Effect of process technology and coating material on the cassava stick characteristics

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Abstract. Cassava is one potential commodity widely cultivated in Indonesia. One development opportunities of cassava products is cassava french fries. Technological process of making cassava french fries can be done by combining technology using pressure boiling and soaking treatment as coating materials. The purpose of this research is to know the influence of process technology and coating materials to the quality characteristics of cassava french fries. The method used in this study is completely randomized design and the data were analyzed using SPSS software 21. In the early stages do influence when the boiling process by applying pressure, as well as the immersion on the characteristics of cassava french fries. Some of the coating material used in this study include: rice flour, tapioca, maltodextrin, guar gum. Based on the research results and the process steps of coating material types affect the quality of cassava sticks produced.

Key words: process technology, coating material, french fries, cassava

1. INTRODUCTION
Processing technology of fries has been sold commercially. One of the opportunities to increase local potential in Indonesia is by using local raw material sources, such as cassava. Potential of cassava in Indonesia is very large and has the opportunity to be increased added value so that more can be commercialized more widely by processing into cassava sticks like french fries.

One of the weaknesses fried cassava processed technology that has a hard texture when fried after fried. The combination of processing technology that is high pressure processing with coating using coating is one of opportunity to improve the quality of cassava stick produced.

The previous study performs the process technology of making french fries by combining the initial pretreatment treatment with a combination of freezing treatment [1]. Khatijah, 2003 did research making potato french fries by using coating material from cassava or tapioca starch modified [2]. According to other study, edible coatings can be used to reduce levels of fat in fried foods because it is a good barrier to fat, so that the absorption of oil into the material during frying will decrease [3]. Albert and Mittal (2001) stated that the use of edible coating of corn starch on cereal products can reduce fat absorption by 59% during frying [4]. The further research states that the use of edible coating on French fries can reduce the absorption of oil by 40.6% [5]. Starch of 3% as edible coating material can be used to decrease oil absorption during frying pineapple chips 35.46% [6].
Basic quality characteristics of fries include: colour, taste, odour, texture and fat content [7-8]. Colour is one of the appearance attributes of food materials, since it influences consumer acceptability [9]. French fries texture is of critical importance to consumer acceptability [10]. French fries of advantageous texture are delicate, with crispy skin and floury interior [8, 11].

The combination of processing technology is very important to improve the quality of cassava sticks before the process of freezing for storage. Proper frying technique is also an input in the frying process. In this study aims to influence the combination of process mechanism to the physical characteristics of cassava stick produced.

2. METHODOLOGY

Materials used in the study include: cassava, tapioca, maltodextrin, rice flour, guar gum, CaCl₂, sodium metabisulfite. The equipment used includes: presto pan, freezer, chromometer, texture Brookfiled analyzer, oven, and desiccator. As for some treatments as listed in the following table.

In general, the stages of the process of processing of cassava include stages: slicing, stripping, soaking in sodium metabisulphite 1%, boiling process by using presto pan, soaking in 1% CaCl₂ solution, coating process and storage in freezer.

| No | Code | Treatments |
|----|------|------------|
| 1  | S1   | Control    |
| 2  | S2   | Control with CaCl₂ addition |
| 3  | S3   | Control Coating treatment |
| 4  | S4   | CaCl₂, Coating with 1% rice flour |
| 5  | S5   | CaCl₂, Coating with 1% Maltodextrin |
| 6  | S6   | CaCl₂, Coating with 1% tapioca |
| 7  | S7   | CaCl₂, Coating with 1% guar gum |
| 8  | S8   | CaCl₂, Coating with 2% rice flour |
| 9  | S9   | CaCl₂, Coating with 2% Maltodextrin |
| 10 | S10  | CaCl₂, Coating with 2% Tapioca |
| 11 | S11  | CaCl₂, Coating with 2% Guar Gum |
| 12 | S12  | Sodium Metabisulfite and Saccharomiches Cerevisae treatment 24 hours |
| 13 | S13  | Sodium Metabisulfite and lactic acid bacteria 10% 24 hours fermentation |
| 14 | S14  | Sodium Metabisulfite and lactic acid bacteria 20% 24 hours fermentation |
| 15 | S15  | Sodium Metabisulfite and lactic acid bacteria 40% 24 hours fermentation |
| 16 | S16  | Sodium Metabisulfite and lactic acid bacteria 80% 24 hours fermentation |

For the next treatment, cassava which has done the process stages as in the table 1, frying process is done by using gas stove with medium heat for 5 minutes. In more detail, sample code and treatment are listed in the table 2.

The analyzes include: water content, texture (Hardness, adhesiveness, stringiness) and color (L, a, b and whiteness index). Based on the results obtained, then conducted ANOVA analysis of different tests between treatments and further testing Duncan using SPSS 2.1 software.
Table 2. Treatment of the process stages, the type of coating material on ripe cassava

| No | Code  | Treatments                                      |
|----|-------|------------------------------------------------|
| 1  | SM1   | Control                                        |
| 2  | SM2   | Control with CaCl2 addition                    |
| 3  | SM3   | Control Coating treatment                      |
| 4  | SM4   | CaCl2, Coating with 1% rice flour              |
| 5  | SM5   | CaCl2, Coating with 1% Maltodextrin            |
| 6  | SM6   | CaCl2, Coating with 1% tapioca                |
| 7  | SM7   | CaCl2, Coating with 1% guar gum                |
| 8  | SM8   | CaCl2, Coating with 2% rice flour              |
| 9  | SM9   | CaCl2, Coating with 2% Maltodextrin            |
| 10 | SM10  | CaCl2, Coating with 2% Tapioka                 |
| 11 | SM11  | CaCl2, Coating with 2% Guar Gum                |
| 12 | SM12  | Sodium Metabisulfit and Saccaromiches Cerevisae treatment 24 hours |
| 13 | SM13  | Sodium Metabisulfit and lactic acid bacteria 10% 24 hours fermentation |
| 14 | SM14  | Sodium Metabisulfit and lactic acid bacteria 20% 24 hours fermentation |
| 15 | SM15  | Sodium Metabisulfit and lactic acid bacteria 40% 24 hours fermentation |
| 16 | SM16  | Sodium Metabisulfit and lactic acid bacteria 80% 24 hours fermentation |

3. RESULTS AND DISCUSSION

3.1 Moisture Content of Cassava Stick

In the process of frying, there is a process of moving mass and heat, with oil as a medium conductor of heat [12-13]. The heat received by the material, will be used for water evaporation, starch gelatinization, protein denaturation, browning and caramelization. Some of the water contained in the material will evaporate and the original room filled with water will be replaced with oil [14]. Control of the time and temperature of scratching is needed to produce optimal quality [12, 13, 15]. One of the important parameters of characteristics analysis of cassava stick is moisture content. Based on the results of water content analysis of raw and cooked cassava sticks analyzed between treatments as listed in Table 3.

Table 3. The result Analysis of Cassava Stick Moisture Content

| Sample | Moisture Content of Raw Material (%) | Moisture Content of Cooked Material (%) |
|--------|--------------------------------------|----------------------------------------|
| S1     | 54.40                                | 36.54                                  |
| S2     | 61.84                                | 42.52                                  |
| S3     | 63.87                                | 36.43                                  |
| S4     | 63.84                                | 51.85                                  |
| S5     | 65.01                                | 41.65                                  |
| S6     | 63.47                                | 44.61                                  |
| S7     | 63.79                                | 47.83                                  |
| S8     | 68.84                                | 44.82                                  |
| S9     | 63.70                                | 51.17                                  |
| S10    | 69.67                                | 33.79                                  |
| S11    | 56.44                                | 39.50                                  |
| S12    | 54.24                                | 38.88                                  |
| S13    | 52.37                                | 32.34                                  |
| S14    | 56.00                                | 34.72                                  |
| S15    | 57.46                                | 40.02                                  |
| S16    | 66.97                                | 53.44                                  |
Based on the results of analysis, water content in raw cassava sticks have a higher water content than the water content of fried cassava sticks. It is possible that the moisture content contained in the cassava stick is evaporated with the cooking oil that goes into the structure of the resulting cassava stick. Water content of raw cassava sticks ranged from 52.37% to 69.67%. Water content of mature cassava sticks ranged from 32.34% to 53.44%. The previous study compares the water content of MacDonald potatoes with other potatoes after the frying process. This type of potato greatly affects the content of the resulting mature potatoes [16].

Frying technology also plays an important role. Deep fat frying is a cooking and drying technology that occurs through contact with hot oil, resulting in heat transfer and mass simultaneously. The temperature of the deep fat frying process generally ranges from 150-190 °C [13, 15, 17]. The frying technology used in this research is by using cooking oil until boiling for 5 minutes. The frying step combines heat treatment at high moisture is responsible for gelatinization of starch, softening of potato tissue and least partial in activation of enzymes [18].

3.2 Texture Characteristic of Cassava Stick

Texture is an important parameter that determines the quality of the physical characteristics of cassava stick. The texture parameters of cassava sticks include the characteristic of hardness, adhesiveness and stringiness. Characteristic texture of raw cassava stick as shown in Table 4.

There are some studies showing the basic ingredients that contribute better covering characteristics and final texture of fried products [19, 20]. Textural changes during frying process are the result of many physical, chemical, and structural changes produced in this complex process unit operation, which includes heat and mass transfer together with chemical reactions. Good-quality French fries must have a crispy crust of about 1–2 mm, where, most of the oil is located, and a wet, soft center, like a cooked potato [13, 21].

| Sample | Hardness | Adhesiveness | Stringiness |
|--------|----------|--------------|-------------|
| S1     | 1144.17d | 0.05a        | 0.03a       |
| S2     | 291.50abc| 1.32d        | 0.06a       |
| S3     | 341.50c  | 0.91bcd      | 0.10ab      |
| S4     | 89.83a   | 0.09a        | 0.02a       |
| S5     | 342.00c  | 0.86bcd      | 0.29abc     |
| S6     | 287.50bcd| 1.05ed       | 0.53b       |
| S7     | 324.33bc | 0.73bc       | 0.42bc      |
| S8     | 103.83ab | 0.17a        | 0.03a       |
| S9     | 290.67abc| 0.47ab       | 0.05a       |
| S10    | 75.67a   | 0.12a        | 0.04a       |
| S11    | 2480.00gf| 0.86bcd      | 0.59b       |
| S12    | 2786.33b | 0.92bcd      | 0.05a       |
| S13    | 2286.83ef| 0.95ed       | 0.93d       |
| S14    | 2517.00s | 0.93ed       | 0.07a       |
| S15    | 2263.50a | 0.91bcd      | 0.10ab      |
| S16    | 149.00abc| 1.11ed       | 0.02a       |

Means within a row not sharing the same letter are significantly different at P≤0.05.

The characteristics of the resulting texture can be known after the frying process. The combination of process technology that is done greatly affects the quality of sticks produced in evaporating water, absorbing oil and forming texture of mature cassava sticks produced. Based on the results of quality analysis of cassava sticks produced as stated in the table 5.
Table 5. Results of Color Analysis of Cooked Stick Cassava Coating Treatment

| Sample | Hardness | Adhesivness | Stringiness |
|--------|----------|-------------|-------------|
| S1     | 511.83f  | 0.71\(^{abcde}\) | 0.47\(^{cd}\) |
| S2     | 479.33ef | 0.80\(^{bcde}\) | 0.09\(^{ab}\) |
| S3     | 417.25def | 0.74\(^{bcde}\) | 0.66\(^e\) |
| S4     | 399.50\(^{def}\) | 0.23\(^{bcd}\) | 0.03\(^a\) |
| S5     | 296.83\(^{abcdef}\) | 0.99\(^e\) | 0.39\(^{ab}\) |
| S6     | 313.33\(^{abcdef}\) | 0.94\(^e\) | 0.10\(^ab\) |
| S7     | 251.33\(^{bcde}\) | 0.76\(^{bcde}\) | 0.08\(^ab\) |
| S8     | 147.83\(^{abc}\) | 0.18\(^{abc}\) | 0.06\(^ab\) |
| S9     | 104.83\(^a\) | 0.04\(^a\) | 0.01\(^a\) |
| S10    | 85.50\(^a\) | 0.11\(^ab\) | 0.02\(^a\) |
| S11    | 306.67\(^{abcdef}\) | 0.48\(^{abde}\) | 0.06\(^ab\) |
| S12    | 279.17\(^{abcdef}\) | 0.81\(^{de}\) | 0.06\(^ab\) |
| S13    | 215.33\(^{bcd}\) | 0.89\(^{de}\) | 0.04\(^a\) |
| S14    | 361.17\(^{bcde}\) | 0.57\(^{bcde}\) | 0.44\(^{ab}\) |
| S15    | 261.00\(^{abcdef}\) | 0.61\(^{bcde}\) | 0.04\(^ab\) |
| S16    | 133.50\(^{ab}\) | 0.58\(^{ab\text{cde}}\) | 0.29\(^{ab}\) |

Means within a row not sharing the same letter are significantly different at P≤0.05.

Based on the result of cassava sticks texture analysis showed different hardness values between treatments. CaCl\(_2\) Immersion Treatment, Coating with Tapioca Starch has a softer texture than any other treatment. Things to note in making cassava stick that has a crunchy texture but when eaten gently on the inside. The combination of the right coating treatment will result in a crisp and gentle level of hardness when bitten.

### 3.3 Color Characteristic of Cassava Stick

The color change in raw cassava stick can be influenced by blanching factor, process stages and type of coating material used. The blanching technique greatly influences the potential of enzymatic browning reactions. Some types of coating materials can also affect the quality of the resulting cassava sticks. The results of color quality analysis and whiteness index of raw cassava sticks produced as listed in the table 6.

Based on the results of ANOVA analysis, the results show that each treatment shows differences for the values of L, a, b and WI (Whiteness Index). Lightness values for average controls are higher than coating treatment. This is possible because the material used affects the quality of the color of the cassava stick produced. This certainly affects the value of whiteness index or the degree of white cassava stick produced.

Frying techniques and some reactions related to the frying mechanism greatly affect the quality of the resulting color. The type and coating concentration greatly affects the water evaporation capability and the oil absorption that contribute to the resulting color. Based on the results of color analysis of mature cassava sticks as listed in the table.

The effect factors of browning reaction enzymatically affect the color of raw cassava sticks. In addition to browning reactions on raw cassava sticks. The possibility of browning reactions on raw cassava sticks is possible due to the influence of heat from the cooking oil used. Based on the result of the analysis of different treatment types resulted in different quality of colors between treatments, both for L, a, b and WI. French fries colour is the result of the Maillard reaction which depends on the content of superficial reducing sugars, temperature and frying time [22].
Table 6. Result of Color Analysis of Raw Cassava Coating Treatment

| Sample | L   | a       | b       | WI      |
|--------|-----|---------|---------|---------|
| S1     | 90.34<sup>f</sup> | -1.13<sup>cd</sup> | 13.71<sup>f</sup> | 96.88<sup>f</sup> |
| S2     | 62.01<sup>ab</sup> | -0.81<sup>de</sup> | 8.58<sup>d</sup> | 95.67<sup>ab</sup> |
| S3     | 61.55<sup>b</sup> | -0.68<sup>ef</sup> | 5.55<sup>ab</sup> | 95.68<sup>ab</sup> |
| S4     | 69.77<sup>c</sup> | -2.28<sup>a</sup> | 4.91<sup>a</sup> | 96.06<sup>c</sup> |
| S5     | 64.94<sup>b</sup> | -0.57<sup>f</sup> | 6.35<sup>bcd</sup> | 95.83<sup>b</sup> |
| S6     | 65.50<sup>b</sup> | -1.14<sup>bc</sup> | 6.96<sup>c</sup> | 95.84<sup>b</sup> |
| S7     | 61.70<sup>ab</sup> | -1.42<sup>bc</sup> | 5.75<sup>ab</sup> | 95.68<sup>ab</sup> |
| S8     | 75.99<sup>d</sup> | -2.13<sup>a</sup> | 4.84<sup>a</sup> | 96.40<sup>d</sup> |
| S9     | 70.76<sup>c</sup> | -2.36<sup>a</sup> | 5.56<sup>ab</sup> | 96.11<sup>c</sup> |
| S10    | 59.78<sup>a</sup> | -1.25<sup>cd</sup> | 5.26<sup>ab</sup> | 95.62<sup>a</sup> |
| S11    | 96.18<sup>g</sup> | -1.53<sup>bc</sup> | 11.68<sup>ef</sup> | 97.26<sup>g</sup> |
| S12    | 80.77<sup>e</sup> | -0.83<sup>def</sup> | 8.92<sup>f</sup> | 96.61<sup>e</sup> |
| S13    | 83.40<sup>f</sup> | -0.63<sup>ef</sup> | 11.83<sup>ef</sup> | 96.66<sup>e</sup> |
| S14    | 92.79<sup>fg</sup> | -1.83<sup>ab</sup> | 10.92<sup>e</sup> | 97.19<sup>fg</sup> |
| S15    | 93.54<sup>f</sup> | -2.15<sup>a</sup> | 12.63<sup>fg</sup> | 97.09<sup>fg</sup> |
| S16    | 60.03<sup>a</sup> | -1.55<sup>bc</sup> | 5.08<sup>ab</sup> | 95.61<sup>a</sup> |

Means within a row not sharing the same letter are significantly different at P≤0.05.

Table 7. Result of Color Analysis of Cooked Cassava Coating Treatment

| Sample | L (lightness) | a       | b       | WI (Whiteness Index) |
|--------|---------------|---------|---------|----------------------|
| S1     | 71.48<sup>def</sup> | 1.86<sup>f</sup> | 25.56<sup>b</sup> | 95.70<sup>cd</sup> |
| S2     | 72.65<sup>def</sup> | -2.20<sup>c</sup> | 21.77<sup>g</sup> | 95.85<sup>def</sup> |
| S3     | 80.81<sup>fg</sup> | -2.82<sup>b</sup> | 22.37<sup>c</sup> | 96.12<sup>fgb</sup> |
| S4     | 57.39<sup>a</sup> | -0.53<sup>e</sup> | 11.25<sup>a</sup> | 95.45<sup>ab</sup> |
| S5     | 75.67<sup>def</sup> | -3.11<sup>ab</sup> | 19.84<sup>f</sup> | 96.02<sup>fg</sup> |
| S6     | 70.20<sup>cd</sup> | -2.18<sup>c</sup> | 17.03<sup>d</sup> | 95.88<sup>def</sup> |
| S7     | 69.26<sup>bc</sup> | -1.97<sup>cd</sup> | 15.08<sup>c</sup> | 95.89<sup>def</sup> |
| S8     | 62.17<sup>ab</sup> | -1.69<sup>cd</sup> | 13.02<sup>b</sup> | 95.63<sup>bc</sup> |
| S9     | 60.29<sup>a</sup> | -1.86<sup>cd</sup> | 14.32<sup>c</sup> | 95.53<sup>ab</sup> |
| S10    | 55.76<sup>a</sup> | -1.41<sup>d</sup> | 17.02<sup>d</sup> | 95.32<sup>a</sup> |
| S11    | 79.54<sup>fg</sup> | -1.72<sup>cd</sup> | 19.52<sup>ef</sup> | 96.19<sup>gh</sup> |
| S12    | 77.71<sup>defg</sup> | -3.05<sup>ab</sup> | 26.47<sup>b</sup> | 95.84<sup>de</sup> |
| S13    | 73.41<sup>def</sup> | -1.94<sup>cd</sup> | 20.60<sup>f</sup> | 95.92<sup>defg</sup> |
| S14    | 84.70<sup>g</sup> | -3.47<sup>a</sup> | 19.30<sup>g</sup> | 96.38<sup>h</sup> |
| S15    | 76.63<sup>def</sup> | -2.85<sup>b</sup> | 17.21<sup>d</sup> | 96.13<sup>gb</sup> |
| S16    | 62.27<sup>ab</sup> | -3.33<sup>ab</sup> | 13.86<sup>bc</sup> | 95.61<sup>bc</sup> |

Means within a row not sharing the same letter are significantly different at P≤0.05.

4. CONCLUSIONS
Processing technology of cassava stick can be done by combining several stages. The combination of process method produces different water content characteristics between treatments as well as different for the characteristics of mature cassava sticks. The texture of raw and mature cassava sticks is different for different process methods. High hardness texture with soft inside becomes an important
characteristic in making cassava stick. Some types of coatings affect the quality of cassava and mature sticks. Optimization of the combination of process stage types and coating types is needed to produce optimal characteristics for further commercialization of the product.

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