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Organoleptic Properties, Proximate Compositions, and Antioxidant Activity of Carrot – Navel Orange Marmalade

Dzul Fadly[1]*, Nur Afni Rahmatiya Abdul[2], Yuges Saputri Muttalib[2], Bohari Bohari[3]

[1]Department of Food Technology, Faculty of Agriculture, Tanjungpura University, Pontianak, Indonesia; [2]Department of Nutrition, Faculty of Health Sciences, Esa Unggul University, Jakarta, Indonesia; [3]Department of Nutrition, Faculty of Medicine, Sultan Ageng Tirtayasa University, Serang, Indonesia

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***Correspondence:** Dzul Fadly, Department of Food Technology, Faculty of Agriculture, Tanjungpura University, Pontianak, Indonesia. E-mail: dzul.fadly@faperta.untan.ac.id
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Abstract

BACKGROUND: Oxidative stress due to free radicals leads to degenerative diseases such as cardiovascular disease. For prevention, high antioxidants food content is needed.

AIM: The study aimed to identify the antioxidant activity, proximate compositions, and organoleptic properties of carrot – navel orange marmalade.

METHODS: It was an experimental study with five formulations of marmalades, that is, F1 (100 g orange: 0 g carrot), F2 (100 g orange: 25 g carrot), F3 (100 g orange: 50 g carrot), F4 (100 g orange: 75 g carrot), and F5 (100 g orange: 100 g carrot). The organoleptic test assessment was executed through the visual analog scale instrument on hedonic and hedonic quality parameters. The measurement of proximate compositions was conducted according to the Association of Official Analytical Chemists. The carbohydrate was used by difference calculation, while the Brix measured by refractometer. The antioxidant activity was identified by the 1,1-Diphenyl-2-picrylhydrazyl method.

RESULTS: The addition of juice and shredded carrot into navel orange marmalade tended to increase organoleptic values. Based on the sensory evaluation, the hedonic value of marmalade F1 had the lowest sensory acceptance value. The marmalade F2 (25% carrot) was dedicated as the most acceptable product with a medium bright color, quite pleasant aroma, a bit sweet, quite thick texture, and overall was quite attractive. Furthermore the carrot added significantly influenced the proximate (carbohydrate, protein, fat, fiber, water, and ash) ($p < 0.05$) and significantly increased the Brix ($p < 0.05$). The combination of carrot and orange resulted in a high antioxidant marmalade, with IC_{50} ranged 16.54 ± 0.02–19.83 ± 0.04 ppm.

CONCLUSION: This study revealed that carrot – navel orange marmalade could be a suitable source of antioxidants.

Introduction

Free radicals are components that are harmful to the body. Radicals can oxidize both fat in the human body and other living things, including food ingredients. Several causes of the radical's generation are ultraviolet rays, oxygen, heating, and others. In the human body, there are free radicals that might cause oxidative damage. Imbalances between free radicals such as reactive oxygen species with antioxidant activity lead to oxidative stress [1]. Prolong oxidative stress due to the excess of free radicals might trigger cellular damage and cause degenerative diseases. This process becomes the etiology and initiates various degenerative chronic diseases, such as diabetes mellitus, inflammation, coronary heart disease, and cancer [2], [3], [4].

Antioxidants are very beneficial for health in preventing the aging process and degenerative diseases. The excess free radicals generated in the body may overwhelm natural cellular antioxidant defenses and contribute to cellular functional impairment. Antioxidants will act as free radicals scavenging and protect other molecules in the cells from oxidation damage by free radicals or reactive oxygen [5]. Their capability in neutralizing the free radicals may reflect the phytochemical compounds, including phenolics and flavonoids [6]. Those compounds would scavenge free radicals by donating H^+ [7].

Nowadays, people tend to back to nature lifestyle. They choose to improve the used natural compounds than chemical or synthetic compounds. Various antioxidants obtained from natural ingredients are currently used to enhance antioxidant intake through functional food development. Functional food refers to a product consumed in the food form, not pills, capsules, or any other dosages [8]. Carrots and navel oranges are known as high antioxidant sources. It may are potent to develop to be functional food with high antioxidant activity. Those fruit and vegetables are easy to process into various home food products, also available almost in local markets, both developed or developing countries. Marmalade is a preserved food made from fruit juice. It has a semi-solid texture with sucrose, citric acid, pectin, and pieces of fruit skin (albedo). The manufacture of jam, jelly, or marmalade was rarely used vegetables as raw materials. This study aimed to formulate a carrot-navel orange marmalade and determine the organoleptic properties, proximate compositions, and antioxidant activity.

Materials and Methods

Product formulations

This study was an experiment with a completely randomized design. The main ingredients used were carrots and navel oranges. All of the ingredients used were gathered from a local market in Jakarta, Indonesia. All the products formulated were sorted and cleaned before formulated into marmalade products. There were five formulations of marmalade, which are displayed in Table 1. The products were then submitted to Saraswati Indo Genetech Laboratory, Bogor, for further analysis.

Table 1: Product formulations

Ingredients	Formulations				
	F1	F2	F3	F4	F5
Navel orange (g)	100	100	100	100	100
Carrot (g)	0	25	50	75	100
Lemon water (ml)	15	15	15	15	15
Pectin (g)	3	3	3	3	3
sugar (g)	60	60	60	60	60

The main ingredients used as a primary ingredient were navel orange and carrot. The usage of navel orange in this study was in high concentration and remained the same in all formulations. The carrot was used as a factor affecting the product with different amounts of addition. Then, lemon water, pectin, and sugar were used as complementary ingredients used in small and remained the same amount in each formulation.

Product manufacturing was including some steps, such as juices preparation, carrot and orange peels shreds preparation, and marmalade making. The juices made by: Carrots were chopped by food processor "Chopper Philips HR-2939 N" and then filtered, while oranges were cut and squeezed. The shreds preparation was done by cleaning the carrot and orange; blanched for about 2–3 min; carrot and orange peels were finely shredded. As the last steps, marmalade was produced by mix both juice with lemon, sugar, and pectin, stirred evenly. Heated the mixture to temperature 70°C while stirring until forming a gel; turn off the stove; added the shreds of carrots and oranges peels. The total amount of carrots and orange used was divided into 50% juice and 50% shreds for each formulation.

Organoleptic properties assessment

About 25 semi-trained panelists assessed the organoleptic properties of marmalade products. The assessment was executed using a visual analog scale; with the scale used was 0–10. The tests included hedonic (color, aroma, taste, texture, and overall) to analyze sensory acceptance and hedonic quality (color, aroma, taste, texture, and overall) characteristics. Hedonic parameters measured from 0 to 10 (dislike – very like) for all parameters. Hedonic quality parameters measured from 0 to 10 for color (very bright orange – very dark orange), aroma (very unpleasant – very pleasant), taste (very bitter – very sweet), texture (very liquid – very thick), and overall (very unattractive – very attractive).

Proximate composition and Brix determination

Proximate compositions were determined by AOAC methods, sub-components of 925.09 (moisture), 923.03 (total ash), 979.09 (crude protein), 962.09 (crude fiber), and 920.29 (fat) [9]. Carbohydrate content was determined by difference calculation [10]. The Brix measured by refractometer [11].

Antioxidant activities determination

The 1,1-Diphenyl-2-picrylhydrazyl (DPPH) measurement was executed with slight modification Molyneux [12]. About 100 μL samples (0.62–4.96 mg/mL) or 19% ethanol or ascorbic acid (as standard) mixed with 50 μL 100 mM Tris-HCl (pH 7.4) and then added with 5 μL 500 M (2.5 mg/mL) DPPH. About 90% of ethanol used as a blank solution, and the DPPH solution without samples was presented as a control. The mixture was then shaken vigorously for 1–3 min and allowed to stand at room temperature for 30 min in dark conditions. The absorbance of the solution was measured using a spectrophotometer with a wavelength of 517 nm. Antioxidant activity is expressed as IC_{50} (half maximal inhibitory concentration). The formula calculates the percentage of free radical inhibitory:

$$\text{Inhibition (\%)} = \frac{\text{Blank absorbancy - sample absorbancy}}{\text{Blank absorbancy}} \times 100$$

Data analysis

Data were managed using Microsoft excel 365 for windows. *SPPS version 20.0* for windows from SPSS Institute Inc., Cary, NC, was used for statistical analysis. The data of organoleptic and proximate composition were analyzed by one-way ANOVA test and separated by Duncan multiple-range tests at p = 0.05.

Results and Discussion

Organoleptic properties

Organoleptic properties were determined by sensory evaluation toward hedonic and hedonic quality measurements. The result of our organoleptic assessment results is summarized in Table 2. We evaluated the hedonic and hedonic quality of five products. The result of hedonic parameters showed significant differences (p < 0.05) on texture, and the hedonic quality obtained substantial differences (p < 0.05) on color, taste, and texture.

Table 2: Organoleptic values of carrot – navel orange marmalade

Parameters	Formulations (mean ± SD)					p-value
	F1	F2	F3	F4	F5	
Hedonic						
Color	4.80 ± 1.94	6.50 ± 1.45	6.50 ± 1.92	6.60 ± 1.12	6.50 ± 1.31	0.06
Aroma	5.34 ± 1.36	5.55 ± 1.88	5.45 ± 2.03	6.07 ± 1.32	5.45 ± 1.57	0.56
Taste	5.70 ± 1.86	6.50 ± 1.69	6.30 ± 1.52	5.90 ± 1.45	6.80 ± 1.87	0.75
Texture	5.86 ± $1.85^{a,b}$	6.57 ± 1.39^{b}	6.19 ± 1.89^{b}	6.18 ± 1.35^{b}	5.16 ± 1.67^{a}	0.04
Overall	5.95 ± 1.27	6.53 ± 1.41	6.37 ± 1.58	6.23 ± 1.22	5.93 ± 1.44	0.47
Hedonic quality						
Color	6.20 ± $2.06^{a,b}$	5.50 ± 2.13^{a}	6.60 ± $2.37^{a,b}$	7.10 ± 1.42^{b}	7.00 ± 1.26^{b}	0.03
Aroma	5.78 ± 1.33	5.45 ± 1.73	5.50 ± 1.87	6.03 ± 1.12	5.52 ± 1.55	0.64
Taste	6.97 ± 1.47^{b}	6.84 ± $1.12^{a,b}$	6.56 ± $1.53^{a,b}$	7.26 ± 1.22^{b}	6.07 ± 1.26^{a}	0.02
Texture	6.80 ± $1.65^{b,c,d}$	7.30 ± $1.53^{b,c,d}$	7.50 ± 1.33^{d}	6.60 ± $1.34^{b,c}$	5.50 ± 1.81^{a}	0.00
Overall	6.00 ± 1.60	6.84 ± 1.40	6.71 ± 1.82	6.52 ± 1.17	5.97 ± 1.38	0.13

The numbers followed by different superscript letters in the same row represent significantly different values (p ≤ 0.05). The parameters measured from 0 to 10

The color of marmalade was ranged from bright orange to dark orange. The more carrots added, the darker the marmalade produced. The brighter color generated was due to the lower addition of the carrot seems to decrease sensory acceptance. Carrots contain beta-carotene, while navel orange is also composed of the carotenoid compound, the type of pigment responsible for the orange color, which influenced the color of food products [13]. Volatile compounds in citrus fruits play an important role in shaping the odor and flavor. Oranges have a distinctive citrus fruit odor [14]. Some of the volatile components of the orange flavors are ethanol, octanol, nonanal, citral, ethyl butanoate, d-limonene, and a-pinene [15]. The addition of carrot decreased the sourness of navel orange marmalade, and the texture of marmalade was influenced by pectin compounds used for a gel-forming synthesis in the manufacture of marmalade.

The addition of the carrot had a significant impact on the organoleptic values. This addition may improve sensory acceptances (hedonic). It can be identified from the value of F1 (0% carrots) obtained the lowest value, among others, in all hedonic parameters. According to the sensory evaluation conducted by the 25 semi-trained panelists, it was revealed that the hedonic or sensory acceptance, marmalade F2 (25% carrot) dedicated as the most acceptable product, among others. Product F2 had a medium bright color, quite pleasant aroma, a little sweet, quite thick texture, and quite attractive.

Proximate compositions and brix

The assessments on proximate parameters were conducted on carbohydrate, protein, fat, water, ash, and fiber, while ºBrix sugar was also measured. The result obtained is displayed in Table 3. The addition of carrots into navel orange marmalade significantly influenced the proximate parameters, that is, carbohydrate, protein, fat, water, ash, and fiber (p < 0.05).

Table 3: Proximate composition and Brix of carrot – navel orange marmalade

Parameters	Formulation (mean ± SD)					p-value
	F1	F2	F3	F4	F5	
Carbohydrate (%)	76.04 ± 0.13^{d}	73.27 ± 0.43^{b}	71.02 ± 0.77^{a}	74.48 ± 0.20^{c}	70.52 ± 0.46^{a}	0.000
Protein (%)	3.10 ± $0.02^{a,b}$	3.15 ± 0.06b	3.64 ± 0.01^{c}	3.21 ± 0.00^{b}	3.00 ± 0.10^{a}	0.000
Fat (%)	<0.02	<0.02	<0.20	<0.02	<0.02	-
Water (%)	20.54 ± 0.11^{a}	23.18 ± 0.38^{c}	24.89 ± 0.77^{d}	21.83 ± 0.19^{b}	25.89 ± 0.36^{d}	0.000
Ash (%)	0.32 ± 0.00^{a}	0.40 ± 0.01^{b}	0.45 ± 0.01^{c}	0.48 ± 0.00^{d}	0.59 ± 0.00^{e}	0.000
Fiber (%)	1.87 ± 0.10^{b}	1.53 ± 0.07^{a}	1.88 ± 0.04^{b}	1.44 ± 0.07^{a}	1.31 ± 0.11^{a}	0.003
Brix (ºBx)	5.12 ± 0.08^{a}	8.45 ± 0.05^{b}	10.20 ± 0.10^{c}	12.50 ± 0.10^{d}	15.14 ± 0.05^{e}	0.000

The numbers followed by different superscript letters in the same row represent significantly different values (p ≤ 0.05)

From the results, it can be seen that the marmalade had high carbohydrates (70.52 ± 0.46–76.04 ± 0.13%), proteins about 3.00 ± 0.10–3.64 ± 0.01%. A very low fat found <0.02% in all formulations since materials used in this product were vegetable and fruit, foodstuffs with very low or do not contain any fat. Then, the waters were about 20.54 ± 0.11–25.89 ± 0.36%, ashes about 0.32 ± 0.00–0.59 ± 0.00 %, and fibers were about 1.44 ± 0.07–1.88 ± 0.04%.

The Brix value seemed in line with the number of carrots added; more carrots caused a higher level of Brix. In this study, also Brix was different at α=0.05, which means the carrot affected this parameter significantly. The Brix indicated the percentage of water-soluble solids in the liquid [16] and was dedicated as one of the essential criteria for liquid food. Brix may indicate the total sugar content due to a linear correlation between Brix and total sugar content. Thus, total sugar content could be calculated from the Brix [17]. The percentage of available sugar was associated with non-reducing sugar and reducing sugar value, Brix, stalk weight, gravity, invertase enzyme, and pH [18], [19]. Another study revealed that Brix significantly correlate to ash content; the greater Brix led to higher ash content, though the ash value also depends on material purity [20]. The same also proved in this study. We revealed a similar pattern between the value of ash and Brix.

Antioxidant activity

Antioxidant activity of carrots – navel marmalade was identified by DPPH methods. The

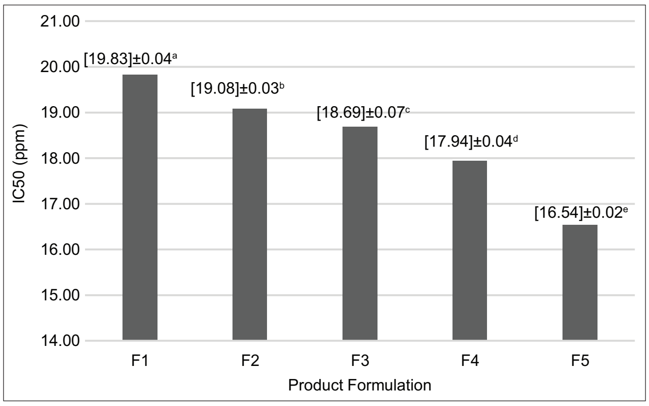

Figure 1: Antioxidant activities of carrot – navel orange marmalade, presented in IC50 (ppm). The numbers followed by different superscript letters represent significantly different values (p ≤ 0.05)

result is displayed in Figure 1. All the products were measured and presented in the half-maximal inhibitory concentration (IC_{50}).

In this marmalade, the antioxidant of marmalade was obtained from the ingredients used in making the product, including navel orange, carrot, and lemon water. Those three are known as antioxidant sources. The navel orange and lemon water contain a high amount of Vitamin C, a powerful antioxidant compound, and carrot contributes to carotenoids, which also act as antioxidant compounds. However, the lemon water used in this study was aimed to improve the taste of the product. It was added as the same amount between formulations and declared as not a treatment factor of the product. Thus, lemon water cannot be a factor affecting differences in antioxidant products.

Besides, responsible for pigmentations, it seems carrots possessed antioxidant substances. The result showed that the more carrots added, the stronger the antioxidant activity was obtained. It can be seen from our result, the IC_{50} value of F1 (0% carrots) < F2 (25% carrots) < F3 (50% carrots) < F4 (75% carrots) < F5 (100% carrots). This value also statistically different each other at α=0.05, means the carrot added at those level were influence the antioxidant of product. Carrots (*Daucus carota*) are a good source of natural antioxidants, such as carotenoids and phenolic compounds, vitamins, and flavonoids [21], [22]. Carotenoid has a polyene backbone consisting of a series of conjugated C=C bonds as primary structural elements responsible for the pigmentation properties and their scavenging effect against free radicals [23]. Furthermore, the phenolic compound consisted may contribute to the free-radical scavenging effect of carrots. A study found that caffeoyl esters were identified as the main compound of phenolics content in freshly shredded carrots [24].

A significant amount of antioxidants are naturally present in orange. Some substances would contribute as the essential antioxidant elements consist of oranges, such as L-ascorbic acid, flavonoids, polyphenolic compounds, and carotenoids [25], [26]. A previous study revealed that Vitamin C is the most crucial antioxidant compound (65–90%) of total antioxidants in orange juice [25].

In our product, carrot – navel orange marmalade, the peel of orange was added to build up the main marmalade characteristics. The orange peel evidence consists of some flavonoids substances. The isolated methanolic extract of orange peel mainly consisting of isolated flavonoid glycosides indicated an antioxidant potential. On quantitative high-pressure liquid chromatography analysis, the major flavonoid glycoside found in orange peel was hesperidin [27]. Therefore, together with hesperidin, Vitamin C contributes to the significant antioxidant from the orange navel in our marmalade products.

Conclusion

The addition of juice and shredded carrot into the orange marmalade (consisting of juice and shredded peel of navel orange) improves the organoleptic values, influences the proximate composition, and increases the Brix of products. Moreover, the more carrot added in orange marmalade may improve the antioxidant activities of marmalade and result in high antioxidant food products.

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