Characteristics of physical, chemical, and organoleptic properties of inulin-enriched pudding as a complementary food

D Kristanti¹ and A Herminiati¹

¹ Development Center for Appropriate Technology, Indonesian Institute of Sciences, Jl. Aipda KS. Tubun No. 5 Subang 41213
Corresponding author, e-mail: dita.kristanti@gmail.com

Abstract. The products for complementary feeding circulating in the market are in the form of baby porridge, biscuits, and powdered milk. The functional food product to support the growth and development of children under five in the pudding form, which is made from skim milk as the raw ingredient and modified cassava flour (mocaf) as the supporting ingredient and enriched with inulin that acts to increase calcium absorption, is not yet on the market. The development of this product is expected to meet the nutritional requirements of infants aged 12-36 months. This study aimed to analyze the characteristics (chemical, physical, and organoleptic properties) of the inulin-enriched pudding. The pudding was made using four formulas; i.e., F1 (10% db mocaf and 0.8 g/100 ml inulin), F2 (10% db mocaf and 1.6 g/100 ml inulin), F3 (15% db mocaf and 0.8 g/100 ml inulin), and F4 (15% db mocaf and 1.6 g/100 ml inulin). The results of this study showed that the best pudding for complementary feeding based on the characteristics of physical properties was F2 which had a gel strength of 843.03 g Force and a syneresis of 7.78%. The F2’s organoleptic properties were as follows: milky white color, distinctive aroma of milk, a rather sweet taste, and soft textured. Besides that, the contribution of one serving of F2 pudding to the recommended dietary allowance (RDA) of children aged 1-3 years was as follows: 2.46 g of protein, 1.67 g of fat, 8.11 g of carbohydrates, and 57.32 kcal of energy.

1. Introduction
The products for complementary feeding currently circulating in the market are in the form of baby porridge, biscuits, and powdered milk. One of the complementary foods to support the growth and development of children under five that can be developed is pudding. It is a dessert that uses milk as the main ingredient which contains protein and calcium. The protein functions as a bone growth regulator while calcium plays a role in bone formation and height growth. The calcium intake in children under five needs to be optimally given because it will affect their growth and development. The complementary foods containing calcium can be given to the infants aged 12-36 months.

The use of mocaf is expected to increase the competitiveness of local resources. Mocaf is flour made from cassava which is produced by modifying the cassava flour with fermentation using lactic acid bacteria (LAB). The cassava flour modification technology using LAB fermentation caused the changes in the characteristics of the flour produced such as the increased viscosity, gelation ability, rehydration capacity, and ease of dissolution [1].

In the formulation of food products, mocaf has the properties as the binder, thickener, and filler that can be applied when making the pudding. The additional ingredient that has good physical functional properties as thickener, gelling agent, and stabilizer is needed when making pudding. The additional ingredient can be obtained from carrageenan, and the sweet taste is obtained from the addition of sugar [2].

The protein intake in children under five must be optimally given because it will affect their growth and development. The calcium intake of the Indonesian people is still low, one of which is due to the
low consumption of milk as a source of calcium. Each person only consumes about half a glass of milk in a week [3]. The calcium intake deficiency or impaired intestinal calcium absorption may have different effects at various age levels. This condition may cause rickets if it occurs in children under five, and it may lead to osteomalacia if it occurs in adults [4], [5].

The complementary food given to the infants aged 12-36 months must contain carbohydrates and protein according to RDA, and it should be enriched with inulin. The functional food that has a physiological activity to increase calcium absorption is needed to increase the absorption of this mineral [6]. The identification of the component and the composition of functional food that can positively affect the calcium absorption also needs to be performed [7]. One of the components that can increase the calcium absorption is inulin. The study results showed that inulin could increase calcium solubility in the lumen of the small intestine due to the short-chain fatty acids (SCFAs) formation which can decrease the pH of the small intestine resulting in the increased absorptive surface area and the increased calbindin production as the calcium-transport protein [8].

Based on the above description, the pudding formulation used the skim milk as the raw ingredient and mocaf as the supporting ingredient which was enriched with inulin. This product is expected to play a role in increasing the calcium absorption and fulfilling the nutritional requirement of the infants aged 12-36 months. This study aimed to analyze the characteristics (chemical, physical, and organoleptic properties) of the inulin-enriched pudding.

2. Materials and Methods

2.1 The materials
The raw and supporting ingredients used in this study were skim milk from Ny. Liem store in Bandung, mocaf from “Tanjung Siang” Small and Medium Enterprises (SME) in Subang, Orafti® inulin (Synergy1-Oligofructose 112), fine granulated sugar, carrageenan, and water.

2.2 Research Methods
Four pudding formulations were made in this study. The formulations are presented in Table 1, and the flow diagram of the pudding production process can be seen in Figure 1.

| Materials           | Formulations |
|---------------------|--------------|
|                     | F1 | F2 | F3 | F4 |
| Skim milk (g)       | 9  | 9  | 9  | 9  |
| Mocaf flour (g)     | 2  | 2  | 3  | 3  |
| Inulin (g)          | 0.8| 1.6| 0.8| 1.6|
| Fine granulated sugar (g) | 8 | 8 | 7 | 7 |
| Carrageenan (g)     | 1  | 1  | 1  | 1  |
| Water (ml)          | 100| 100| 100| 100|

The pudding was made through several stages as follows: 1) weighing the raw and supporting ingredients; 2) dry-mixing the raw and supporting ingredients by using a mixer; 3) cooking the dried pudding ingredients by adding the water into the pan; 4) stirring the ingredients until dissolved (± 1 minute); 5) heating on a stove over medium heat for six minutes while stirring regularly until the final temperature of the pudding solution reached 85-95 °C; 6) pouring the pudding solution into the mold and then cooling it to room temperature; 7) cooling the pudding again in the refrigerator at 5 °C for ±12 hours.
2.2.1 The characteristics of physical analysis. The characteristics of physical properties were determined by performing gel strength analysis using an Stable Micro System TA.Xtplus which settings as follows: P 36R probe model; 0.50 mm/s of test speed; 5 g of force target; 10 mm of distance; and 30 of retrun distance and syneresis analysis using an modification of the [9] method.

2.2.2 The characteristics of chemical analysis. To determine the characteristics of chemical properties, a proximate analysis was performed which included: analysis of the moisture content by the gravimetric method [10], ash content by the gravimetric method [10], protein content by the Dumas combustion method by using DuMAster Buchi D-480, Switzerland, and fat content by Soxhlet method [11]. The carbohydrate content was determined using by difference method [10], and the total energy was determined based on the conversion formula of carbohydrates, fat, and protein contents.

2.2.3 The organoleptic test. The organoleptic test used the scoring tests on taste, texture, color, and aroma while the overall acceptance was determined by the hedonic test [12]. The organoleptic assessment was carried out by 33 mothers who had children under five in Posyandu Blok Kopti Cigadung Subang using the attribute rating scale presented in Table 2 below.
Table 2. The attribute rating scale of organoleptic.

| Scale | Color          | Aroma                  | taste     | Texture  | overall acceptance |
|-------|----------------|------------------------|-----------|----------|--------------------|
| 5     | milky white    | very typical of milk   | very sweet| very soft | very like          |
| 4     | slightly yellowish white | typical of milk    | sweet    | soft     | like               |
| 3     | yellowish white | rather distinctive of milk | rather sweet | rather soft | rather like        |
| 2     | very yellowish white | distinctive of milk | tasteless | chewy    | dislike            |
| 1     | Yellow         | very distinctive of milk | very tasteless | very chewy | very dislike       |

The assessment of the best pudding for complementary feeding organoleptic was carried out by 10 childrens (1-5 years old). The assessment using the attribute hedonic scale with 1 (super bad), 2 (really bad), 3 (bad), 4 (maybe good or maybe bad), 4 (good), 5 (really good), 6 (super good) to assess the children's facial expressions based on the [13] method.

2.2.4 Characteristics of physical and chemical properties of the F2 CF pudding flour. The microstructure of the F2 CF pudding flour was conducted using Scanning Electron Microscope (SEM) JSM-6510 series. The Ca, Fe, and Zn content of F2 CF pudding flour was determined in duplo by flame atomic absorption spectrometry.

3. Results and Discussion

The development of inulin-enriched pudding product as a complementary food and the regulation regarding the use of inulin refer to the Food Standards Australia New Zealand (FSANZ) that allows the addition of inulin-derived and GOS-derived substances for single or combination use in the foods formulated for children under five up to a total maximum of 0.6 g/100 g and 1.6 g/serving. Furthermore, the European Union’s Novel Food Regulation (EC 258/97) recommends that the content found in inulin (a combination of 90% oligalactosyl-lactose and 10 oligofructosyl-saccharose) should not exceed 0.8 g/100 ml for the formulation of the food products for children under five that add inulin. According to the Food and Drug Administration (2003), the use of inulin at a level of 90% is as follows: 6 g/day for infants under 12 months of age, 15 g/day for infants aged 13-24 months, and 20 g/day for infants over 25 months of age [14].

Inulin can function as a prebiotic in the complementary foods. The study results showed that inulin as a prebiotic could produce SCFAs which included propionate, butyrate, acetate, and lactate. The lactic acid can make the intestinal pH become acidic. This condition causes the calcium ions to become more soluble, thereby increasing the calcium absorption in the large intestine [15].

3.1 Characteristics of physical properties of the pudding as a complementary food

The results of the analysis on the physical properties of the pudding as a complementary food (CF pudding) can be seen in Table 3 below.

3.1.1 The gel strength of the CF pudding. The CF pudding is a food product for the children under five that still has no Indonesian National Standards and regulations from the Ministry of Health for the determination of the pudding’s gel strength. The commercial CF pudding products that are already on the market are used as a comparison for the pudding’s gel strength. Of the four formulas, only F2 and F3 puddings were within the range of gel strength of the commercial CF pudding products. The comparison of the CF pudding’s gel strength between the formulas can be seen in Table 3. The
differences in gel strength values can influence the food texture. The pudding with low gel strength will produce a soft-textured pudding. The soft texture causes a decrease in the consumer’s acceptance level. The study results showed that the difference in gel strength in each CF pudding formula did not affect the consumer’s acceptance level [2]. It was evident from the results of the organoleptic test on the texture and overall acceptance of the CF puddings that were not significantly different. The consumers were more tolerant of organoleptic changes in milk pudding which was added with a functional food (i.e., HAMS) because they were more interested in the product claims that had the potential to improve health [16].

Table 3. The physical properties of the CF pudding.

| CF pudding | Kekuatan gel (g Force) | Sineresis (%) |
|------------|------------------------|---------------|
| F1         | 848.02±11.77\(^c\)     | 6.16±1.36\(^b\) |
| F2         | 1009.04±14.73\(^a\)    | 7.78±0.43\(^b\) |
| F3         | 921.92±15.60\(^b\)     | 7.93±1.49\(^b\) |
| F4         | 601.49±29.40\(^d\)     | 13.01±1.15\(^a\) |
| Commercial | 870.32 - 1096.74       | 8.74 – 10.06   |

Values are expressed as mean±standard deviation. Means in the same column with different letters were significantly different at p < 0.05

3.1.2 The syneresis of the CF pudding. Syneresis is the extraction of a liquid from a gel that occurs due to slow gel contraction, and it is affected by time. The study results showed that the greater the syneresis value, the easier the gel formed to release water. Therefore, it is not preferred by the consumers [9]. The results of CF pudding’s syneresis can be seen in Table 3. The analysis results indicated that the syneresis of F1, F2, and F3 CF puddings was better than the F4. According to Subaryono et al. (2003), the product stored at low temperature (e.g., ice cream or pudding) must have high gel strength and low syneresis [2]. Based on the results of gel strength and syneresis analyses, it is known that the F2 formula is the best CF pudding compared to other formulas.

3.1.3 Characteristics of chemical properties of the CF pudding

The chemical analysis performed in this study was the analysis of moisture, ash, protein, fat, and carbohydrate contents. This analysis aimed to determine the nutritional content of the CF pudding. The results of the chemical analysis are presented in Table 4.

Table 4. The chemical properties of the CF pudding.

| CF pudding | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Carbohydrate (%) |
|------------|--------------|---------|-------------|---------|------------------|
| F1         | 80.16±0.73\(^a\) | 4.99±0.18\(^b\) | 3.09±0.30\(^a\) | 2.56±0.18\(^a\) | 9.19±0.60\(^a\) |
| F2         | 79.97±0.17\(^a\) | 4.73±0.38\(^a\) | 3.07±0.39\(^a\) | 2.09±0.19\(^b\) | 10.14±0.26\(^a\) |
| F3         | 80.32±0.57\(^a\) | 4.77±0.61\(^a\) | 3.27±0.39\(^a\) | 2.86±0.19\(^a\) | 8.78±1.27\(^a\) |
| F4         | 79.92±0.17\(^a\) | 4.72±0.41\(^a\) | 3.12±0.29\(^a\) | 2.59±0.09\(^a\) | 9.64±0.58\(^a\) |

Values are expressed as mean ± standard deviation. Means in the same column with different letters were significantly different at p < 0.05.

The results indicate that there are no significant differences in the moisture, ash, protein, fat, and carbohydrate contents between the four CF pudding formulas. The protein content of the CF pudding was influenced by the addition of skim milk. The concentration of the skim milk added to the four formulas was the same. Meanwhile, the carbohydrate content was influenced by the addition of mocaf. Although the concentration of the mocaf added to the F3 and F4 formulas was different, the analysis results of the carbohydrate content showed no significant difference. However, the addition of a higher
amount of inulin to the F2 and F4 formulas showed a relatively higher difference in carbohydrate content.

### 3.2 Characteristics of organoleptic properties of the CF pudding

The results of an organoleptic test of the CF pudding formulas can be seen in Table 5. The results showed that the addition of mocaf and inulin did not have significant effects on the organoleptic properties (i.e., color, aroma, taste, and texture).

| CF pudding | Color       | Aroma       | Taste       | Texture     | Overall acceptability |
|-------------|-------------|-------------|-------------|-------------|-----------------------|
| F1          | 4.39±1.04\(^a\) | 3.00±0.93\(^a\) | 3.39±0.66\(^a\) | 3.85±0.51\(^a\) | 3.37±1.45\(^a\) |
| F2          | 4.61±0.66\(^a\) | 3.09±0.88\(^a\) | 3.42±0.87\(^a\) | 3.79±0.60\(^a\) | 3.69±0.79\(^a\) |
| F3          | 4.30±0.88\(^a\) | 3.12±0.96\(^a\) | 3.18±0.92\(^a\) | 3.88±0.60\(^a\) | 3.56±1.15\(^a\) |
| F4          | 4.36±0.86\(^a\) | 3.24±1.00\(^a\) | 3.21±0.74\(^a\) | 3.76±0.66\(^a\) | 3.63±0.72\(^a\) |

Values are expressed as mean ± standard deviation. Means in the same column with different letters were significantly different at p < 0.05

Based on the score of the organoleptic test on the CF pudding’s colors, the F1, F3, and F4 CF puddings had a slightly yellowish white color while the F2 CF pudding had milky white color. These colors were influenced by the skim milk as the raw ingredient. Meanwhile, the addition of inulin did not affect the pudding’s color. In line with the results of a previous study, the addition of 90 g/kg inulin did not affect the color of the strawberry-flavored gummy jellies [17].

The results of the organoleptic test score of the CF pudding’s aroma indicated that the F1, F2, F3, and F4 CF puddings had a rather distinctive aroma of milk. It was influenced by the addition of inulin and mocaf which made the aroma of milk to be reduced.

Based on the score of the organoleptic test on the CF pudding’s taste, all the CF puddings had a rather sweet taste. The results of a previous study indicated that the addition of inulin to pudding formulation could reduce the sweet taste of the pudding [16]. The results of the organoleptic test on the taste showed that the four CF pudding formulations could be given to the children under five because the taste was relatively not too sweet. However, the analysis of the total sugar content of the CF pudding needs to be performed, with the requirement not to exceed 30 g/100 g of product [18].

The results of the organoleptic test on the CF pudding’s texture showed that the four CF pudding formulas had a soft texture. These results were consistent with the previous study results, the inulin addition of 90 g/kg in strawberry-flavored gummy jellies made the texture softer [17]. The inulin extract had the ability to bind water with high solubility which would affect the product’s texture [19]. The results of the organoleptic test on the texture indicate that the four CF pudding formulas can be given to the infants aged 9-59 months as a snack. Soft-textured foods can already be given to the 9-month-old infants, and family foods can begin to be introduced to 10-month-old infants as a snack once a day [20]. Based on the scores of the organoleptic test, the four CF pudding formulas could be accepted by the panelists. The scores belonged to the “like” category. The highest score was obtained by the F2 CF pudding. The results of the overall assessment on the CF pudding indicated that the addition of mocaf and inulin with different concentrations was proven not to change the organoleptic properties of the CF pudding. Figure 2 and Figure 3 showed that a good response from consumers sensory perception of CF pudding based on F2.
The best CF pudding based on the organoleptic and physical properties was the F2 CF pudding. To determine the nutrient adequacy of the CF pudding with the target of children aged 1-3 years, it is necessary to calculate the contribution of nutrients from one serving of CF pudding. Based on the results of chemical analysis on the protein, fat, carbohydrates, and energy contents, the nutrient content in one serving of the F2 CF pudding was 80 g. The nutrient contribution from one serving of the F2 CF pudding is presented in Table 6 below.

Table 6. The nutrient contribution from one serving of the F2 CF pudding.

| Nutrient content     | Amount per serving | RDA for 1-3 years old | Nutrient contribution (%) |
|----------------------|--------------------|-----------------------|---------------------------|
| Protein (%)          | 2.46               | 26                    | 9.45                      |
| Fat (%)              | 1.67               | 44                    | 3.80                      |
| Carbohydrates (%)    | 8.11               | 155                   | 5.23                      |
| Total Energy (kcal)  | 57.32              | 1125                  | 5.09                      |

Based on the data presented in Table 6, the F2 CF pudding gave a higher contribution to the RDA for protein than the RDAs for carbohydrates and fat because the largest composition of pudding ingredients was skim milk. This product is expected to be an alternative to complementary foods which contributes to the nutritional fulfillment of the children under five and is preferred by the children under five as the consumers. The suggestions from the mothers of the children under five who became panelists in this study need to be considered so that this product can be accepted by the consumers; i.e., the use of fruit extracts or chocolate as an addition to the aroma and color of the CF pudding product. The claims for functional food products that can improve health will only have a small impact on the customer acceptance, and the organoleptic properties of the product still have to be considered [21].

3.3 Characteristics of physical and chemical properties of the F2 CF pudding flour

The microstructure of the F2 CF pudding flour presented in Figure 4 and the minerals (Ca, Fe, and Zn) content of the F2 CF pudding flour are presented in Table 7. The varying particle size of the F2 CF pudding flour was indicated homogeneously mixed. The morphology surface of the F2 CF pudding flour was same as the inulin-enriched instant yogurt [22]. The inulin in the flour mixture shown by arrows, spherical and amorphous.
The microstructure of inulin powder from chicory roots showed sperichal with a size of 50-100 μm and amorphous surface [23], [24].

![Microstructure of the F2 CF pudding flour.](image)

**Figure 4.** Microstructure of the F2 CF pudding flour.

**Table 7.** The minerals content of the F2 CP pudding flour.

| Nutrient content | F2 CF pudding flour (mg/100 g) |
|------------------|---------------------------------|
| Calcium (Ca)     | 385.11±4.04                    |
| Iron (Fe)        | 0.58±0.02                      |
| Zinc (Zn)        | 2.09±0.02                      |

The calcium content of the F2 CP pudding flour was in accordance with the Indonesian National Standard (SNI) for CF instant powder, but the iron and zinc contents were not appropriate. Base on the SNI, CF instant powder must contain more than 200 mg/100 g of calcium, 5 mg/100 g of iron, and 2.5 mg/100 g zinc [18]. The iron and zinc contents of F2 CF pudding flour can be increased by the addition of micronutrient mix powder. The fortification of micronutrient powders containing iron, vitamin A, zinc and other vitamins and minerals to complementary food was beneficial for male and female children under 2 years old [25].

**4. Conclusion**

The F2 CF pudding has the best characteristics based on the physical, chemical, and organoleptic properties with the formulation of 10% db mocaf and 0.8 g/100 g inulin. The contribution of one serving of the F2 CF pudding to the RDA of children aged 1-3 years is as follows: 9.45% protein, 3.8% fat, 5.23% carbohydrates, and 57.32 kcal energy.

This study needs to be continued towards the analysis of the effectiveness of the product using animal models, with the aim of obtaining the evidence of scientific claims regarding the addition of inulin that acts as a prebiotic and can increase calcium absorption.
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