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ANTIOXIDANT AND NUTRITIONAL CHARACTERISTICS OF TWO INNOVATIVE SUGAR FREE FRUIT JELLIES

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Abstract

Fruit jellies are very popular sweets for all ages, but due to the significant amounts of sugar added in classic jellies (54-58%), they have begun to be avoided by more and more consumers, either for health reasons or to prevent certain diseases or to control weight. The first aim of this paper was to obtain two varieties of jellies: one from orange (OJ) and the other from kiwi fruit (KJ), using dried Stevia rebaudiana leaves powder as sweetner. A second aim of the paper was to determine the content of vitamin C (titrimetric iodometric method), total polyphenols (Folin-Ciocalteu assay), antioxidant activity (CUPRAC method) of the finished products compared to the raw materials, as well as the analysis of the nutritional and sensory characteristics of the two types of jellies. Among the raw materials, kiwi fruit was noted for the highest content of vitamin C (90.82±3.22 mg/100 g) and for the strongest antioxidant activity (9.68±0.31mg Trolox/g). From the two finished products, KJ was the richest in ascorbic acid 80.25±2.44 mg/100g and have had the higher antioxidant activity (8.98±0.28 mg Trolox/g). In terms of total polyphenols, they were present in larger quantities in oranges (4.93±0.08 mg gallic acid/g) and in OJ (7.90±0.12 mg gallic acid/g). Stevia rebaudiana used as a sweetener has a very high content of total polyphenols (34.22±0.83 mg gallic acid/g) and a very good antioxidant activity (112.75±2.28 mg Trolox/g). Both types of jellies are distinguished by a low energy intake (53.82 kcal/100 g for KJ, respectively 41.76 kcal/100g for OJ), a significant dietary fiber intake (8,58 g/100 g for KJ and 6.03 g/100 g for OJ) and a low sugar content (8.35 g/100 g for KJ, respectively 7,89 g/100 g for OJ - and this is natural fruit sugar). The two types of jellies were very well appreciated from an organoleptic point of view (hedonic scoring method from 1 to 5), OJ having slightly higher scores in terms of taste and aroma, compared to KJ.

Key words: antioxidant activity, jelly, kiwi fruit, oranges, polyphenols, *Stevia rebaudiana*.

INTRODUCTION

Conventional fruit jellies are part of the category of products processed from fruit and preserved with sugar. They are gelled products obtained from fruit juices mixed with sugar, pectin, with or without the addition of organic acids. The added sugar is 54-58 kg/100 kg jelly (Banu et al., 2013).

Because the sugar used in the manufacture of conventional jellies can trigger many diseases that affect the human body, such as obesity, diabetes, tooth decay, it has become necessary to replace it with other natural sweeteners safe for the consumers health (Reissig et al., 2016; Saveski et al., 2015; Khouryieh et al., 2005).

Among the natural sweeteners, the leaves of *Stevia rebaudiana* Bertoni (*Asteraceae* family) are gaining more and more interest nowadays. It is estimated to be about 300 times sweeter than sucrose, due to the content of specific diterpene glycosides called steviosides and rebaudiosides, which although they taste very sweet, are non-nutritive (calorie-free) and non-toxic (Salehi et al., 2019; Suresh et al., 2018; Marcinek & Krejpcio, 2015). Some studies have even shown that *Stevia rebaudiana* Bertoni leaves have antidiabetic effects, increasing insulin production and stabilizing blood sugar levels (Xiao & Hermansen, 2005; Chen et al., 2006). Stevia is also an important source of antioxidants (vitamin C, polyphenols, flavonoids, carotenoids) but also of mineral elements (potassium, iron, calcium, magnesium, phosphorus) (Absan et al., 2020).

Fruits are highly revered for their nutritional properties, serving as a primary source of vitamins and minerals in many people's diets. Recent attention has focused on phyto-nutrients naturally present in many fruits. These compounds include polyphenols, anthocyanins, carotenoids, and other antioxidant compounds that play an important role in preventing cancer and heart disease (Baker et al., 2005).

It has been experimentally determined that jellies contain flavonoid profiles similar to those of the natural fruits from which they are obtained. The content of total polyphenols is influenced by the variety of fruit, the degree of ripeness of the fruit and the industrial process used (Tomas-Lorente et al., 1992).

Although fruits are thermally processed to obtain jellies and some of the thermolabile antioxidants are destroyed (especially vitamin C), it has been found that fruit jellies also have a good antioxidant activity (Kim & Padilla-Zakour, 2004).

Kiwi fruits belong to the genus *Actinidia* and originate from China. There are over 60 species belonging to the genus *Actinidia*, but few of them are of economic importance. *A. deliciosa* and *A. chinensis* are the most common species in the world (Sanz et al., 2021). Kiwi fruit contains high amounts of antioxidants such as vitamin C, vitamin E, carotenoids and polyphenolic compounds, but also folate, minerals K, Mg, and Cu as well as dietary fiber (Pinelli et al., 2013; Skinner et al., 2011).

Oranges, tasty and juicy fruits, belong to the *Rutaceae* family and are botanically known as *Citrus sinensis.* Significant amounts of antioxidant compounds are also found in oranges: vitamin C, carotenoids, polyphenols, flavonoids, as well as dietary fiber, calcium, potassium (Parle & Chaturvedi, 2012). Some studies have shown that the antioxidants present in oranges provide protection against several degenerative diseases, reduce the risk of developing cardiovascular disease and cancer (Benavente-García et al., 1997; Parle & Chaturvedi, 2012; Adenaike & Abakpa, 2021).

The first purpose of this paper was to obtain two varieties of fruit jelly (one from kiwi and the other from orange) sweetened with *Stevia rebaudiana* Bertoni dried leaves powder and minimally heat processed. The second aim of the paper was to analyze the obtained jellies in terms of vitamin C content, total polyphenols, antioxidant activity, as well as their nutritional and organoleptic characteristics evaluation.

MATERIALS AND METHODS

Jellies preparation

All the raw and auxiliary materials used to jellies preparation were purchased from the Romanian market. Recipes used to obtain the two assortments of finished products (kiwi jelly - KJ, respectively orange jelly - OJ) are presented in Table 1

Table 1. Recipes used to jelly assortments preparation

Finished product / **Raw and auxiliary materials (g)**	**KJ**	**OJ**
Kiwi juice	400	-
Orange juice	-	400
Stevia leaf powder	6	6
Agar-agar powder	20	20
Vanilla pods powder	1	1

In order to prepare the jellies, the kiwi and respectively orange fresh juices were obtained first, using a Tefal ZE 585H38 Easy Fruit centrifugal juicer. Then, stevia powder, agar-agar and vanilla were dissolved in each type of juice. The mixture, for each product, was brought to a boil and kept for 1 min, stirring constantly. Then, the hot jelly was poured into molds, allowed to cool and then refrigerated (4°C) for at least 4 hours. From the jellies thus obtained as well as from the raw materials and stevia powder, samples were taken to determine the content of vitamin C, total polyphenols and antioxidant activity.

Vitamin C determination

The titration iodometric method was used to determine the vitamin C content of the samples, based on the color reaction between starch and a solution of iodine in potassium iodide. Ascorbic acid was determined quantitatively by titration with a solution of potassium dichromate in the presence of starch and potassium iodide. The working method was performed as presented by Dumbrava et al. (2016), the results being expressed in mg vitamin C/100 g.

Assessment of the total polyphenol content

The Folin-Ciocâlteu method was used to determine the total polyphenols in raw materials and finished products. This method is based on the reducing properties of polyphenols compared to the hexavalent molybdenum from the poly-phosphomolybdate contained in the reagent Folin-Ciocâlteu (Folin & Ciocâlteu, 1927). Hexavalent molybdenum is partially reduced by polyphenols, in a strongly acidic environment at lower states (+4, +5) which in an alkaline environment are colored in blue, having absorption bands at approx. 750 nm (Huang et al., 2005; Prior et al., 2005). The working methodology was the same as the one presented by Dumbrava et al. (2020), the results being expressed in mg gallic acid/g.

Assessment of the antioxidant activity

CUPRAC (cupric ion reducing antioxidant capacity) method was used to determine the antioxidant activity of both raw materials and finished products. In this method, the reagent copper (II) - neocuprine is used as the chromogenic oxidizing agent. The samples absorbance is read at 450 nm. Since the bis (neocuproine) copper (I) cation chromophore is soluble in both organic solvents and water, the CUPRAC method can determine the antioxidant activity of both fat-soluble and water-soluble antioxidants present in the test sample. Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), an antioxidant that mimics the structure of vitamin E but is both fat-soluble and water-soluble, is used as a reference substance (Apak et al., 2007). The working method used was similar to the one presented by Dumbrava et al. (2020), the results being expressed in mg Trolox/g.

Statistical analysis

All determinations were performed in triplicate and the results were expressed as a mean values ± standard deviation (SD). Microsoft Excel 2010 was used for statistical data processing.

Assessment of the proximate composition and energy value

The Nutritional Data Base USDA was used to determine the proximate composition and energy value of the two types of obtained jellies.

Sensory evaluation

Sensory analysis of KJ (kiwi jelly) and OJ (orange jelly) was performed by 30 untrained panelists aged 14 to 51 years (18 females and 12 males), non-smokers, no known food allergies. The KJ and OJ samples were presented to the panelists in a single sensory session, placed in disposable white plates, labeled with four-digit characters. Panelists were asked to evaluate the following sensory characteristics of the samples: appearance, color, odor, texture, taste and aroma. Between two sample evaluations, participants were asked to rinse their mouths with plain water. The five-point hedonic scale was used as follows: 1 = extremely dislike; 2 = slightly dislike; 3 = neither like nor dislike; 4 = slightly like; 5 = extremely like (Lim, 2011). The level of acceptability and the range of scores were classified in the same way as presented by Dumbrava et al. (2020).

RESULTS AND DISCUSSIONS

Vitamin C content

Results on vitamin C content in raw materials, stevia powder and finished products are presented in Table 2.

Table 2. Ascorbic acid content in raw materials, stevia powder and finished products

Sample	Ascorbic acid content (mg/100 g)
Kiwi pulp	90.82±3.22
Orange pulp	65.22±2.14
Stevia powder	12.89±0.14
Kiwi jelly (KJ)	80.25±2.44
Orange jelly (OJ)	52.34±2.16

Among the raw materials, kiwi pulp was richer in vitamin C (90.82±3.22 mg/100 g) than orange pulp (65.22±2.14 mg/100 g). Nangbes et al. (2014) found lower values for ascorbic acid content in orange pulp, 50.23 mg/100 g for ripe fruit and 56.26 mg/100 g for unripe fruit. Najwa and Azrina (2017) also reported a lower orange pulp vitamin C concentration of 58.30±0.53 mg/100 g.

For kiwi pulp Elhefian et al. (2019) reported a similar value: 90.20 mg/100 g, while Tyagi et al. (2015) found a higher concentration of ascorbic acid: 105 mg/100 g. An ascorbic acid concentration of 12.89±0.14 mg/100 g was determined for the dried leaf powder of *Stevia rebaudiana* Bertoni, a slightly lower value than reported by Kim et al. (2011): 14.98 mg/100 g DW.

In the case of finished products, the concentration of ascorbic acid is slightly lower than in the raw materials, during the heat processing of the jellies there are losses in this thermolabile vitamin. Because the thermal processing was minimal, the boiling time of the products during the production process being only 1 min, the concentration of vitamin C in the jellies is high, KJ being richer in vitamin C (80.25±2.44 mg/100 g) with 53.32% than OJ (52.34±2.16 mg/100 g).

Total polyphenols content

Table 3 shows the experimentally obtained data for the total polyphenol content in the raw materials, stevia powder and finished products. Total polyphenol content was higher in orange pulp (4.93±0.08 mg gallic acid/g) than in kiwi pulp (2.61±0.04 mg gallic acid/100 g) and stevia powder was noted by a very high amount of these compounds (34.22±0.83 mg/100 g).

Table 3. Total polyphenols content in raw materials, stevia powder and finished products

Sample	Total polyphenols (mg gallic acid/g)
Kiwi pulp	2.61±0.04
Orange pulp	4.93±0.08
Stevia powder	34.22±0.83
Kiwi jelly (KJ)	3.98±0.06
Orange jelly	7.90±0.12

Sir Elkhatim et al. (2018) analyzing the total polyphenol content in the mixture of orange pulp and seeds, reported higher values ranged between 19.2 and 16.2 mg of gallic acid equivalent/g.

For kiwi pulp, Alim et al. (2019) determined values of 9.5 mg gallic acid equivalent/g dry weight, also, Pal et al. (2015) studying the variation of total polyphenols concentration in the kiwi pulp of different kiwi fruit varieties at various degrees of maturity, found values between 0.84 and 2.15 mg gallic acid equivalent/g fresh weight, our data being slighty higer than superior limit of this range.

Kaushik et al. reported in stevia leaves higher total polyphenol values of 42 mg/100 g dry leaf. OJ (7.90±0.12 mg gallic acid/g) was distinguished by an almost double content of total polyphenols compared to KJ (3.98±0.06 mg gallic acid/g), both being richer in these compounds than the pulp of the fruits from which were obtained.

Antioxidant activity

The experimental data resulting from antioxidant activity analysis presented in Table 4, show that kiwi pulp had higher antioxidant activity (9.68±0.31 mg Trolox/g) than orange pulp (7.05±0.14 mg Trolox/g).

It was also found that stevia powder had a very strong antioxidant activity (112.75±2.28 mg Trolox/g), so that the finished products, although subjected to a short heat treatment, kept a good antioxidant activity (8.98±0.28 mg Trolox/g for KJ respectively 6.86±0.11 mg Trolox/g for OJ), very close to that of the fresh fruits from which they were prepared.

As it is known, the antioxidant composition of fruits depends a lot on the variety, soil and climatic conditions, degree of ripeness, storage conditions, so that the values found in the literature for the antioxidant activity of kiwi and orange pulp, respectively, have presented some differences. Thus, Sharma et al. (2012) reported a lower antioxidant activity for kiwi pulp (1.175 mg Trolox/g FW), with an increase in 1-methylcyclopropene-treated fruit during the post-harvest life (3.125 mg Trolox/g FW). Wang et al., (2008) found an antioxidant activity of 9.02 mg Trolox/g FW for oranges, while Park et al. (2014) reported 1.39 mg Trolox/g FW. Covarrubias-Cárdenas et al. (2018) reported for *Stevia rebaudiana* Bertoni leaf powder aqueous and ethanolic extracts respectively, values of antioxidant activity between 60.21 and 150.81 mg Trolox/g, depending also on the extraction time, respectively on the concentration of the ethanolic solution.

Table 4. Antioxidant activity of raw materials, stevia powder and finished products

Sample	Antioxidant activity (mg Trolox/g)
Kiwi pulp	9.68±0.31
Orange pulp	7.05±0.14
Stevia powder	112.75±2.28
Kiwi jelly (KJ)	8.98±0.28
Orange jelly (OJ)	6.86±0.11

Nutritional profile of finished products

The proximate composition and energy value for the two varieties of jellies (KJ and OJ) are presented in Table 5.

Table 5. Proximate composition and energy value of KJ and OJ

	KJ	OJ
Protein (g/100 g)	0.97	0.65
Total fat (g/100 g)	0.42	0.18
-saturated fat (g/100 g)	0.02	0.02
Total carbohydrates (g/100 g)	20.19	16.93
-sugar (g/100 g)	8.35	7.89
-dietary fiber (g/100 g)	8,58	6.03
Energy value (kcal/100 g)	53.82	41.76

Both finished products had a low energy value (53.82 kcal/100 g for KJ and 41.76 kcal/100 g for OJ), a very low content of lipids (0.42 g total fat/100 g for KJ, respectively 0.18 g total fat for OJ) and proteins (0.97 g/100 g for KJ, respectively 0.65 g/100 g for OJ), in their proximate composition predominating carbohydrates (20.19 g/100 g in KJ and 16.93 g/100 g in OJ). Sugars (8.35 g/100 g în KJ, respectively 7.89 g/100 g in OJ) are in a much smaller quantity (and naturally derived from fruit) compared to classic jellies with added sugar (54-58%). Instead, there is a significant dietary fiber content in both products (8.58 g/100 g in KJ, respectively 6.03 g/100 g in OJ).

Sensory analysis

The results of the sensory analysis, presented in Figure 1, show that both types of jellies were well appreciated by panelists, the orange jelly variant (OJ) having an overall average of 4.6 which places the product in the class with a high level of acceptability (HA), and kiwi jelly (KJ) was rated with an overall average of 4.4 which places it in the class of acceptable products (A). The two products had the same average score in terms of appearance and texture (4.4 and 4.3 respectively) but in terms of color, taste, smell and aroma, OJ was better appreciated than KJ

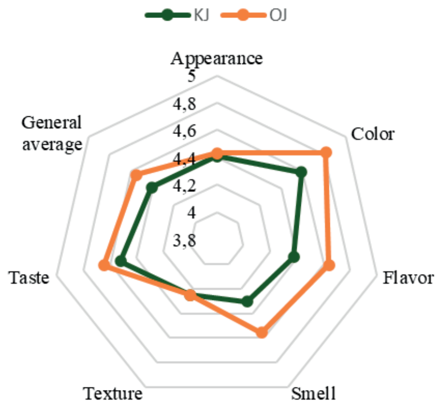

Figure 1. Global values of the sensory evaluation of KJ and OJ by using a 5-point hedonic scale

CONCLUSIONS

Concentrated fruit products, including jellies, are a category of canned products loved by consumers of all ages. As conventional jellies contain significant amounts of added sugar, which is a drawback, as it can cause certain health problems for consumers, it has become necessary to find ways to obtain these products using other types of natural sweeteners that eliminate the disadvantages of sugar, but which to ensure, however, a sensory quality well accepted for finished products and also, if possible, add health benefits. The present paper aims to prepare two varieties of fruit jellies, one of kiwi and the second of oranges, sweetened with powder from dried leaves of *Stevia rebaudiana* Bertoni and using agar-agar as gelling agent.

The products obtained, as they were minimally thermally processed, were distinguished by a vitamin C content very close to that of raw materials, a level of total polyphenols even higher than that of raw materials and a good antioxidant activity. To the high values of total polyphenols content and of antioxidant activity registered for kiwi jelly respectively for orange jelly, stevia powder used as a sweetener also brought an important contribution. Although orange jelly was noted for its almost double total polyphenol content compared to kiwi jelly because the latter contained a higher amount of vitamin C, the antioxidant activity of kiwi jelly was higher.

Nutritional profile analysis of the two varieties of jellies showed that both were low in calories, low in sugar compared to classic jellies or other sweet products, and can bring a fairly good intake of dietary fiber.

In terms of sensory analysis, both products were well appreciated by panelists, but orange jelly was slightly better evaluated in terms of color, taste, smell and aroma than kiwi jelly, thus obtaining a score that places it in the class of highly acceptable products, while kiwi jelly was included in the class of acceptable products.

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