthodontic treatment.

Protein levels of the formulated gummy jellies were lower than the commercially available ones. While these confectioneries consist primarily of sucrose, glucose syrup, starch, gelatin, and water, with a number of minor components including food acids, flavorings, and colorings, our formulations are a mix of fruit juice/puree, gelatin, and agar. Agar is the dried colloidal polysaccharide extract of certain marine algae and does not have protein in its composition [48,49]. Most fruits are low in protein; therefore, none of the ingredients used in the experimental formulations is an abundant source of protein.

The serving size of jelly candies is 25 g, as established in the Portuguese Serving Size Guide [23]. According to EU regulations 1924/2006 [50] and 1047/2012 [51], the developed berries mix gummy jelly can claim to have low energetic value and to be sugar-free, since they only provide 39.8 kcal and contain less than 5 g of sugar per 100 g. Conversely, the orange and honey gummy jellies can be considered light because their calories and sugar are less than 30% of the traditional product.

3.4 Sensorial properties

The results of the descriptive test for sensorial profile are presented in Figure 6, and they correspond to the average of the scores attributed by the 37 panelists to the different attributes in each sample. The evaluation scale was from 1 (least intense) to 5 (most intense) in each of the characteristics evaluated. The taste attributes were rated very

Table 4: Nutritional value of the developed gummy jellies, compared to their commercially available counterparts

	Orange and honey (100 g)	Berries mix (100 g)	Commercial orange or red (100 g)
Energy (kcal/kJ)	73.8/308.6	39.8/166.4	351/1,490
Total carbohydrates (g)	14.40	6.69	81.0
Sugar (g)	8.81	4.63	58.0
Protein (g)	4.04	3.25	5.3
Total fat (g)	<0.5	<0.5	<0.5
Sodium (mg)	0.07	0.04	0.02

similarly for the two developed formulations but quite different from the commercial product evaluated. Our products were less sweet, particularly the berries formulation, which did not include honey, more acid, more bitter, and more astringent. Nevertheless, the difference in the global appreciation of taste was not so evident, which means that the panelists appreciated the taste of the developed products almost as much as the commercial product despite being much less sweet.

Regarding the textural attributes (Figure 6), again the formulations developed were classified with very similar scores, except for the presence of granules, which was higher in the formulation that contained berries. This berry mix also contained strawberries among other fruits, and these possess very small seeds that can contribute to this effect in texture. In the case of textural properties, also very important differences were found between the products developed and the commercial sample, particularly by being this last firmer, less soft (harder), less juicy but more elastic. Concerning the global appreciation of texture, the formulations developed were scored slightly higher than the commercial sample, indicating the preferences of the panelists for the sensations that our gummy jellies activated on the mouth when tasting them.

As for the aroma characteristics (Figure 6), the panelists did not differentiate both formulations developed, but they considered that the commercial sample had a sweeter aroma and therefore was slightly more appreciated.

In global, the sensorial analysis revealed that the orange and honey and the berries mix gummy jellies were scored very similarly by the members of the sensorial panel, but when comparing them with the commercial sample, they preferred the commercial one and the buying intentions were therefore higher.

In the preference test, the judges were asked to rate the different samples from 1 (least preferred) to 3 (most preferred), and the results are presented in Figure 7. The results indicate that the commercial sample was preferred in all attributes evaluated (appearance, taste, texture, and global appreciation), because the average scores were higher. Nevertheless, the difference in the average scores for the second best sample was not so high, indicating that the orange and honey gummy jellies

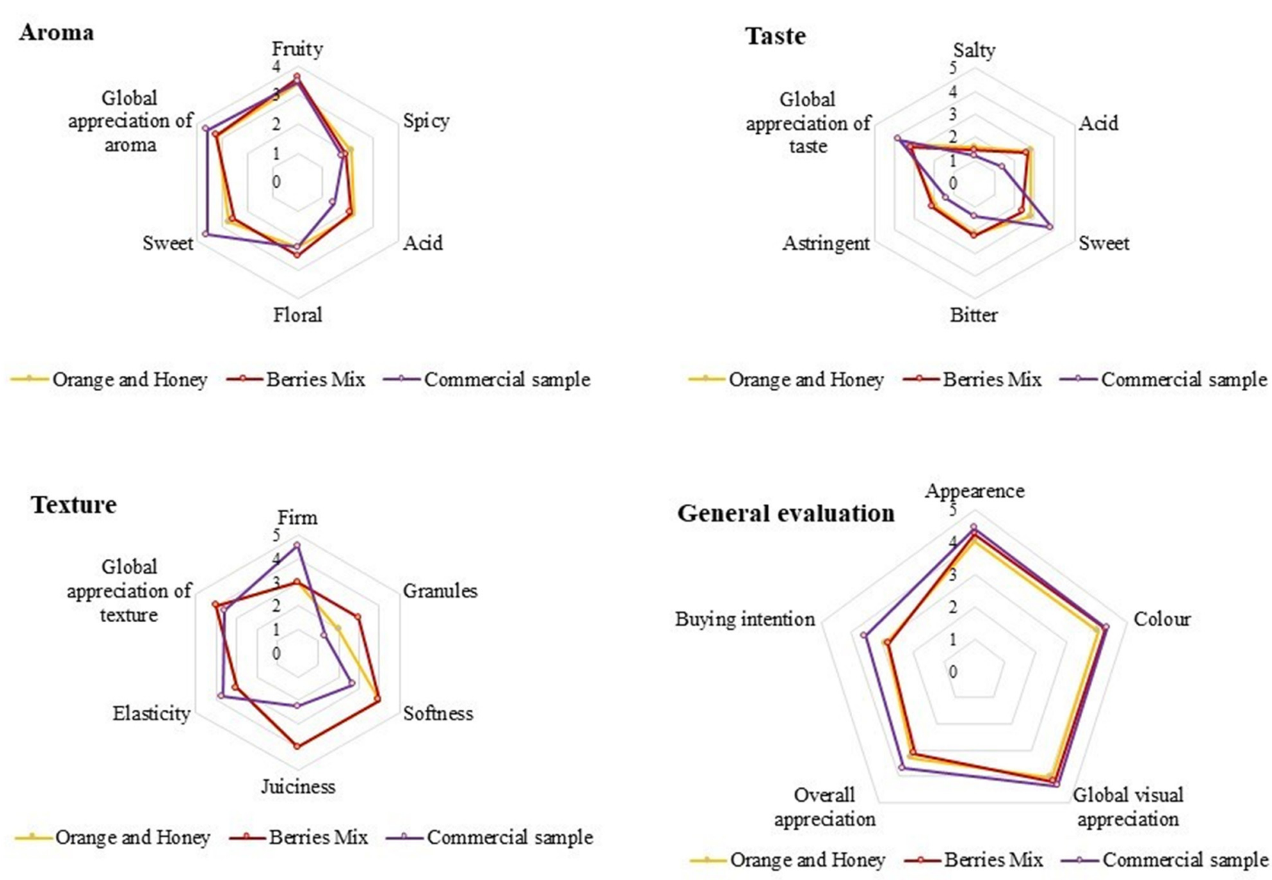

Figure 6: Descriptive sensorial profiles of the two developed gummy jellies and a commercial sample.

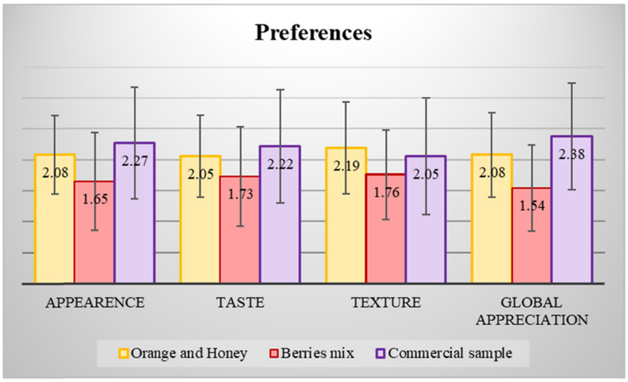

Figure 7: Preferences for the developed gummy jellies comparing with a commercial sample.

might have a relatively good acceptance by the consumers, more than the berries mix gummy jelly. This work revealed that the development of new gummy jelly products made with berries puree and orange juice sweetened with honey might be an alternative for healthy candy products that meet consumer demands for healthier alternatives. This might be particularly important if the new products are the market driver for the specific segments of the population that value healthy lifestyles and/or have some chronic noncommunicable diseases like diabetes or obesity.

4 Conclusion

The results of this study showed that the gummy jellies formulated with berries and orange and honey as a sweetener have antioxidant activity conferred by the ingredients included in the formulations and were safe from the microbiological point of view, attending values of mesophilic aerobic populations and moisture content. The developed products had uniform color and textural properties, although differing according to the variety, with the orange formulation presenting higher hardness and springiness but lower resilience.

The nutritional value of the developed formulations allows some claims: sugar free for the mixed berries formulation and light sugar for the orange and honey formulation.

The sensorial evaluation revealed that the formulations made with fruits were less valued than the commercial sample for some characteristics, but the orange formulation, in particular, was almost as much appreciated as the commercial sweetened sample.

Our research showed that it seems possible to obtain gummy jellies with acceptable sensory attributes, which may be marketed for diabetic patients or for individuals who desire to reduce their weight. However, further analysis is required to understand the gummies' stability over time so as to establish an appropriate and safe shelf life, as well as to devise appropriate production and packaging solutions to make the product available at a larger scale.

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Data availability statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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