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Chemical and sensory properties evaluations in sea salt fortified with *Moringa oleifera* leaf extract

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Abstract

As a natural ingredient containing many nutrients and beneficial to human health, *Moringa oleifera* leaf extract can be used as a food-fortification ingredient. Fortifying daily seasonings such as salt with *M. oleifera* leaf extract can help to fulfill human daily nutrition requirements and deliver health benefits. This research aimed to study the influence of fortifying sea salt with *M. oleifera* leaf extract on the product's chemical characteristics and sensory properties. *M. oleifera* leaf extract was added into fine salt with different concentrations of 20% and 40% (w/v) and heated at 55°C for 10 mins. The chemical properties were analysed to evaluate the nutritional properties of the product, for instance, β-carotene, vitamin C, moisture and NaCl content. Subsequently, sensory properties are presented to assess product preference from panellists. The result showed that the β-carotene and vitamin C in 20% and 40% treatments were 12.641 to 27.922 µg/kg and 5.06 to 7.392 mg/kg, respectively. The moisture content in control, 20%, and 40% treatments were all below 5%. NaCl content, as the major compound in the product, was affected by adding *M. oleifera* leaf extract into the product. Applying 40% *M. oleifera* leaf extract to the salt significantly decreased the NaCl content of the product compared with 20% treatment and control. All sensory properties attributes have decreased as an increase of *M. oleifera* leaf extract concentration. Compared with the 40% treatment, the 20% treatment showed a higher value of sensory properties. A preference for salt fortification was also shown at the 20% treatment in the neutral midpoint. Thus, an additional 20% of *M. oleifera* leaf extract provided higher nutritional content than the control and was more acceptable to consumers than the 40% treatment.

1. Introduction

Salt is one of the essential mineral components of a healthy diet, used in food preparation and food manufacturing processes which is added at the table or during cooking. Physically, salt is a white crystal with the largest chemical compound being sodium chloride (NaCl >80%) (Durack *et al*., 2008; Sumada *et al*., 2018). The elements of sodium and chloride include types of macro minerals needed by the human body in large quantities (> 100 mg/day). Sodium is the main cation in extracellular fluid in the body. With chlorine, sodium helps the movement of nerve impulses, maintains body fluid balance, and regulates heart rate (Grillo *et al*., 2019). According to the World Health Organization's recommendation (WHO, 2012), the limit of sodium intake to less than 2,300 mg per day or equal to about 1 teaspoon of table salt.

Globally, salt has been fortified with iodine as the preferred approach to addressing iodine deficiency in the human population (Thoma *et al*., 2011). Double fortification of salt with iodine and iron has been reported (Shields and Ansari, 2021) to prevent iron anemia deficiency. Modupe *et al*. (2019) reported on the triple fortification of salt with folic acid, iron and iodine. The fortified salt was formulated by spraying a solution and adding encapsulated ferrous fumarate. Improvement in the nutritional content of table salt and its economic value is needed by adding extracts of natural ingredients that are abundant in Indonesia. Also, salt is ideally suitable for fortification to overcome many nutritional deficiencies because it is consumed widely and regularly. The main concern of the fortification process is effective,

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bio-available, acceptable and affordable fortificant. The product should be easily accessible and should be regularly consumed in the local diet. Furthermore, detailed composition in the product must exist and be enforced by law (Nantel, 2001).

Health is the main priority that affects fitness and physical appearance and is a priceless treasure. Nutrients required for the body to function and maintain overall health consist of energy substances (carbohydrates, starch), building blocks (protein), and regulatory substances (vitamins, minerals, water) (Lukaski, 2004; Cavill *et al*., 2006).

Several herbs of nature help in restoring the balance of the body and maintaining good health. Based on Fuglie (2001), *M. oleifera* leaves are an excellent source of beta carotene (four times the amount in carrots), vitamin C (seven times the amount in oranges), vitamin B, calcium (four times the amount in milk), iron (twenty-five times the amount in spinach), protein (twice the amount in milk), potassium (three times the amount in bananas) and more than 40 antioxidants and also various other important minerals. *Moringa oleifera* leaves are among the best of eternal tropical vegetables. Dhakar *et al*. (2011) and Offor *et al*. (2014) reported that there are about 300 diseases that can be cured by consuming or using *M. oleifera* plant-based supplements. In addition, the *M. oleifera* plant, which is easily found on Madura Island - Indonesia, can grow quickly and is very tolerant in extreme climates, has attracted researchers to crude extract *M. oleifera* leaves using water extraction as ingredients for the fortification of table salt. Crude extract of *M. oleifera* leaves have high phytochemicals contents, hypocholesterolemic agent, antioxidant and anti-inflammatory activity such as alkaloids, phenols, glycosides and terpenoids (Yong-Bing *et al*., 2019). In this study, salt was fortified by using crude *M. oleifera* leaf extract as an additive with different concentrations. The objective of this research was to study the influence of fortifying sea salt with *M. oleifera* leaf extract on the chemical characteristics and sensory properties of the product.

2. Materials and methods

2.1 Chemicals and reagents

All the solvents and chemicals used in this study were of analytical grade and were obtained from Merck.

2.2 Samples collection

Fresh leaves of *M. oleifera* were collected from Bangkalan Regency, Madura Island, East Java Province, Indonesia. The leaves were removed from branches, spread on a plastic tray and air-dried at room temperature for a week. The premium quality of coarse salt was obtained from salt farmers in Madura Island. Coarse salt (360 g) was diluted in 1 L of distilled water and crystallized into fine salt.

2.3 Moringa oleifera leaf extraction

Dried *M. oleifera* leaves were ground to a fine powder in a mechanical blender. The powders (200 g) were mixed well with 1 L distilled water and stored at 4°C for 3 days as suggested by Ali *et al*. (2015) with slight modifications. The moringa extract was then filtered through a 40-mesh screen (Whatman, Germany) and stored at -20°C until use.

2.4 Preparation of the product

Moringa oleifera extract was added to 100 g of fine salt with different concentrations of 20%, and 40% (w/v) at 55°C for 10 mins. The control sample was fine salt without moringa extract. Fortified salts were analyzed for β-carotene, vitamin C, NaCl content, moisture content and organoleptic tests. All treatments were conducted in three replicates.

2.5 Physicochemical and sensory evaluation of products

2.5.1 Moisture content

Fortified salt (5 g) was put into a petri dish of known weight and then put into an oven pre-set at 110°C for 3 hrs. The sample was cooled in desiccators and reweighted, then returned to an oven at 110°C for 30 mins until a constant weight was obtained (Horwitz, 2006).

$$\text{Moisture content (\%)} = \frac{\text{weight of initial sample} - \text{weight of final sample}}{\text{weight of initial sample}} \times 100$$

2.5.2 Sodium chloride content

Fortified salt (5 g) was put into a 250 mL Erlenmeyer flask, and approximately 150 mL of distilled water was added to it. The samples were then homogenized and quantitatively transferred into a 100 mL beaker, 1 mL of chromate indicator was added to it and the sample was titrated with 1 M silver nitrate solution. The endpoint of the titration was identified as the first appearance of a red-brown colour of silver chromate (American Society for Testing and Materials (ASTM), 2012).

$$\text{Sodium Chloride Content (\%)} = \frac{V \times M \times MW \times Df}{SW \times 10} \times 100$$

where, V = volume of silver nitrate used for titration (mL), M = Calculated molarity of silver nitrate solution, MW = Molecular weight of sodium chloride, Df = Dilution factor, SW = Sample weight (g) and 10 = correction factor to give percentage value.

2.5.3 Vitamin C content

Fortified salt (10 g) was dissolved in 100 mL of distilled water and homogenized. The filtrate samples of 10 mL were taken out and put into an Erlenmeyer flask. Then, the solution was added with 1 mL of starch and 10 mL of distilled water. The titration process used 0.01 N iodine standard solution until a blue colour endpoint was formed. Vitamin C content was calculated based on: 1 mL of 0.01 iodine = 0.88 mg of ascorbic acid (Riscahyani *et al*., 2019).

2.5.4 β-Carotene content

Fortified salt was analyzed for β-carotene content according to Biswas's method (Biswas *et al*., 2011) with slight modifications. Sample (1 g) was accurately weighed in a glass test tube to which 3 mL of acetone was added and vortexed at a high speed for 1 min. Then, 3 mL ether was added to the sample and vortexed for 10 min. The supernatant was collected into a separate test tube and the compound was vortexed with 3 mL ether once again as above. The absorbance of the sample was determined at 450 nm wavelength in a UV-Vis spectrophotometer (Shimadzu UV-VIS 2700 Spectrophotometer).

2.5.5 Sensory evaluation

Sensory evaluation of fortified salt was carried out by employing 30 untrained panellists from university staff using a numeric scoring system of a hedonic scale. They were asked to score their preferences for sensory attributes such as colour, texture, taste, flavour, and appearance of sea salt fortified with Moringa extract. The range of scores was from 1 (disliked extremely), 2 (dislike moderately), 3 (neither like nor dislike), 4 (liked moderately) and 5 (liked extremely) using questionnaire sheets as followed by Saeed *et al*. (2020).

2.6 Statistical analysis

The obtained data were analyzed using Analysis of Variance (ANOVA) and performed by R programming language version 4.1.1. Duncan's test was performed to calculate multiple comparisons for the data. All differences were considered significant at $P<0.05$.

3. Results and discussion

3.1 Chemical properties

Table 1 shows the chemical properties of the control and treatment salts. These results indicate the addition of leaf extract of *M. oleifera* has a significant effect on the levels of β-carotene, vitamin C, moisture content and NaCl in the salt. The results of β-carotene in control and treatments showed significantly different results ($P<0.05$). Control salt did not contain β-carotene, while β -carotene was present in 40% treatment (27.922 µg/kg) followed by 20% (12.641 µg/kg), respectively. The content of β -carotene in the salt treatments is due to the fortification process of the leaf extract of *M. oleifera* into the salt. The results of previous studies proved that the leaves of *M. oleifera* are rich in β–carotene (37800 µg/100 g) (Joshi and Mehta, 2010). It has been previously reported that the addition of *M. oleifera* has a significant effect on the β-carotene content in bread (Sengev *et al*., 2013) and muffins (Srinivasamurthy *et al*., 2017). β-carotene is a source of provitamin A which is beneficial for free radical scavenging, normal growth, immune function, and vision (Grune *et al*., 2010).

Salt fortified with *M. oleifera* leaf extract showed a significantly higher yield ($P<0.05$) in vitamin C content. The highest vitamin C content was indicated by the 40% treatment of 5.060 mg/kg, then the 20 % and control treatments with 7.392 mg/kg and 0 mg/kg, respectively. The content of vitamin C in the treated salt occurs because it has been fortified using *M. oleifera* extract. This is in agreement with the results of Srinivasamurty's research (2017), where the addition of *M. oleifera* leaf powder to muffins has been shown to have a significant effect ($P<0.05$) on the increase in vitamin C content. *Moringa oleifera* leaves have been reported to be rich in β-carotene, vitamin C, protein, calcium and potassium which are good sources of antioxidants, fats and several antioxidant compounds such as carotenoids, ascorbic acid, flavonoids, and phenolics (Siddhuraju and Becker, 2003). The content of vitamin C in *M. oleifera* is seven times greater than the content of vitamin C in oranges (Fuglie, 2005). Joshi and Mehta (2010) reported that the vitamin C content in the dehydrated *M. oleifera* leaf with the sun-dried sample was 92 mg/100 g, shadow dried sample was 140 mg/100 g, and the oven-dried sample was 56 mg/100 g.

Table 1. Composition of β-carotene, vitamin C, moisture content and NaCl of salt fortified with *M. oleifera* leaf extract.

Treatment	β-carotene (µg/kg)	Vitamin C (mg/kg)	Moisture Content (%)	NaCl (%)
Control	$0.000±0.000^{a}$	$0.000±0.000^{a}$	$4.830±0.001^{a}$	$91.260±2.026^{a}$
20%	$12.641±0.657^{b}$	$5.060±0.025^{b}$	$3.456±0.014^{b}$	$87.260±1.472^{ab}$
40%	$27.922±0.560^{c}$	$7.392±0.001^{c}$	$3.460±0.018^{b}$	$84.823±1.630^{b}$

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different based on Duncan Multiple Range Test (DMRT) results with α = 0.05.

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According to Table 1, the moisture content of all control and treatments was below 5%. The salt moisture content in salt in this study was higher than the result of Maflahah and Asfan (2020) who reported moisture content in dragon fruit peel salts of 0.79%. The moisture content in the control and treatments showed a significant difference (P<0.05). In the treatments, the moisture content was significantly lower than in the control. This condition is because of the heating method in fortification processing, causing water in raw material to evaporate and triggering low moisture content in treatments. According to Gao *et al*. (2014), heating could cause salt moisture content to decrease. In their study, the moisture content of solar salt (10.9%) was higher than roasted salt (0.18%).

The moisture content of concentrations between the 20% and 40% treatments did not differ significantly (P>0.05). This is due to the same temperature treatment and heating time of 20% and 40% treatments. Therefore, the water content contained between treatments did not differ significantly.

Table 1 shows that the NaCl levels in the control salt were the highest and the lowest in the 40% treatment salt. The control NaCl levels were significantly different to the 40% treatment and were not significantly different from the 20 mL treatments. The value of NaCl levels in the control, treatment of 20%, and 40% were 91.260%, 87.260%, and 84.823%, respectively. NaCl as the major compound in the product were affected by the addition of *M. oleifera* leaf extract. Applying 40% *M. oleifera* leaf extract to the salt significantly decreased the NaCl content of the product compared with 20% treatment and control. NaCl content in natural sea salt ranges from 90-98% (Kirchner and Fisher, 2009). NaCl is one of the main compounds that act as a contributor to sodium in salt. Health concerns promote to consume of low sodium salt as high daily sodium intake can cause an increase in blood pressure in the body (WHO, 2012).

3.2 Sensory analysis

The sensory properties of salt fortified with *M. oleifera* have been shown in Table 2. All sensory analysis properties including color, texture, taste, odor and appearance showed a significant difference (P<0.05). Overall, the preference for salt fortified with *M. oleifera* was decreased when the concentration of *M. oleifera* leaf extract was increased. This was found to be in accordance with Sengev *et al*. (2013), where the addition of *M. oleifera* leaf powder significantly decreased preference in all evaluated attributes. In addition, the best preference was given to control.

According to the DMRT result, the color score was affected significantly by the concentration of *M. oleifera* leaf extract (P<0.05). In addition, the color score of the control was 5.000 (scale 1 to 5), which is higher than 20 and 40% treatments by 1,627 and 2,520, respectively. The higher concentration of *M. oleifera* extracts reduced the color score due to the color of the salt becoming dark green and not being attractive to the panelists. Based on Otunola *et al*. (2013), the lowest score of color was performed by cookies with a high proportion of *M. oleifera* powder. A similar result had been reported by various researchers (Otunola *et al*., 2013; Sengev *et al*., 2013; Kuikman *et al*., 2015), where they reported diminished color scores in yogurt, muffin and bread because of the increase of *M. oleifera* proportion in the products.

The results of the texture score in the control, 20%, and 40% were found to be 4.00, 3.280 and 2.413, respectively. The texture scores in all controls and treatments were found to be significantly different (P<0.05). Control salt had the highest acceptance compared to the others, while the texture in the 20% treatment had a higher acceptance than 40%. A similar result was reported by Kuikman and O'Connor (2015), where the texture score of Moringa yogurt was the lowest than other treatments such as Moringa-banana, Moringa-sweet potato and Moringa-avocado yogurt. Hekmat *et al*. (2015) elucidated that the addition of 1% *M. oleifera* in yogurt had the lowest score than another treatment.

The taste score has the same pattern as the texture. The control taste score was significantly higher than the treatments, while the texture score in the 20% treatment was significantly higher than the 40% treatment. The taste score for the control salt was 3,778, while the 20% and 40% treatments were 3,093 and 2,400, respectively. The odor scores with 40% (2.893) treatment showed a significantly lower value than the control (3,656) and 20% treatment (3,333). It is shown that based on the odor

Table 2. Sensory properties of salt fortified with *M. oleifera* leaf extract.

Treatment	Color	Texture	Taste	Odour	Appearance
Control	5.000±0.694^a	4.000±0.350^a	3.778±0.192^a	3.656±0.000^a	4.111±0.000^a
20%	3.373±0.460^b	3.280±0.378^b	3.093±0.083^b	3.333±0.183^a	3.480±0.266^a
40%	2.480±0.257^c	2.413±0.061^c	2.400±0.423^c	2.893±0.234^b	2.227±0.320^b

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different based on Duncan Multiple Range Test (DMRT) results with α = 0.05.

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results, the control and 20% were more receptive compared to the 40% treatment. In other words, the gradual decrease of taste and odor scores was due to the increase in the concentration of *M. oleifera* leaf extract in salts. Hekmat *et al*. (2015) revealed that the addition of 1% *M. oleifera* has shown a reduction in the flavor score of yogurts. The high proportion of *M. oleifera* in food fortification caused the herbal smell and intense green color in the product (Hekmat *et al*., 2015; Grosshagauer *et al*., 2021; Soni and Kumar, 2021).

The appearance score of salts was affected significantly by the addition of *M. oleifera* leaf extract. As seen in Table 2, there was a steady decrease of salts appearance scores caused by the increase in *M. oleifera* leaf extract concentration. The appearance scores in control, 20% and 40%, respectively, were 4.11, 3.480 and 2.227. Then, the appearance scores in control and 20% were significantly different ($P<0.05$) against 40%. While the appearance in the control and 20% was not significantly different ($P>0.05$). Generally, based on the sensory properties results, the salt fortified with 20% *M. oleifera* is acceptable to panelists compared with 40% treatment.

4. Conclusion

Applying *M. oleifera* leaf extract for salt fortification influenced the chemical properties of the salt. The addition of *M. oleifera* leaf extract concentration significantly led to an increase in β-carotene and vitamin C in the product. Moreover applying 40% *M. oleifera* leaf extract to the salt significantly decreased the NaCl content of the product. All attributes of sensory properties were found to decrease with an increase in *M. oleifera* leaf extract concentration. The 20% treatment showed a higher value of sensory properties. An additional 20% of *M. oleifera* leaf extract gives more nutritional content than the control and a more acceptable consumer attitude than 40% treatment.

Conflict of interest

The authors declare no conflict of interest.

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