# Formulation Techniques and Variations of CMC (Carboxymethyl Cellulose) Concentrations to Improve on Making Gluten-Free Corn Macaron

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**Abstract.** Macaron a bakery product with the raw main-based material almond flour. Almond flour is quite expensive. One alternative that can be used as raw material for making macaron is corn flour to improve the characteristics of macaron from corn flour add a food additive in the form of CMC (Carboxymethyl Cellulose). The purpose of this research activity to implement formulation techniques and variations in the addition of CMC concentrations to the characteristics of gluten-free corn flour macaron. The research activity was carried out using two repetitions with a Completely Randomized Design. The treatments used were almond flour macaron, corn macaron, and the addition of CMC (1, 2 and 4%). Based on the results of the study, different physical characteristics were obtained between treatments. Color values (L, a, b, C) of macaron between treatments showed different results. Treatment of different formulas and concentrations of CMC addition resulted in different thickness/weight and diameter/weight ratios. The texture value of the almond macaron hardness parameter has the same statistical characteristics as corn flour macaron added with 2 and 4% CMC. The protein and fat content of almond flour macaron is still higher than that of corn flour macaron according to the proximate content of the flour raw material used.

## 1 Introduction

One of the snack products that has been increasingly popular in society is Macaron. Macaron belongs to the dessert class originating from Italy and further modified in France [1,2]. Macaron is a form of bakery product that belongs to the category of cookies made from meringue and almond flour with various sensory characteristics [3, 4, 5]. Macaron has a fairly sweet taste, so other alternative sources of raw materials can be used so that it can be further accepted by consumers. The increased added value of Macaron products can be achieved by modifying them to have high protein and sugar-free content, making them suitable for use by diabetes patients [6].

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Alternative technologies can be implemented in processing gluten-free products to enhance the added value of Macaron products. Gluten-free products such as cookies should pay attention to their physical and sensory characteristics [4, 7]. Several studies are still being carried out to produce dry bakery-like products that can be accepted by consumers [8, 9]. Kim et al [1] added antioxidants to increase the added value of macaron. Another macaron modification technology by adding walnut oilcake-by-product to improve the characteristics of the resulting product [10]. One of the opportunities to increase the added value of the quality of macaron products is by processing them using other ingredients in the form of local flour. Opportunities for existing local flour can be identified to be used as a source of raw materials for processed products [11]. Some local flours have the potential to contain quite high levels of protein such as corn flour and hanjeli.

However, to improve the formulation and characteristics of the final product, macaron can be added with food additives from several types of hydrocolloids. Several hydrocolloid derivatives can increase the viscosity of the dough and form a texture during the proofing and baking processes in bakery products [12]. The hydrocolloid components that can be used for bakery products are HPMC (Hydroxy Propyl Methyl Cellulose) and CMC (Carboxy Methyl Cellulose) using corn starch as raw material [13]. Cellulose derivatives such as CMC, HPMC, and MC (Methyl Cellulose) contain hydrophilic and hydrophobic components which will form the dough structure during the proofing process and form a network in the baking process [12,14,15;16;17]. The process of processing bakery products using corn flour is very important for further research. The combination of the use of additional ingredients in the form of CMC is expected to increase the added value of macaron products.

To improve the characteristics of corn macaron, other additional ingredients can be used, namely in the form of CMC from corn flour. The quality characteristics produced can be compared with the quality of macaron which is processed from almond flour. The purpose of this research activity is to implement formulation techniques and variations in addition to CMC concentrations to the characteristics of gluten-free corn flour macaron.

## 2 Method

Materials needed in this research activity include commercial corn flour from Mugo, North Jakarta. Other chemicals, namely: Engineering CMC from Setia Guna Bogor, and commercial cellulose from Setia Guna, Bogor-Indonesia. Chemicals Analysis from commercial suppliers Merck. Equipment needed: mixer, oven, macaron mold, Soxhlet, kjedahl, burette, scales, Minolta chromameter.

In the first stage, macaron processing was carried out using almond flour as a control. The next stage is the macaron process using corn flour. The formulation for processing macaron with the composition is shown in the Table 1.

**Table 1**. Macaron Composition Formulation

| Sample | Almond Flour (g) | Corn Flour (g) | Sugar Powder (g) | White Egg (g) | Crystal Sugar (g) | CMC (%) |
|---|---|---|---|---|---|---|
| Control Almond | 45 | - | 62,6 | 20 | 25 | - |
| Control Corn | - | 30 | 50 | 40 | 25 | - |
| CMC 1% | - | 30 | 50 | 40 | 25 | 1 |
| CMC 2% | - | 30 | 50 | 40 | 25 | 2 |
| CMC 4% | - | 30 | 50 | 40 | 25 | 4 |

The stages of the processing process include: mixing powdered sugar and almond flour or corn flour along with CMC (for treatment) until well mixed. Mixture evenly with a mixer of white egg and sugar until fluffy. The two doughs are then mixed evenly using a spatula then put in a pipping bag and printed on a baking sheet. The dough that has been printed on the baking sheet is then placed in the oven at 150° C for 15 minutes until completely dry. Dried macarons are packaged so that they are safe for further analysis.

Macaron was analyzed for each sample for weight, diameter, and thickness using a mass balance and caliper. Macaron is also analyzed for color characteristics (L,a,b, hue, and whiteness index). The results obtained were then analyzed for thickness/weight ratio and diameter/weight ratio. To find out the textural characteristics of macaron, hardness, adhesiveness and springness analysis of macaron was carried out. Macaron samples were analyzed for proximate levels (water, ash, fat, protein and carbohydrates by different) [18]. The data obtained was then compiled and analyzed by ANOVA using SPSS 24 software. Meanwhile, the results of the real difference test were analyzed by Duncan's advanced test.

## 3 Results and Discussion

### 3.1 Macaron's Physical Appearance

The physical appearance of macaron almonds compared to macaron from corn flour is shown in Figure 1. Almond macaron has a whiter color compared to corn flour macaron. This corresponds to the color of the flour, namely almond flour is whiter than corn flour.


**Fig 1.** Almond Food product profile compared to Corn Macaroni (control, 1% CMC, 2% CMC and 4% CMC)

The physical appearance of the resulting macaron shows that the type of flour affects the shape of the resulting macaron. The almond flour macaron has a more moist characteristic compared to the corn flour macaron which looks more dry. Corn flour macaron with the addition of CMC has a shape resembling the characteristics of egg nog which is a form of dry bakery that is rich in eggs compared to the shape of the macaron. The addition of CMC also resulted in the appearance of a greater development than without the addition of CMC in corn flour macarons. Pop et al [10] improved the characteristics of macaron by incorporating by-products from walnut oilcake. Modifications involving the addition of several ingredients are conducted to enhance the value-added process and macaron products.

### 3.2 Color Analysis

Color is an important organoleptic parameter. To determine the effect of the type and concentration of the formula on the color of the resulting macaron as shown in Table 2.

The differences in the type and concentration of the materials used affect the color parameters (L, a, b and hue) produced. The different types of flour, namely almond and corn flour, indirectly affect the basic color of the resulting macaron. The whiteness index (WI)

value showed a significant difference between treatments. The highest WI value was 68.96 for the almond macaron sample, which statistically had the same value as corn flour macaron with the addition of 4% CMC. The use of non-gluten flour as the raw material generally decreases the L (lightness) of gluten-free cookies [7]. The colour of macaron is also heavily influenced by the raw materials used, in which yellow-colored corn flour is used as the main based raw material.

**Table 2.** Macaron Color Analysis Results

| No | Sample | L | a | b | Hue | Whiteness Index |
|---|---|---|---|---|---|---|
| 1 | Control Almond | 72.74c | -0.30c | 14.82c | 14.83c | 68.96a |
| 2 | Control Corn | 73.09c | 3.72c | 26.38a | 26.64a | 62.13c |
| 3 | CMC 1% | 76.03b | 0.82b | 24.06b | 24.08b | 66.00b |
| 4 | CMC 2% | 77.03b | 0.82b | 24.06b | 24.08b | 66.72b |
| 5 | CMC 4% | 80.50a | 0.74b | 24.17b | 24.18b | 68.93a |

Note: Numbers followed by different letters indicate significantly different with a 95% confidence interval

## 3.3 Development Ratio

The development ratio is to see the development opportunities of the macarons produced. To analyze the swelling capacity of the macaron produced, the swelling analysis was measured by looking at the ratio of the thickness/weight and diameter of the macaron/weight. Based on the results of the development ratio analysis, the results are as shown in Table 3.

**Table 3.** Development Ratio Analysis Results

| No | Sample | Weight (gram) | Diameter (mm) | Thick (mm) | Ratio Thick/Weight (mm/gram) | Ratio Diameter/Weight (mm/gram) |
|---|---|---|---|---|---|---|
| 1 | Control Almon | 3.85a | 34.93b | 12.00b | 3.13bc | 9.16b |
| 2 | Control Corn | 4.35a | 34.80b | 11.50b | 2.65c | 8.07b |
| 3 | CMC 1% | 2.76b | 37.63b | 8.50c | 3.13bc | 13.77a |
| 4 | CMC 2% | 2.32b | 33.73b | 9.80c | 4.25a | 14.60a |
| 5 | CMC 4% | 4.38a | 35.13b | 15.40a | 3.59ab | 8.22b |

Note: Numbers followed by different letters indicate significantly different with a 95% confidence interval

Based on the results of the analysis, there are differences in the type and concentration of the formula affecting the resulting swelling ratio. The highest thickness/weight ratio is found in macarons with the addition of 2% CMC. Meanwhile, the highest diameter/weight ratio was found in macarons with the addition of 2% CMC and 1% CMC. The addition of CMC which is too high (4% concentration) reduced the resulting swelling ratio. The addition of 1.8% CMC can produce optimal rice crackers [14]. The type of raw material and the resulting product will influence the concentration of CMC added.

## 3.4 Texture Analysis

The resulting macaron texture was analyzed using a Brookfield texture analyzer. The analysis carried out included an analysis of the hardness, adhesiveness, and springness of the

macarons that had been produced. Based on the results of the texture analysis of macaron almond compared to corn flour macaron, the results are shown in Table 4.

**Table 4.** Results of Macaron Texture Analysis

| No | Sample | Hardness (g) | Adhesivness (mj) | Springness (mj) |
|---|---|---|---|---|
| 1 | Control Almon | 995.83c | 0.56a | 0.48a |
| 2 | Control Corn | 2100.83b | 0.17b | 0.16b |
| 3 | CMC 1% | 2730.83a | 0.11b | 0.10b |
| 4 | CMC 2% | 2267.33c | 0.00b | 0.00b |
| 5 | CMC 4 % | 1441.33c | 0.18b | 0.07b |

Note: Numbers followed by different letters indicate significantly different with a 95% confidence interval

There are differences in the type and concentration of materials used for the macaron formulation process, resulting in significantly different harnesses, adhesiveness, and springness. The lowest hardness value was obtained from almond flour macaron, which statistically still had the same hardness level as corn flour macaron with the addition of 2 or 4% CMC. The highest adhesiveness and springness values were found in almond flour macaron, where the almond flour raw material which contains many fat and protein components had an influence on the adhesiveness and springness of the resulting macaron. Luangsakul and Chiralaksanakul [19] conducted research on reducing sugar levels in the process of making almond macaron, where different types and concentrations of sugar in the formulation process affect the texture of the resulting macaron.

The use of starch, gum, and hydrocolloids will produce interactions that can affect the texture of bakery products [20]. Furthermore, Herawati [12] the differences in the use of types of starch and flour affect the interaction of the components present in bakery product formulations. Flour still contains fiber components that affect the texture of the resulting bakery products. The addition of hydrocolloid components such as CMC is expected to help the process of forming gluten-free bakery products such as this macaron.

### 3.5 Proximate Analysis

To determine the proximate level of macaron from corn flour, an analysis of the water, ash, protein, and fat content was carried out and the carbohydrate content was calculated by different. Based on the results of the analysis of the proximate levels of corn flour macaron, the results are shown in Table 5.

**Table 5.** Results of Macaron Proximate Analysis

| No | Sample | Moisture Content (%) | Ash Content (%) | Fat Content (%) | Protein Content (%) | Carbohydrate Content (%) |
|---|---|---|---|---|---|---|
| 1 | Control Almond | 4.18c | 1.21a | 15.72a | 10.67a | 68.22e |
| 2 | Control Corn | 3.51e | 0.29c | 0.98c | 5.06e | 91.97a |
| 3 | CMC 1% | 4.57b | 0.73b | 3.68b | 7.36b | 83.65d |
| 4 | CMC 2% | 3.51d | 0.59b | 0.62d | 6.53c | 88.76b |
| 5 | CMC 4 % | 5.44a | 0.68b | 0.87c | 5.99d | 87.02c |

Note: Numbers followed by different letters indicate significantly different with a 95% confidence interval

Almond macarons contain higher levels of fat and protein compared to macarons made from corn flour. The source of raw materials greatly affects the proximate level of the

macaron produced. Based on the results of the analysis of proximate levels above, the contents of water, ash, protein, fat and carbohydrates were significantly different based on the results of statistical analysis with differences in the type and concentration of the formula used.

Corn flour contains 10.20% protein content and 1.55% fat content [21]. Herawati and Kamsiati [12] analyzed the proximate content of commercial corn flour containing a protein content of 8.41% and a fat content of 0.89%. Based on the proximate results, the variety of sources of raw material for corn flour affects the proximate content of the flour. The protein content from the results of Herawati and Kamsiati's research [12] is still higher than other local flours, except for hanjeli flour which has a protein content of 14%. This can be a reference for considering the selection of flour raw material sources for processing macaron or other dry bakery products.

## 4 Conclusion

Almond flour macaron has a brighter and moisterous appearance according to its raw material from almond flour. The color characteristics (L, a, b, hue and whitness index) showed differences between the treatments, both the almond flour control and the corn flour control and treatment. The thickness/weight ratio and diameter/weight ratio of corn flour macaron with the addition of 2% CMC showed the greatest development compared to other treatments. The texture value of the almond macaron hardness parameter has the same statistical characteristics as corn flour macaron added with 2 and 4% CMC. Protein and fat content of almond flour macaron is still higher than that of corn flour macaron according to the proximate content of the flour raw material used.

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