Viscosity, fat content, total acidity, and antioxidant capacity of reduced-fat mayonnaise made with Watermelon (*Citrullus lanatus*) rind flour as stabilizer

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Abstract. Reduced-fat mayonnaise should have an oil content of below 70%. In order to improve the quality of reduced-fat mayonnaise, a stabilizer should be included. Watermelon (*Citrullus lanatus*) rind flour is a fruit waste containing antioxidants, fats, and carbohydrates, and has the potency to be used as an alternative stabilizer for processed food. The objective of this study was to determine the effect of watermelon rind flour on the viscosity, fat content, total acidity, and antioxidant capacity of reduced-fat (50% fat) mayonnaise. A completely randomized design was used in this study. The treatments were 2%, 4%, and 6% of watermelon rind flour addition and replicated four times. The results showed that mayonnaise viscosity, fat content, and antioxidant capacity were significantly affected (P<0.01) by the addition of watermelon rind flour without altering total acidity. In conclusion, the addition of watermelon rind powder at 6% to reduced-fat mayonnaise increased its antioxidant capacity and almost achieved the viscosity of the original (full-fat) mayonnaise.

1. Introduction

Mayonnaise is a condiment used as dressing with a distinctive tangy taste, white appearance, thick, and creamy texture. Most commercial mayonnaise available in the market is full-fat mayonnaise. The typical fat content of full-fat mayonnaise is above 70%. Although it is made from vegetable oil, customers still worries about its impact on health, e.g., increasing the risk of cardiovascular disease and obesity. Reduced-fat mayonnaise is then introduced to the market as an alternative product to fulfill customer needs.

Reduced-fat mayonnaise is formulated by replacing some of the oil with non-fat ingredients that can maintain the quality of mayonnaise, both physically, chemically, and organoleptically [1]. However, poor viscosity and reduced nutritional content would be achieved when fat replacer cannot to maintain viscosity and lack nutrition. This can be overcome by adding an ingredient that can replace fat for improving both viscosity and nutritional value of reduced-fat mayonnaise.

Watermelon is a tropical fruit that is widely distributed in the world. Watermelon is characterized by its outer skin appearance, which has dark green and light green stripes and is included in the family of cucumber (*Curcubitaceae*). The watermelon is divided into three major parts, i.e., the rind, the flesh, and the seeds. The proportion of each part is 68% for the flesh, 30% for the rind, and only 2% for the seeds [2]. Watermelon rind is a food waste that is rarely consumed. It contains 10.61% of moisture,
13.09% of ash, 2.44% of fat, 11.17% of protein, and 56.00% of carbohydrates [3]. There are many types of carbohydrates, including pectin, making up the structure of watermelon rind.

Pectin is a polysaccharide that is included in the hydrocolloid compound. Watermelon rind contains 13% of pectin [4]. Pectin can be used as a gelling agent for thickening and stabilizing food [5] and as an emulsifying agent [6]. Pectin levels in the albedo of watermelon rind are about 3.10% higher than tamarillo pectin levels (1.86%) [7]. Pectin would aid in texture and affect the viscosity of mayonnaise.

Apart from pectin, watermelon rind also contains antioxidants and fat. The most abundant antioxidants found in watermelon rind are citrulline and lycopene. Watermelon is a good source of amino acids, vitamin C, citrulline, beta carotene as precursors of vitamin A, potassium, and antioxidants such as lycopene [8].

Based on the properties of watermelon rind, it is possible to add watermelon rind in the form of flour to reduced-fat mayonnaise. The objective of this study was to determine the effect of watermelon rind flour on reduced-fat mayonnaise on the viscosity, fat content, total acidity, and antioxidant capacity of the mayonnaise.

2. Material and method

2.1. Material

The research materials used were mayonnaise made from soybean oil (70% (control full-fat), 50% (reduced-fat)), egg yolk (20%), vinegar (5%), sugar (3%), salt (1%), ground white pepper (0.5%), and mustard (0.5%). Watermelon rind flour was prepared by drying the fresh rind and grinding. The watermelon rind flour was added according to the treatment.

Research materials for variable testing include 0.1 N NaOH, phenolphthalein indicator, distilled water, 2,2-diphenyl-1-picrylhydrazyl (DPPH) reagent solution, methanol, quercetin, and n-hexane. The research tools used include analytical scales, beaker glass, measuring cups, erlenmeyer, burette, spectrophotometer, measuring flask, vortex, test tube, fat extraction flask, filter cloth, condenser, and rotary evaporator, while the tools for making mayonnaise include mixers, analytical scales, basin, and spatula.

2.2. Method

The research method used was a completely randomized design using 1 control group, 3 treatment groups, and 4 replications as shown in Table 1.

| Group name | Description |
|------------|-------------|
| Control    | Full-fat mayonnaise with 70% oil |
| RF2        | Reduced-fat mayonnaise with the addition of 2% watermelon rind flour and 50% oil |
| RF4        | Reduced-fat mayonnaise with the addition of 4% watermelon rind flour and 50% oil |
| RF6        | Reduced-fat mayonnaise with the addition of 6% watermelon rind flour and 50% oil |

2.3. Watermelon rind flour preparation

Watermelon rind flour was prepared from fresh red watermelon purchased from a local market. The watermelon was split into two parts and then the flesh was removed. The outer part of the watermelon rind was peeled off and the albedo was used for making flour. The albedo was cut into 2 × 2 cm sizes, dried in the oven for 4 d at a temperature of 60°C or until the final weight was stable. The moisture content of the flour was limited to 10% and measured using a moisture balance. Dried albedo was then ground, sieved using a 90 mesh sieve, and packed for the further use.
2.4. Mayonnaise manufacture
Soybean oil was used for the control (70%) and the treatment groups (50%). Other ingredients used were egg yolk (20%), vinegar (5%), sugar (3%), salt (1%), pepper (0.5%), mustard (0.5%), and watermelon rind flour according to the treatment groups. The sugar, salt, pepper, and mustard were mixed at speed 1 (using a mixer) for 1 min until well-mixed. After that, the spices were mixed with egg yolk (2/3 part) and beaten at speed 2 (using a mixer) until the yolk color turned into a whitish-yellow and foamed. Oil, vinegar, and the remaining egg yolk were then mixed at speed 2 (using a mixer). Lastly, the watermelon rind flour was added and mixed with mayonnaise according to the treatment groups. Reduced-fat mayonnaise was put into the container and stored for 24 h for analyses [9].

2.5. Data analysis
Data were analyzed using a one-way analysis of variance (ANOVA). The mean value of each group was separated using Duncan’s multiple range test at a 95% significance level.

3. Result and discussion

3.1. Viscosity
The results of the analysis of variance showed that the addition of watermelon rind flour increased the viscosity of the reduced-fat mayonnaise significantly (P<0.01). The mayonnaise viscosity can be measured using a viscometer and/or rheometer [12]. Table 2 showed that a higher addition of watermelon rind flour resulted in a higher viscosity. The viscosity values ranged from 3177.5 to 3805 cP.

| Table 2. The viscosity of the mayonnaise |
|-----------------------------------------|
| Group | Viscosity (cP) |
|-------|----------------|
| Control | 3,805.0±77.24d |
| RF2 | 3,177.5±66.02a |
| RF4 | 3,367.5±88.08b |
| RF6 | 3,580.0±60.55c |

Data are presented as mean ± standard deviation.

The mean value of each group was separated using Duncan’s multiple range test at a 95% significance level.

Watermelon rind flour can be used as a thickener which affected the viscosity of the mayonnaise. The more watermelon rind flour was added in this study, the viscosity would be thicker. Watermelon rind flour contains fiber. Dietary fiber is a carbohydrate polymer that can be classified into two types, namely water-soluble fibers (pectin and some hemicelluloses), water-insoluble fibers such as cellulose, lignin, and resistant starch. The pectin content in the watermelon rind is about 13% [4]. Pectin can be used as a gelling agent for thickening and stabilizing [5] and as an emulsifying agent [6] for food.

The highest addition level, 6%, of watermelon rind flour resulted in a thicker mayonnaise in this study as compared with other treatment groups. The viscosity of RF6 was close to that of control. The viscosity of mayonnaise affected the texture, moisture content, and droplets of mayonnaise. Reduced-fat mayonnaise used 50% soybean oil and that oil was replaced with the carbohydrate-rich ingredients that improved the viscosity of the mayonnaise. The reduction of oil can reduce viscosity and textured liquid [13]. As watermelon rind flour contained pectin, the thickening, stabilizing, and emulsifying effects of pectin improved the viscosity of the reduced-fat mayonnaise. This is the same as amylpectin and amylose in the banana peel flour [25] and elephant foot yam flour [26]. Mayonnaise added with elephant foot yam flour as a stabilizer had a viscosity ranges from 1,686 to 3,153 cP [26]. RF6 had a viscosity level close to the control compared to other treatments.
3.2. Total acidity
The results of the analysis of variance showed that the addition of watermelon rind flour to reduced-fat mayonnaise had no significant effect on total acidity. Table 3 showed a change in the mean values of total acidity of the mayonnaise added with watermelon rind flour. A higher watermelon rind flour addition resulted in lower total acidity value. The average total acidity values ranged from 0.63% to 0.94%.

Table 3. Total acidity of the mayonnaise.

| Group†  | Total acidity (%) |
|---------|-------------------|
| Control | 0.94±0.05         |
| RF2     | 0.88±0.08         |
| RF4     | 0.70±0.06         |
| RF6     | 0.63±0.06         |

Data are presented as mean ± standard deviation.
†The treatments refer to Table 1.

The addition of watermelon rind flour decreased total acidity of the mayonnaise slightly. If the pH value is high, the H⁺ ion is few and if the pH value is low, the H⁺ ion will increase [14]. The total acidity of the mayonnaise might be influenced by the presence of vitamin C from the watermelon rind flour. The total acidity and pH value are inversely proportional, where if the pH approaches alkaline condition, the total acidity is getting lower. If the pH is increasingly acidic, the total acidity is higher. The addition of alkaline flour can reduce acidity [25]. This is in accordance with the results from this study that the watermelon rind flour had an alkalinizing effect thus slightly reducing total acidity.

3.3. Fat content
The results of the analysis of variance showed that the addition of watermelon rind flour to reduced-fat mayonnaise had a very significant effect on decreasing fat content (P<0.01). Table 4 showed a change in the mean values of fat content of the mayonnaise added with watermelon rind flour. A higher watermelon rind flour addition resulted in lower fat content. The average fat content ranged from 51.90% to 71.94%.

Table 4. Fat content of the mayonnaise.

| Group†  | Fat content (%) |
|---------|-----------------|
| Control | 71.94±0.74c     |
| RF2     | 55.00±0.65h     |
| RF4     | 53.41±0.89ab    |
| RF6     | 51.90±0.43a     |

Data are presented as mean ± standard deviation.
†The treatments refer to Table 1.
abc Different superscripts indicate the differences among groups (P<0.01).

The fat content of the mayonnaise was from the oil used, egg yolk, and the addition of watermelon rind flour. The highest fat content was contributed from soybean oil as the main ingredient of mayonnaise. Soybean oil contains triglycerides and polyunsaturated fatty acids [15]. Soybean oil has a very high content of unsaturated fatty acids such as oleic acid and linoleic acid [16]. The main fatty acids are saturated palmitic carbonoxide, stearic acid, unsaturated oleic acid, and linoleic acid. Apart from soybean oil, watermelon rind also contributes to fat content. However, the fat content of watermelon rind flour is not that much. The fat content of the watermelon rind was 2.44% [3]. A higher addition of watermelon rind flour resulted in lower fat content. This was because the watermelon rind flour absorbs more oil and the proportion of total solid was replaced by the addition of carbohydrate.

Watermelon rind flour can bind up to 4 g of oil [17]. The difference in the value of fat content between the control and other treatments was the oil content used in the mayonnaise. The control treatment used 70% oil without the addition of watermelon rind flour and the treatment RF2-RF6 used
50% oil with the addition of watermelon rind flour. The more watermelon rind flour was added, the less fat content will be produced. The mayonnaise with the addition of porang flour as a stabilizer has a fat content of around 37.68-56.19% [26].

3.4. Antioxidant capacity

The results of the analysis of variance showed that the addition of watermelon rind flour to reduced-fat mayonnaise had a very significant effect on increasing antioxidant capacity (P<0.01). The average value of mayonnaise antioxidant content with the addition of watermelon rind flour is presented in Table 5. Table 5 showed a change in the mean value of mayonnaise antioxidant capacity of the product. A higher watermelon rind flour resulted in higher the antioxidant capacity. The mean value of the antioxidant capacity ranged from 51.64% to 74.02%.

Table 5. Antioxidant capacity of the mayonnaise.

| Group† | Antioxidant capacity (%) |
|--------|--------------------------|
| Control | 51.64±0.93a |
| RF2     | 68.88±0.87b |
| RF4     | 71.57±0.77c |
| RF6     | 74.02±0.38d |

Data are presented as mean ± standard deviation.
†The treatments refer to Table 1.
abc,d Different superscripts indicate the differences among groups (P<0.01).

The addition of watermelon rind flour at 6% caused higher antioxidant levels than other treatment groups. The antioxidant capacity of the control had the lowest value because the antioxidants only came from the oil and other ingredients, while the treatment groups used the watermelon rind flour which contains antioxidants. The albedo of watermelon rind has citrulline as an antioxidant [18]. The citrulline concentration in watermelon rind ranges from 2 to 20 mg/g dry matter [19]. This citrulline compound in the watermelon rind is 60% higher compared to other fruits [20]. Citrulline is converted into other amino acids, namely arginine for the precursor of nitric oxide [21].

Apart from citrulline, the antioxidant substance contained in watermelon rind flour is lycopene. Lycopene is an antioxidant that is beneficial for skin health [22]. Plants have a cell wall that can function as a barrier to intracellular substances such as volatile compounds (phenols and flavonoids) and dyes [23]. Flavonoids, terpenoids, and phenolic compounds can significantly influence the antioxidant effect [24]. Therefore, watermelon rind flour addition increased the antioxidant capacity of reduced-fat mayonnaise.

4. Conclusion

The addition of watermelon rind flour at 6% to reduced-fat mayonnaise provided a viscosity value of 3,580.0 cP, a total acidity of 0.63%, an antioxidant capacity of 74.02%, and a fat content of 51.90%. It can be concluded that watermelon rind flour can be used as a stabilizer for manufacturing reduced-fat mayonnaise.

References
[1] Lee I, Lee S, Lee N and Ko S 2013 Reduced Fat Mayonnaise Formulated with Gelatinized Rice Starch and Xanthan Gum. Cereal Chem. 90 29–34
[2] Kumar P 1985 Watermelon-utilization of Peel Waste for Pickle Processing. Indian Food Packer. 39 49–52
[3] Al-Sayed H M A and Ahmed A R 2013 Utilization of Watermelon Rinds and Sharlyn Melon Peels as a Natural Source of Dietary Fiber and Antioxidants in Cake. Annals of Agricultural Science. 58 83–95
[4] Saragih M A, Johan V S and Pato U 2017 Pengaruh penambahan kelopak rosella terhadap mutu sensori permen jelly dari albedo semangka. Jurnal Online Mahasiswa Fakultas Pertanian
Development of the metabolic syndrome in Zucker diabetic fatty rats mayonnaise formulations prepared with watermelon pomace juice enhances arginine availability and ameliorates biological activities.

Optimization of polysaccharides extraction from watermelon rinds: Structure, functional and sensorial properties of reduced fat mayonnaise formulations prepared with rice starch and starch gum mixtures. *Emirates Journal of Food and Agriculture* **27** 463–8

Febriningrum P N 2013 Pengaruh konsentrasi substrat kulit nanas dan kecepatan pengadukan terhadap pertumbuhan Lactobacillus plantarum untuk produksi asam laktat. *Jurnal Rekayasa Kimia dan Lingkungan* **9** 144–51

Karasulu H Y, Karasulu E, Buyukhelvacigil M, Yildiz M, Ertugrul A, Buyukhelvacigil K, Ustun Z and Grael N 2011 Soybean Oil: Production Process, Benefits and Uses in Pharmaceutical Dosage Form, Soybean and Health (Intech Open)

Jokic S, Sudar R, Svilovic S, Vidovic S, Bilic M, Velic D and Jurkovic V 2013 Fatty acid composition of oil obtained from soybeans by extraction with supercritical carbon dioxide *J. Food Sci.* **31**(2) 116–125

Romdhane M B, Haddar A, Ghazala I, Jedoud K B, Helbert C B and Ellouz Chaabouni S 2017 Optimization of polysaccharides extraction from watermelon rinds: Structure, functional and biological activities. *Food Chemist.* **21** 355–64

Ismayani, Bahri S and Nurhaeni 2013 Kajian kadar fenolat dan aktivitas antioksidan jus kulit buah semangka (Citrullus lanatus) *Online Journal of Natural Science* **2**(3) 100–10

Perkins-Feazie P and Collins J K 2004 Flesh quality and lycopene stability of freshcut watermelon. *Postharvest Biology and Technology* **31** 159–66

Guoyao W, Julie K C, Veazie P P, Dolan K D, Kelly K A and Meiningen J C 2007 Dietary supplementation with watermelon pomace juice enhances arginine availability and ameliorates the metabolic syndrome in Zucker diabetic fatty rats *Am. Society Nutr.* **6** 334–41

Yadla A K, Baig M S, Aishwarya, Alekhya, Nirmala, Teja N, Venkatesh and Sandhya M 2013 Development of watermelon rind incorporated fruit butter *International Journal of Engineering Research and Technology (IJERT)* **2** 70–75

Mawarni A N and Fihriyah N H 2015 Pengaruh Konsentrasi Starter terhadap Kadar Asam Laktat dalam Pembuatan Fruithurt dari Kulit Buah Semangka *Seminar Nasional Sains dan Teknologi* (Jakarta : Fakultas Teknik Universitas Muhammadiyah) pp 1–5

Santhawan S and Anprung P 2014 Enzymatically depolymerized mangosteen aril pectin as a stabilizer for low cholesterol mayonnaise *Int. Food Res. J.* **21** 999–1009

Gomes I A, Lindenblatt C T, Masson L M P, Gomes F D S, Freitas-Silva O and Silva P L 2016
Effect of oregano essential oil on oxidative stability of low-acid mayonnaise *IOSR Journal of Pharmacy* **6** 45–52

[25] Evanuarini H and Susilo A 2020 The Quality of Low Fat Mayonnaise Using Banana Peel Flour as Stabilizer. *The 4th Animal Production International Seminar* **478** 012091

[26] Evanuarini H, Nurliyani, Indratiningsih and Hastuti P 2015 Characteristic of low fat mayonnaise containing porang flour as stabilizer *Pakistan Journal of Nutrition*. **14** 392–95