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Antioxidant and nutritional characteristics of some raw vegan appetizers based on vegetables

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Abstract

Raw vegan foods are obtained exclusively from non-thermally processed vegetable raw materials, are considered "living food" bringing an important supply of enzymes, vitamins and other bioactive principles valuable for human health and that is why they are recommended in the daily menus not only of vegans and vegetarians but also of omnivores.

The purpose of this work was primarily to create two raw vegan appetizers based on vegetables: one (RVA1) using carrots, celery, leeks, cherry tomatoes, red bell pepper, garlic and the second (RVA2) with zucchini, avocado, kapia pepper, chili pepper, tomato, garlic. Another aim of the paper was the analysis of the raw vegan appetizers in terms of vitamin C content (iodometric assay), carotenoids (spectrophotometric method), total polyphenols (Folin-Ciocalteu assay), antioxidant activity (CUPRAC method), proximate composition and sensory properties (5-point hedonic scale method). The RVA1 assortment stood out for the highest vitamin C content (106.18±1.08 mg ascorbic acid/g), while RVA2 had a higher amount of total polyphenols (3.14±0.06 mg GAE/g) and carotenoids (73.04±0.24 μg/g). Antioxidant activity of RVA2 was slightly higher (10.27±0.46 mg Trolox/g) than that of RVA1 (9.62±0.46 mg Trolox/g). Of the two raw vegan appetizers, RVA1 had a much lower caloric content than RVA2, in the first product quantitatively predominating carbohydrates, and in the second lipids. At the sensory analysis, both products obtained very good scores (over 4.5) for all characteristics, RVA2 being better appreciated in terms of texture, taste and aroma (4.70, 4.85 and 4.80) than RVA1 (4.55, 4.70 and 4.75).

Key words: raw vegan appetizer, vegetables, polyphenols, antioxidant activity, carotenoids.

1. Introduction

As vegetarian diets have grown in popularity, veganism has gained recognition as a healthy and potentially therapeutic food choice [1]. Health and long life are the main goals of raw plant food diets, as well as remedies and prophylaxis. The concept of eating raw vegetable diets developed for several reasons. Max Bircher-Benner (1867-1939), a Swiss physician, successfully treated patients with raw vegetable diets in his private clinic. From his experience, Are Waerland (1876-1955) found that lacto-vegetarian diets, mainly raw plant foods, were effective treatments of his diseases. Heating the food above 118 degrees F. causes chemical changes that create acidic

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toxins, including carcinogens, mutagens, and free radicals. Cooking destroys living enzymes that aid digestion and health. Fruits, vegetables and nuts in their natural, non-heat-processed state are alkalizing and beneficial to human health [2-4]. There are plenty of vegetables that can be eaten raw and from which it can make different raw vegan appetizers that are appealing both in terms of health benefits and sensory characteristics. Bell peppers (*Capsicum annum* L.) have a long history as a source of healthy and biologically active compounds such as flavonoids, phenolic compounds, carotenoids and vitamins, especially vitamins C and E. Provitamins A and other carotenoids in peppers are known for their powerful antioxidant properties [5]. Various studies have been done on the potential of red peppers to reduce oxidative stress, inflammation, pain, fat intake and body weight, while also proving to have anti-tumor, anti-diabetic, anti-inflammatory properties [6-8]. Tomato fruits (*Solanum lycopersicum* L., *Solanaceae* family) originated in South America, are now used and cultivated in different parts of the world due to their nutritional and sensory characteristics, highly appreciated by consumers [9]. Lycopene is the main pigment responsible for the characteristic red color of ripe tomato fruits and tomato products. It has attracted attention because of its biological and physicochemical properties, in particular because of its effects as a natural antioxidant. Regular consumption of tomato products can help improve the body's defense capacity against oxidative stress due to its content of flavonoids, carotenoids, and polyphenols [10,11]. Despite being a poor source of protein (1.0g/100g fresh weight), provitamin A (27 IU/100g) and vitamin E (0.30 mg/100g), eggplants (*Solanum melongena* L.) are rich in minerals and antioxidants. In folk medicine, eggplant is indicated for the treatment of several diseases, including diabetes, arthritis, asthma and bronchitis. In addition, several studies have provided evidence that eggplant extracts have a significant effect in reducing cholesterol in humans [12,13]. Carrots (*Daucus carota* L.) - the most important crop in the *Apiaceae* family, have a unique combination of three flavonoids: kaempferol, quercetin and luteolin and are also rich in other phenols, including chlorogenic, caffeic and p-hydroxybenzoic acids, along with numerous cinnamic acid derivatives. The carotenoids widely distributed in orange carrots are powerful antioxidants that can neutralize the effect of free radicals and are also important sources of provitamin A [14]. Celery (*Apium graveolens* L., *Apiaceae* family), along of numerous phenolic compounds with remarkable antioxidant properties, contains vitamins A, B1, B2, B6, C, E, K, P and minerals such as iron, calcium, phosphorus, magnesium and zinc. The vitamin C in celery strengthens the immune system and at the same time makes the body more resistant to new diseases [15]. Onion (*Allium cepa* L.) has been valued as a food and a medicinal plant since ancient times, being an important source of several phytonutrients such as flavonoids, fructo-oligosaccharides (FOS), thiosulfates and other sulfur compounds. Organosulfur compounds have antimicrobial, antiallergenic, anti-inflammatory and antithrombotic activity. Besides this, flavonoids in onions, such as quercetin and kaempferol, also have various biological roles important for maintaining health, such as: antiviral properties, antimicrobial, anticancer activities, along with heart and brain protection [16].

Considering the above mentioned, this work aimed to develop two varieties of vegan appetizers based on different fresh vegetables, as well as to characterize the obtained products in terms of vitamin C, carotenoids, total polyphenols content, antioxidant activity, proximate composition and sensory properties.

2. Material and methods

2.1. Preparing raw vegan appetizers

Two assortments of raw vegan appetizer were obtained: RVA1 and RVA2 using the raw and auxiliary materials according to the recipes in Table 1. All raw and auxiliary materials were purchased on the Romanian market.

The vegetables needed for each assortment of raw vegan appetizer were cleaned, washed, weighed and then shredded in a food processor (Bosch MSM14500). Salt, olive oil and dried basil were then added to each appetizer. The two products were then sampled for analysis of ascorbic acid, carotenoid pigments, total polyphenols and antioxidant activity. It is observed that the technology of obtaining the products is simple and environmentally friendly, but as the products are obtained from fresh, non-heat-treated vegetables, they have a short shelf life of only 24 hours (kept in the refrigerator at 4°C).

Table 1. - Recipes used to prepare raw vegan appetizers

Raw vegan appetizer assortment	RVA1	RVA2
Eggplant pulp (%)	45.5	-
Carrots (%)	10.7	-
Avocado pulp (%)	-	25.3
Celery root (%)	12.0	-
Bell pepper (%)	8.0	19.0
Chili pepper (%)	-	1.9
Zucchini (%)	-	38.0
Tomatoes (%)	16.0	7,0
Onion (%)	2.7	-
Garlic (%)	0.3	1.9
Dried basil (%)	0.3	1.3
Extra virgin olive oil (%)	3.5	3.7
Salt (%)	1.0	1.9

The finished products are shown in Figure 1.

RVA1 RVA2

Figure 1. – The raw vegan appetizers

Assessment of ascorbic acid, total polyphenol content, antioxidant activity, proximate composition and sensory analysis

The modified iodometric method presented by Dumbrava *et al*., (2016) [17] was used for ascorbic acid determination. Evaluation of total polyphenol content (TPC) in raw materials and finished products by Folin-Ciocalteu method, analysis of antioxidant activity by Cupric Reducing Antioxidant Capacity Assay (CUPRAC), assessment of proximate composition as well as sensory analysis of finished products by the 5-point hedonic scale method, were performed according to the working methods presented by Dumbrava *et al*., (2020) [18].

Carotenoid compounds determination

For the extraction of carotenoids from the two raw vegan appetizer assortments RVA1 and RVA2, 5.00 g of each product were weighed and ground in a grinder with a little quartz sand and a little extraction mixture of petroleum ether:acetone:ethanol (6:3:1). The sample was then placed in a centrifuge tube filled with the extraction solvent mixture and centrifuged at 3000 rpm for 5 minutes. The supernatant was filtered and collected in brown bottles, the extraction operation being repeated with new portions of the solvent mixture until colorless. The pooled supernatants were then concentrated under vacuum at 45°C in a rotary evaporator to a smaller volume (ca. 50 mL). The primary carotenoid extracts from each sample were then saponified by treatment with an equal volume of 15% KOH alcohol solution and leaving overnight at room temperature in the dark [19]. Saponified samples were placed in a separating funnel to which petroleum ether was added for re-extraction of the unsaponified carotenoids. This was followed by washing with distilled water for complete removal of soaps and alkali from the extracts. Traces of water in the ether extracts obtained were removed by treatment with anhydrous sodium sulphate. The dehydrated samples were evaporated under vacuum to a smaller volume and then stored in brown bottles at -20°C for analysis.

Determination of carotenoid concentration was carried out using a UV-VIS spectrophotometer model JASCO V-670. A 1 cm cuvette was used and the absorbances of the samples were determined in petroleum ether at wavelength: λ=450 nm, with petroleum ether used for compensation. The carotenoid content of the samples was calculated using the formula [19]:

$$\text{µg carotenoids/g plant material} = \frac{A \cdot V \cdot 10^4}{A_{1cm}^{1\%} \cdot m}$$

where:

A - is the absorbance at the given wavelength;
V - volume of the analyzed extract (ml);
A1%1cm - specific absorption coefficient of β-carotene in petroleum ether (2592);
m - mass of the sample (g).

Statistical analysis

For vitamin C content, TPC, carotenoids, antioxidant activity and proximate composition, were calculated the mean values and standard deviations of all replicates, using Excel software (Microsoft Office 2010).

3. Results and Discussion

Vitamin C content

The experimental data on ascorbic acid concentration in the raw materials as well as in the two types of raw vegan appetizers are presented in Table 2.

From the values obtained, results that between the two types of raw vegan appetizer, RVA1 assortment has a 29% higher ascorbic acid content (106.18±1.08 mg/100g) than RVA2 (82.63±0.85 mg/100g). Of the raw materials used, red bell pepper had the highest concentration of vitamin C (365.41±1.26 mg/100g), followed by chili pepper with 165.86±1.28 mg/100g. The lowest values of ascorbic acid content were found in celery root (9.24±0.12 mg/100g), carrots (9.84±0.06 mg/100g) and zucchini (11.18±0.14 mg/100g).

Table 2.- Ascorbic acid content in raw materials and finished products

Sample	Ascorbic acid (mg/100g)
Carrots	9.84±0.06
Eggplant pulp	12.05±0.11
Red bell peper	365.41±1.26
Onion	39.22±0.26
Leeks	42.64±0.38
Celery root	9.24±0.12
Tomatoes	24.35±0.21
Zucchini	11.18±0.14
Chili pepper	165.86±1.28
Garlic	21.88±0.18
RVA1	106.18±1.08
RVA2	82.63±0.85

Afnani *et al*., (2023) [20] determined the ascorbic acid content of bell peppers of different colours (using ethanol, respectively methanol as solvents) and reported values ranging from 251 mg/100g and 757.5 mg/100g. The result in this paper falls within this range, although the method used for determination was different. On the other hand, Zhang and Hamauzu (2003) [21], using 5% metaphosphoric acid extracts to determine the vitamin C content of red bell pepper, found a lower value of 191.2 mg/100g. Nagy *et al*., (2015) [22] reported for different hybrids of chili peppers a very wide range of vitamin C content values: 35.5 - 368.97 mg/100g, in which the result of this paper is also included.

Total polyphenol content

The content of total polyphenols (TPC) in raw materials and in the two varieties of raw vegan appetizer, determined by the Folin-Ciocalteu method, is presented in Table 3.

It can be observed that the raw vegan appetizer assortment RVA2 is with 44% richer in polyphenols (3.14±0.06 mg gallic acid/g) than RVA1 (2.18±0.04 mg gallic acid/g).

Table 3. - Total polyphenols content in raw materials and finished products

Sample	TPC (mg GAE/g)
Carrots	1.89±0.02
Eggplant pulp	2.39±0.04
Red bell peper	1.88±0.02
Onion	1.74±0.03
Leeks	2.14±0.05
Celery root	2.85±0.03
Tomatoes	1.28±0.02
Zucchini	1.85±0.01
Chili pepper	2.37±0.03
Garlic	2.16±0.01
Avocado pulp	0.91±0.02
RVA1	2.18±0.04
RVA2	3.14±0.06

In the case of raw materials, celery root had the highest TPC (2.85±0.03 mg gallic acid/g), followed by eggplant (2.39±0.04 mg gallic acid/g) and chili pepper (2.37±0.03 mg gallic acid/g). The lowest TPC was reported for avocado pulp (0.91±0.02 mg gallic acid/g). In comparison with these results, for celery root, Salamatullah *et al.* (2021) [23] reported a TPC value of 2.2 mg GAE/g, Priecina and Karklina (2014) [24] determined 3.3 mg GAE/g, while Golubkina *et al*. (2020) [25] reported 10.8 mg GAE/g; for eggplant pulp, Jung *et al*., (2011) [26] obtained higher TPC values: 10.82 - 13.83 mg GAE/g¸ in the case of chili peppers, Arnnok et al., (2012) [27] reported TPC values in the broad range of 0.782-4.52 mg GAE/g.

Carotenoids content

The spectrophotometric analysis of the carotenoid compounds concentration in the two assortments of raw vegan appetizer led to the results shown in Table 4.

Table 4. - Carotenoids content in raw vegan appetizers

Sample	Carotenoids content (µg/g)
RVA1	64.28±0.18
RVA2	73.04±0.24

Regarding the content of total carotenoid compounds, the vegan appetizer RVA2 (73.04±0.24 µg/g) was with 13.63% higher than RVA1 (64.28±0.18 µg/g).

Antioxidant properties analysis

Determining the antioxidant activity of the two assortments of raw vegan appetizer and raw materials, determined by CUPRAC method, the data presented in Table 5 were obtained.

Table 5. - RSA for raw materials and finished products

Sample	Antioxidant activity (mg Trolox/g)
Carrots	4.92±0.16
Eggplant pulp	8.58±0.28
Red bell peper	8.82±0.22
Onion	4.21±0.18
Leeks	5.63±0.14
Celery root	5.86±0.21
Tomatoes	3.42±0.11
Zucchini	1.53±0.08
Chili pepper	12.18±0.16
Garlic	2.88±0.06
Avocado pulp	2.04±0.03
RVA1	9.62±0.46
RVA2	10.27±0.46

The results obtained show that the two types of raw vegan appetizer developed in this work show antioxidant activities with quite similar values, the RVA2 variant having 6.76% higher antioxidant activity (10.27±0.46 mg Trolox/g) than the RVA1 variant (9.62±0.46 mg Trolox/g). Of the raw materials, chili peppers had the highest antioxidant activity (12.18±0.16 mg Trolox/g), followed by red bell pepper (8.82±0.22 mg Trolox/g) and eggplant pulp (8.58±0.28 mg Trolox/g). Zucchini (1.53±0.08 mg Trolox/g) and avocado pulp (2.04±0.03 mg Trolox/g) had the lowest antioxidant activity. Lidikova *et al*., (2021) [28] reported for the antioxidant activity of different varieties of peppers, a wide range of values, between 3.93 and 16.43 mg Trolox Equivalents/g, the results of the present study were found in this range. For eggplant pulp, Kaur *et al*., (2014) [29] reported lower values of antioxidant activity determined by CUPRAC method (0.56 - 5.06 mg TE/g), while Koley *et al*., (2019) [30] found even lower values (0.77 - 1.21 mg TE/g).

Proximate composition and energy value

The proximate composition and energy value of the two raw vegan appetizer varieties are shown in Table 6. and Figure 2.

Table 6. - Proximate composition (g/100g) of raw vegan appetizers

Parameters	RVA1	RVA2
Proteins	0.90±0.06	2.20±0.08
Lipids	3.40±0.12	7.60±0.16
Saturated fatty acids	0.50±0.03	1.10±0.04
Carbohydrates	5.50	6.70
Sugar	2.80±0.10	0.90±0.02
Dietary fiber	2.20±0.08	3.1±0.06
Moisture	84.00±0.96	77.07±0.54
Mineral substances	0.70±0.03	1.33±0.11

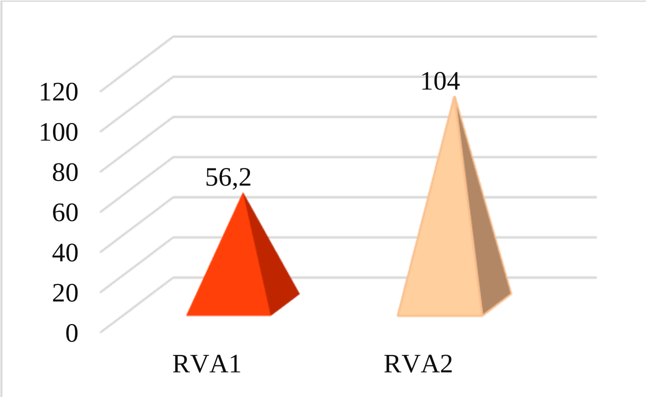

Figure 2. Energy values (kcal/100g) of raw vegan appetizers

The appetizer RVA2 had 2.44 times more protein (2.20±0.08 g/100g), 2.24 times more lipids (7.60±0.16 g/100g) and with 21.82% more carbohydrates (6.70 g/100g), providing 85.05% more energy (104 kcal/100g) than RVA1. The sugar content was 3.11 times higher in RVA1 (2.80±0.10 g/100g) than RVA2 (0.90±0.02 g/100g), while RVA2 was with 40.91% richer in dietary fiber (3.1±0.06 g/100g) than RVA1.

Sensory analysis

Sensory properties of the two raw vegan appetizer assortments, evaluated by 40 panelists aged between 20 - 62 years, led to the results presented in Figure 3.

The two raw vegan appetizers developed in this paper were very well accepted by the panelists, with scores ranging from 4.55 to 4.8. While RVA1 scored the highest for color and external appearance (4.80 for both), RVA2 was more highly rated for odor, taste, texture and overall acceptability (4.75, 4.80, 4.75 and 4.80 respectively).

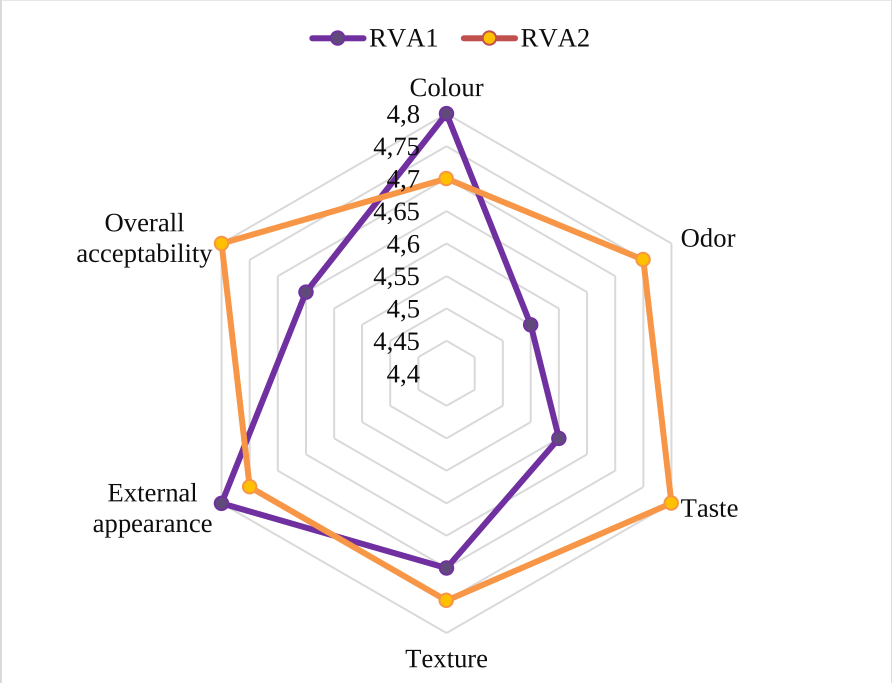

Figure 3. Global values of the raw vegan appetizers sensory properties

4. Conclusion

The two varieties of raw vegan appetizer developed and characterized in this paper, being rich in ascorbic acid, polyphenols, carotenoids and having a high antioxidant activity, without having a high caloric intake, are recommended for the daily diet of all those who want to have a healthy diet. RVA1 is particularly recommended for people who want to lose weight in a healthy way, as its caloric intake is very low and its antioxidant activity is very close in value to RVA2 (which has almost double the caloric intake of RVA1). The products are also very well appreciated from an organoleptic point of view, making them not only a very healthy, but also tasty appetizer. But being raw vegan products and therefore with a reduced shelf life, they could be the subject of a technological transfer to supermarket laboratories or/and to various public food establishments.

Compliance with Ethics Requirements

Author declares that he respects the journal's ethics requirements. Author declares no conflict of interest.

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