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Effect of Different Soaking Pre-treatments on Quality of Potato Chips Granola Variety (*Solanum tuberosum* L.)

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Abstract. Potato chips are one of the snacks flavored by the public. This study aimed to determine the effect of soaking pre-treatment on the quality of Granola potato chips. The research was conducted at the Postharvest Laboratory of BPTP South Sulawesi from June to December 2017. The experimental design of RAL was carried out with 3 replications with 6 immersion treatments, namely in plain water, 0.5% $Ca(OH)_2$ solution, 1% $Ca(OH)_2$, $Na_2S_2O_5$ 0.5%, 1% $Na_2S_2O_5$, 0.5% $CaCl_2$ and 1% $CaCl_2$. The results showed that the chemical and organoleptic characteristics were significantly different between all treatments. The best or the most preferred treatment by the panelists was potato chips soaked in 1% $CaCl_2$ solution with a yield of 20.47%; moisture content 3.80%, 11.79% fiber, 34.79% fat, 30.24% starch, 2.5% ash, and the level of color preference (score 4.80), aroma (score 5.00), texture (score 4.60) and overall acceptance (score 4.85).
Keywords: chips; granola; potato; quality; soaking

INTRODUCTION

Potatoes (*Solanum tuberosum* L.) are an essential food crop and recommended as a food security crop. From 2002 to 2019, over 370 million metric tons were produced worldwide (Shahbandeh, 2021). Potato is a type of vegetable that is widely grown in Indonesia. Potatoes can be used for various purposes in households and industry. In cold countries, potatoes are consumed as a staple food, while in Indonesia, it is consumed as vegetables and snacks. It is a delicious, nutritious, and highly palatable vegetable with 75% water content. Potatoes are a good source of essential protein, vitamins such as vitamin B1, B3, and B6, also potatoes are a good source of minerals such as potassium, phosphorus and magnesium. It is a moderate source of iron while high in Vitamin C. It is low cholesterol and high potassium food containing important antioxidants, which play a part in preventing diseases related to aging (Tolessa, 2018). The diversified uses of potato tubers include table, processed, livestock feed and industrial (starch and alcohol) purposes. Potatoes can be consumed in many forms, including baking, boiling, roasting, frying, steaming, and microwaving. It can be served in any course of a meal from salads, snacks and soups to the main dish, or as a main dish itself. However, the most important one was the potato chips that gained terrific economic value in the processed food industry.

Granola is the dominant variety grown in Indonesia. Based on Satria (2020), the genotype of granola shows the best character for all growth parameters and produces the highest yields compared to the other genotypes. Granola potatoes' productivity in Indonesia is higher than other potato varieties due to their resistance to potato diseases and short growing season (Fuglie et al., 2006). Characteristic potato tuber variety Granola is not appropriate for processing due to low dry matter content, susceptibility to blackspot, and cooking blackening (Wibowo et al., 2004).

One of the problems faced in processing potato chips is the nature of potato tubers that are prone to browning reactions due to enzyme activity. The browning process will decrease the quality and it declines the consumer's interest (Murayama et al., 2015). Several studies have been tried to inhibit the occurrence of enzymatic browning reactions such as chemical, physical (blanching, freezing), controlled atmosphere and coating methods. Chemical pre-treatment is then needed to allow the diffusion of chemical agents into the product (Ioannou & Ghoul,

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2013). Wibowo et al. (2019), found that combination pretreatment using citric acid solution and steam blanching results in better flours properties. The processing option applies pre-treatments to the tubers, such as soaking in sodium sulfite, calcium hydroxide, and calcium chloride can reduce browning (Buckman et al., 2015; Krishnan et al., 2010; Oner & Walker, 2011).

Soaking is a food processing stage that plays an essential role in producing the quality of the food. Soaking in a solution of whiting can not only prevent the non-enzymatic browning process, but it can also make the texture hard and reduce the astringent, bitter and distorted taste (Siregar et al., 2015; Wahyuni, 2012) activate the work of enzymes (Srilaba et al., 2018). Soaking in calcium in potato chips can make the texture crunchy (Mandei & Nuryadi, 2017). Calcium hydroxide solution has been proven to improve fried foods' texture, colour, and taste (Siregar et al., 2015). The addition of calcium chloride contributes to increasing the toughness of cell tissue; the higher the concentration of hardener, the more complex the resulting texture (Kartikawati et al., 2017). Therefore, this study was conducted to determine the effect of pre-treatment using several types of immersion and different concentrations on the potato chips produced

METHODS

Potatoes (*Solanum tuberosum* l., Granola cultivar) were acquired in Tinggi Moncong, Gowa Regency, South Sulawesi, Indonesia. They were cleaned in running water and drained. Next, they were peeled, cut into 10 mm × 10 mm × 90 mm strips, and washed in running water to remove excess surface starch. They were then soaked for 30 min to this study as follows: standard using distilled water; 0.5% $CaCl_2$ solution; 1% $CaCl_2$ solution; 0.5% $Na_2S_2O_5$ solution; 1% $Na_2S_2O_5$ solution; 0.5% $Ca(OH)_2$ solution and 1% $Ca(OH)_2$ solution. After soaking, the samples were blanched in water at 85 °C for 5 min, drained, and dried with paper towels. After the dried periods, they were deep-fried by immersing in palm oil at 180 °C for 4 min in the same proportions and placed on paper towels to drain.

Observation Parameters

The parameters observed include yield, chemical aspects, and sensory. Chemical elements include water content, ash content, starch, fat content, and crude fiber (AOAC, 2000). A sensory panel consisting of 20 agricultural technology research center South Sulawesi employees was required to assess the product. The panelists were familiar with the procedure of sensory evaluation and scoring for the assessment. They were asked to respond on a numerical scale by filling the questionnaire table, from 1 (the lowest) to 5 (the highest). Sensory properties evaluated were consisted of crispiness ("not crispy "to "very crispy"), color ("brown to golden yellow"), flavor ("not detected" to "very intense flavor of potato"), and overall acceptance ("do not like" to "very like"). There was no middle value in this scale to produce two groups of the result, either positive or negative, to each parameter. The judges were requested to record their degree of preferences for crispiness, flavor and taste according to the five-point scale hedonic scale as described by (Rubilar et al., 2012).

The yield of potato chips compares the weight of fried potato chips (ready for consumption) and the weight of unpeeled potatoes. The equation calculates of potato chips:

$$Yield\ (\%)\ \frac{weight\ of\ raw\ potato\ (kg)}{weight\ of\ potato\ chips\ (kg)} \times 100\% \quad \ldots\ldots (1)$$

Experimental design

The experimental design used in this study was a completely randomized design and 3 replications with soaking treatment as follows: water only/control, lime ($CaOH_2$) 0.5%, lime ($CaOH_2$) 1%, Sodium metabisulfite ($Na_2S_2O_5$) 0.5%, Sodium metabisulfite ($Na_2S_2O_5$) 1%, $CaCl_2$ 0.5% and $CaCl_2$ 1%. The collected data are tabulated, analyzed with Analysis of variance method

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(ANOVA), and the real F test was forwarded to the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Yield

Yields of potato chips can be seen in Table 1. The highest yield of potato chips was produced in the soaking process with only water (22.33%), while the lowest yield was 18.60% which was made in 0.5% $Ca(OH)_2$ soaking treatment.

The analysis of variance showed that the soaking treatment had a significant effect on the yield of potato chips. It was the same report that the highest yield of potato chips was the soaking treatment with water only (25.39%) (Dewayani et al., 2020). So it can be said that immersion with $CaCl_2$, $Na_2S_2O_5$, and $Ca(OH)_2$, has the effect of lowering the yield.

Table 1. Characteristics of yields of potato chips some soaking treatment

Treatment	Yield (%)
Control	22.33 [a]
$CaCl_2$ 0.5%	19.90 [ab]
$CaCl_2$ 1%	20.47 [ab]
$Na_2S_2O_5$ 0.5%	21.33 [ab]
$Na_2S_2O_5$ 1 %	20.43 [ab]
$Ca(OH)_2$ 0.5%	18.60 [b]
$Ca(OH)_2$ 1 %	20.87 [ab]

Note: The numbers followed by the same letter in the same column are not significantly different in Duncan's multiple distance test $\alpha = 0.05$

Moisture

The analysis of the variety of water content indicated that the treatment of the type of soaking material had a significant effect on the moisture of the Granola potato chips. The average moisture value of potato chips can be seen in Table 2. In Table 2, it can be seen that soaking has a significant effect on the water content of potato chips.Water content is a determining factor for the quality of potato chips. The moisture of the potato chips produced in this study ranged from 0.98-7.53% (Table 2). SNI 01-4031-1996, regarding the quality requirements of potato chips, requires that the water content of potato chips is a maximum of 3%. None of the potato chips in this study met the requirements because the water content of potato chips was more than 3%. Granola potatoes are potatoes with a low starch content (16 - 18%) and high water content (more than 80%). Zhang et al. (2016), reported that frying technique gave no significant difference among the final total oil, surface oil, structural oil, and penetrated surface oil. According to Asgar (2013), factors affecting the amount of oil absorbed by the product are the material's water content, slice thickness, and pre-frying treatment.

Based on the results obtained in Table 2, the lowest fat content in the Ca(OH)2 treatment was 28.75%, with the lowest water content at 3.79%. According to Haryanti et al. (2013) the low water content of potato tubers will result in lower oil absorption. This is because the higher the water content, the evaporation of water that occurs during the frying process results in more cavities being formed in the material. In addition, inhibition of evaporation of water accelerates the formation of a crust; as a result, the amount of oil absorbed by the material also decreases so that the appearance of french fries tends not to be greasy.

Ash

The results of the ash content of the potato chips can be seen in Table 2, determination of the indicator indicators of the amount of mineral content contained in the potato chips produced. The ash content of the potato chips made in this study ranged from 2.26-2.94% (Table 2), where the lowest ash content was in the water soaking treatment (2.26%) and the highest ash content was in the $Na_2S_2O_5$ 1% soaking treatment (2.94%) and Ca $(OH)_2$ 0.5% (2.90%). Jati et al. (2012) reported that the ash content in food samples shows the number of minerals available in food products.

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Table 2. Chemical characteristics of potato chips are several soaking treatments

Soaking Treatments	Moisture (%)	Ash (%)	Starch (%)	Fat (%)	Fiber (%)
Control /water	5.29 [a]	2.26[d]	30.23[d]	30.26 [e]	15.84 [a]
$CaCl_2$ 0.5%	4.94 [b]	2.73[b]	31.73[a]	35.31[c]	14.82 [d]
$CaCl_2$ 1%	3.80 [c]	2.50 [c]	30.24[d]	34.79[d]	11.79 [c]
$Na_2S_2O_5$ 0.5%	5.35[a]	2.70[b]	30.33[c]	37.68[a]	9.24 [e]
$Na_2S_2O_5$ 1 %	3.52[d]	2.94[a]	29.58[f]	35.34[b]	5.64[g]
$Ca(OH)_2$ 0.5%	4.90[b]	2.90 [a]	30.14[e]	29.51[f]	6.37[f]
$Ca(OH)_2$ 1 %	3.79[c]	2.30[d]	30.40 [b]	28.75[g]	10.99[d]

Note: The numbers followed by the same letter in the same column are not significantly different in Duncan's multiple distance test $\alpha = 0.05$

The increase of ash content affected by longer soaking time could be due to the sufficient time available for calcium to penetrate the cell wall and inside the sweet potato slices matrix. Calcium will then bond with water, creating cross linking network, thus in the same time trapping the calcium inside the sweet potato slice and remain inside the chips after the frying process. According to Anonymous (2009), $CaCl_2$ mainly contains calcium and chloride, while Yuliandari (2019) explains that Natrium metabisulfite contains sodium and sulfur. The presence of this mineral salt increases the ash content in the chips when immersed. This is supported by the research of Pratama et al. (2013), that the ash content produced is strongly influenced by the added sodium metabisulfite, the higher the concentration of sodium metabisulfite added, the more sulfite that seeps into the material. Sulfites that are absorbed in the material will be difficult to come out so that the amount of ash left on the material will increase

SNI 01-4031-1996 concerning the quality requirements for potato chips requires that the ash content of potato chips is a maximum of 3%.Based on these requirements, all the soaking treatments of the resulting potato chips met the criteria because the ash content was < 3%. In this research, blanching was carried out by watering it with hot air, causing the pores of the potato tissue to open so that many minerals were dissolved into the hot air so that the content of the chips product was low.

Starch

The highest starch content was soaking treatment with $CaCl_2$ 0.5% (31.73%) and was significantly different from other treatments. High starch content will produce a crisper texture (Listianti & Ediati, 2019). Crispness could be caused by differences in starch and pectin content, affecting the texture. The results of Parhusip et al. (2021) showed that the decreased starch content with the addition of acacia gum concentration was associated with an increased hardness value. The decrease in starch content and an increase in the hardness value indicated that the resulting texture was less crunchy. Calcium can be used as a soaking agent to increase the hardness of products such as canned papaya, pear, apple, and also the crispness of food products such as chips and flakes (Tjandra et al., 2019). From the research results of Munawaroh et al. (2018), the treatment of $CaCl_2$ concentration, blanching time, and interactions did not significantly affect the starch content value of water yam fries. This is presumably because $CaCl_2$ in food tends to bind to cell tissue in the material, so it does not considerably affect the loss of starch content**.**

Based on Liu et al. (2020) finding, the combined treatment of lactic acid (LA) and calcium chloride (CC) could increase the hardness of potato slices after boiling. Data

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on the nature of calcium-starch complexes induced by extrusion cooking are scarce. Gomez et al. (1989) studied the structural changes in corn and sorghum during alkaline processing and found that some starch granules in the peripheral endosperm were destroyed. The reduction of relative crystallinity of starch during nixtamalization was 15 to 25%, and the loss of birefringence of starch granules was 4 to 7%.

Fat

The results of testing the fat content of potato chips can be seen in Table 2. The fat content of potato chips in this study ranged from 28.75 -37.68%. The highest fat content was in treating potato chips soaked with 0.5% $Na_2S_2O_5$ (37.68%). While the lowest fat content was in $Ca(OH)_2$ 1% (28.75%. This was due to forming a bond between calcium and pectin in the potato tissue so that the potato has a strong tissue structure. As a result, a hard texture. Hard texture can inhibit the process. Evaporation of water during frying made the water evaporated slightly and accelerates crusts' formation; thus, the amount of oil absorbed by the ingredients also decreases. During the frying process, the oil enters the crust and fills the space, initially filled with water.

Another factor affecting oil absorption is the pore profile of potato slices. Where there was no significant difference in oil content of samples with initial pore diameter of 0–0.2 mm. While, TO (mainly STO) increased with the increasing initial pore diameter of 0.3–1.2 mm. The bigger initial pore diameter induced bigger pore volume and porosity (Y. Liu et al., 2021).

Absorbed oil can have a positive impact on the distinctive taste and affect the crispness of the product. It provides unique sensorial attributes attractive to the consumer such as colors, aromas, flavors, and textures that improve overall palatability (Pedreschi et al., 2018).

Fiber

Granola potato chips fiber content ranged from 5.64% - 15.84%, where the highest fiber content was soaking in water/control (15.84%) and the lowest fiber content was soaking in $Na_2S_2O_5$ 1% (5.64%). From the results of statistical tests, it is known that soaking has a significant effect on the fiber content of potato chips, where soaking with $Na_2S_2O_5$ 1% occurs the highest-fiber decomposition and is significantly different from other treatments.

Table 3. Organoleptic characteristics of potato chips in several soaking treatments

Treatment	Color	Flavor	Texture	Overall acceptance
Control	4.44^{abc}	3.90 ^{b}	4.40 ^{ab}	4.02 ^{ab}
$CaCl_2$ 0.5%	4.90 ^{a}	4.50 ^{ab}	4.70 ^{a}	4.50 ^{ab}
$CaCl_2$ 1%	4.80 ^{ab}	5.00 ^{a}	4.60 ^{ab}	4.85 ^{a}
$Na_2S_2O_5$ 0.5%	3.90 ^{c}	4.20 ^{ab}	3.70 ^{b}	3.86 ^{b}
$Na_2S_2O_5$ 1 %	4.40 ^{abc}	4.50 ^{ab}	4.10 ^{ab}	4.70 ^{a}
$Ca(OH)_2$ 0.5%	4.60 ^{abc}	4.20 ^{ab}	4.00 ^{ab}	4.15 ^{ab}
$Ca(OH)_2$ 1 %	4.00 ^{bc}	4.40 ^{ab}	4.30 ^{ab}	4.42 ^{ab}

Note: The numbers followed by the same letter in the same column are not significantly different in Duncan's multiple distance test $\alpha = 0.05$

Color

According to the sensory analysis participants' observations, the color of the french fries varied as follows: NaCl produced a more golden hue. Simultaneously, the control samples were more brownish, and $CaCl_2$ had a paler but uniform coloration. Severini et al. (2003) found that in terms of inactivating polyphenol oxidase, the use of calcium chloride, which is already at low concentrations, would seem better than the use of sodium chloride.

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The color in the material can come from the natural pigments of the food itself, the caramelization reaction, the Maillard reaction, the reaction of organic compounds with air, and the addition of natural and synthetic dyes. Table 3 shows that the panelists' ratings for the hedonic test of the color of potato chips ranged from 3.90-4.90 (somewhat like it). The highest panelist assessment for the color hedonic test was found in potato chips soaked in 0.5% $CaCl_2$ solution (score 4.90 / like). However, based on the hedonic quality test for the seven immersion treatments showed a dark yellow color. The discoloration of the potato chips to dark yellow is not caused by the soaking material but is caused by frying and the Maillard reaction (enzymatic browning).

The existence of a frying process in the processing of potato chips also has an effect on spurring the Maillard reaction. The color of a product is the main attraction before components recognize and like other properties. Heating foods immersed in oil during frying provides many attractive sensorial attributes including taste, flavor, and color (Mariotti et al., 2015; Munawaroh et al., 2018). The color of potato chips is due to the browning process that occurs in the ingredients.

Flavor

The results of the analysis of the average flavor of potato chips ranged from 3.90-5.00. Data from the flavor analysis of potato chips with soaking treatment can be seen in Table 3. Table 3 shows that the soaking treatment significantly affects the flavor ($\alpha = 0.05$). It is suspected that the strong flavor comes from the flavor of oil during the frying process because the ingredients contain amino groups and reducing sugars which can cause a maillard reaction to produce volatile compounds typical of fried products (Sari, 2010).

The strongest flavor was soaked in $CaCl_2$ 1% (score 5.00) and significantly different with control (score 3.90). This research was different from the research conducted by Bakhtiary (2015). Sensory evaluation results demonstrated that samples soaked in the $CaCL_2$ solution had the lowest taste and odour values significantly.

Texture

The organoleptic test using the hedonic scale revealed that the panelist chose the soaking in $CaCl_2$ 0,5-1% from the texture preference. The score was between neutral to like the texture of potato chips. It could be due to the increase of crispness of potato chips therefore preferred by the panelists. Meanwhile, no significant differences in texture were selected by panelists except $Na_2S_2O_5$ 0.5% (score 3.70). The range was between neutral to like. This is presumably because the level of panelists' assessment of each treatment has a texture that is not too much different. The soaking in $Na_2S_2O_5$ 0.5% was not preferred by panelists after the taste preference test. The range was between dislike and neutral.

The immersion treatment with calcium chloride ($CaCl_2$) gave the most preferred potato texture compared to other treatments with the right level of crispness. Research by Andriani et al. (2018) said that soaking calcium chloride ($CaCl_2$) in mango fruit can inhibit the softness of the fruit flesh. In fruit tissue, calcium can affect fruit by increasing cell turgor pressure by improving the integrity of cell structure.

The level of texture preference can be caused by the level of taste of each person who is different (Munawaroh et al, 2018). According to Kita et al. (2005), the texture in french fries has two meanings, namely the texture of the outside (crispy) and the inside (gritty), but in this case, crispness is preferred.

Overall Acceptance

Table 3 showed the preference of panelists to the potato chips produced from soaking treatments of a variety of Granola. Overall acceptance was measured to know the panelist’s choice to measure the chip of the panelists as a response to the effect of chips attribute. The preferred quality of

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samples was presented in the high score in sensory evaluation. The best overall organoleptic treatment was potato chips soaked with 1% $CaCl_2$ (score 4.85) and 1% $Na_2S_2O_5$ (score 4.70). This research was different from the research conducted by Bakhtiary (2015). Sensory evaluation results demonstrated that samples soaked in $CaCL_2$ solution had the lowest values of taste, odor, and overall acceptability significantly.

Table 4. Economic analysis of potato chips processing variety of granola

Description	Soaking of 1% $CaCl_2$		
	Item	Unit	Sum (Rp)
1. Material			
a. Potatoes (kg)	250	20000	5.000.000
b. $CaCl_2$ (kg)	1	22000	22000
c. Cooking oil (kg)	4	25000	100000
d. Basin	2	100.000	200.000
e. Opaque paper (m)	10	1000	10.000
f. Knife (unit)	1	200000	200.000
g. steaming pot	1	350.000	350.000
h. Pan (piece)	1	200.000	200.000
i. Big spoon	1	125.000	125.000
j. Plastic packaging	1	200.000	200.000
k. Frying tool	1	75.000	75.000
l. Oil drainer	1	60.000	60.000
m. Winnower	2	20.000	40.000
n. Potato slicer	1	200.000	200.000
o. Stove and gas tube	1	650.000	650.000
Sub Total (1)			**7.432.000**
2. Labor			
a. Sorting and peeling	1 org/hr	50.000	50.000
b. Slicing	1 org/hr	50.000	50.000
c. Drying	1 org/hr	50.000	50.000
d. Frying	1 org/hr	50.000	50.000
e. Packaging	1 org/hr	50.000	50.000
Sub Total (2)			**250.000**
Other costs			
a. Shrink cost of tools			30.000
Total cost			**7.682.000**
Total of Production (kg)			50
Selling value (Rp/kg)			320.000
Total of revenue (Rp)			16.000.000
Net Income (Rp)			**8.318.000**
R/C ratio			**2,08**
Net B/C			**1,08**

Sodium Metabisulfite increased the lightness of strips before and after frying (Oner & Walker, 2011). The current investigation results showed that soaking of blanched potato slices at 25^{o}Ċ in NaCl and $CaCl_2$ solutions for 5 min before frying reduced acrylamide formation of potato chips dramatically by 46 and 55%, respectively, comparison with blanched potato slices as a control. Although $CaCL_2$ showed more efficiency in inhibiting acrylamide formation than NaCl, potato slices soaked in $CaCl_2$ solution had the weakest taste, odour, and overall acceptability. In contrast, NaCl-soaked samples had the highest values of general acceptability. According to this fact that for consumers, the perceivable sensory attributes are the deciding factors in food

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acceptance, it was concluded that soaking of blanched potato slices in NaCl solution (0/1 M) could be proposed as a reliable mitigation strategy to reduce acrylamide formation in fried potato with more acceptable sensory characteristics for consumers (Bakhtiary, 2015).

Economic Analysis

The results showed that the Granola variety potato chips soaking 1% $CaCl_2$ before frying was the best in terms of appearance, nutritional content, and overall taste potato chips are marketable. From the results of economic analysis, it was known that processing 250 kg of potatoes can produce 50 kg of potato chips, either soaked with 1% $CaCl_2$ solution. With a selling price of Rp. 320,000 / kg, giving a net B/C ratio of 1.08 (1% $CaCl_2$ soaking treatment) The net B/C ratio will increase with further processing because there are no more equipment purchases (Table 4).

CONCLUSION

Soaking pre-treatment significantly affects the yield, moisture, ash, starch, fat, and fiber content of Granola potato chips. Meanwhile, from an organoleptic perspective, the pre-treatment in a 0.5% $CaCl_2$ solution was different from other treatments for several organoleptic characteristics. The best potato chips are potato chips previously soaked with 1% $CaCl_2$ with high yield (20.47%), low moisture (3.80%), low ash (2.5%), high starch content (30.24%), low fat (34.79%), high fiber (11.79%), with highly preferred organoleptic levels, color (score 4.80), flavor (score 5.00, texture (score 4.60), and overall acceptance (score 4.85).

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