**The Effect of Addition Sorghum** **(*Sorghum bicolor* L.) Flour and Pumpkin Puree (*Cucurbita moschata*) on Churros Characteristic**

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**Abstract.** Churros is a snack that has a sweet, savory taste and is usually consumed with chocolate. Churros snack is generally made using wheat flour. This research aims to determine the organoleptic and physicochemical characteristics of churros by substituting sorghum flour and pumpkin puree. Sorghum and pumpkin have good nutritional content, such as crude fiber, carotenoids, and minerals so that this content might increase churros nutritional value. This study uses several proportions of wheat flour, pumpkin puree and sorghum flour. There are six formulas: F1 (100:0:0), F2 (30:0:70) F3 (30:20:50), F4 (30:35:35), F5 (30:50:20), F6 (30:70:0). Each formula analyzed for the organoleptically to determine the best treatment. The organoleptic data obtained were analyzed using ANOVA and a further DMRT (Duncan Multiple Range Test) test. The results obtained from organoleptic testing showed that the churros formulation most preferred by the panelists was the F4 formulation. The results of physicochemical testing showed that the texture level of hardness in F1 was 47.05 N and F4 was 25.50 N, the fracture strength in F1 was 2.47 N, as well as testing for water content in F1 13.08% and F4 13.31%, ash content in F1 0, 79% and F4 1.49%, fat content F1 9.27% and F4 12.4%, crude fiber F1 1.49% and F4 6.21%, carotenoids F1 16.45 ppm and F4 174.35 ppm. Therefore, churros substitute with sorghum flour and pumpkin puree has higher nutritional value than wheat flour.

**Keyword.** Churros, snacks, sorghum flour, pumpkin puree, wheat flour.

**Introduction**

As time progresses, healthy food and economically viable food production has increased rapidly and become a highlight in various circles of society [1]. Currently, sorghum is highlighted as a food that has high quality and low production costs when compared to other cereals [2]. Sorghum flour contains 10.11% protein, 3.65% fat, 2.24% ash, and 80.42% starch [3]. Sorghum flour also has a higher fiber content compared to other types of cereals such as wheat and rice [4]. Sorghum flour has been widely used in the manufacture of bakery products such as biscuits [5], donuts [6], and cakes [7] to improve the nutritional quality of the product. Based on this, sorghum flour is considered to be utilized in other forms of processed bakery. One of the bakery products that are in demand by the public is churros.

Churros is a snack that has 2 textures (dry and soft) [8]. In general, churros are made from wheat flour. Sorghum flour has the potential to be used as a substitute for wheat flour on churros because sorghum flour has dry characteristics. Therefore, sorghum flour can support the dry characteristics of churros. Sorghum flour has a moisture content of 10.27%, which is lower than wheat flour by 14%. Sorghum is one of the important staple foods consumed in the world's warm and semi-arid regions. It is rich in carbohydrates, fiber, vitamins, minerals, and phytochemicals including tannins, phenolic acids, anthocyanins, phytosterols, and policosanols. Sorghum flour contained higher fiber compared to wheat flour. Based on Anadia’s research (2022), the fiber content of sorghum flour is 6.3%, while wheat flour is 1.92% [9]. These nutrients have a positive role in the health and nutrition of humans primarily in people suffering from lifestyle disorders such as celiac disease, diabetes, and obesity [10]. Sorghum flour can reduce the need for wheat flour. wheat flour contains gluten, which is high enough to be dangerous if consumed by children with autism, people with obesity, and hepatitis [11]. Therefore, there is a need for alternative low-gluten food ingredients that can reduce the use of wheat flour [12].

However, sorghum flour might affect the color of churros snacks because sorghum flour has a dull and pale color [13]. One of solution to improve the color of churros substituted with sorghum flour is the addition of plant-based food ingredients that have a color similar to churros products. Pumpkin is one of the food ingredients that can increase the brightness of churros products. Pumpkin has a high content of carotenoids which are a group of yellow to orange pigment compounds [14].

Pumpkin is one of the agricultural commodities that is highly cultivated in Indonesia. The amount of pumpkin production in Java Island in 2011 was recorded in the Central Bureau of Statistics as much as 150,000 tons/year. According to FAO (2013), the yellow pumpkin crop in Indonesia in 2012-2013 experienced an increase of 88,443,148 tons - 89,791,562 tons. Pumpkin can be classified as a fiber-rich food because it meets the requirements of fiber content with an amount of 21.39-21.41% bw and has contents such as carbohydrates, minerals, fats and proteins [15]. In addition, pumpkin contains other nutrients such as calcium, vitamin B, vitamin C, and phosphorus [16].

Sorghum flour and pumpkin puree are often used as additives to make food products. In the research of Rismaya et al., (2018) muffins are made from 100% pumpkin can meet 29-31% of the fiber needs of the Indonesian population/person/day [17]. According to Winiastri (2021), bar snacks with a composition of 80 grams of sorghum flour: 100 grams of pumpkin get the best results in terms of organoleptic [14]. Sorghum flour substitution in sweet bread as much as 30% shows the best formulation which has a crude fiber content of 8.28% [9]. Through research on churros innovation by utilizing sorghum flour and pumpkin has the potential to be developed as a food product that is high in fiber and high in carotenoids. Studies characterization and potential use of pumpkins combined with sorghum flour are still very little explored compare to major commodities such as rice, soybean, and wheat flour. Here we report study of churros substituted using pumpkin puree combined with sorghum. The impact of the substituted of pumpkin and sorghum flour on organoleptic, hardness, fracture level, moisture, ash content, crude fiber, fat and carotenoid pigment was evaluated.

This research was conducted to obtain the formulation of churros products with the addition of sorghum flour (Sorghum bicolor L) and yellow pumpkin (Cucurbita moschata) which have organoleptic values and physicochemical characteristics that are favored by the public.

**Method**

**Materials**

The equipment used in this study are mixers, spatules, spoon, measuring glasses, knives, scissors, stoves, cups, analytical balances, ovens, pipette drops, oven, erlenmeyer 1000 mL, beaker glass, dryer, porcelain cup, and forms. The materials used are sorghum flour from Tambiyaku Surabaya, wheat flour, water, sugar, salt, cinnamon, margarine, eggs, yellow pumpkin, oil, label paper, hexana, scarf paper, alcohol 95%, solution K2SO4 200 ml, NaOH 1.25%, H2SO4 1.25%, Na2S2O3 1.25%, solution luff schroll, HCl 3%, and NaOH 4%.

**Formulation of Churros Snack**

The churros snacks were prepared from wheat flour, sorghum flour, and pureed pumpkin. There were 6 formulas of churros were made. The variation of samples listed in Table 1. The study is based on the Complete Random Plan with 6 treatments and 3 repetitions. All products were prepared in the food processing laboratory of Sebelas Maret University, Madiun. The recipe is given in Table 2.

**TABLE 1.** Formulation of Churros

|  |  |  |  |
| --- | --- | --- | --- |
| **Formulas** | **Wheat Flour** | **Yellow Pureed Pumpkin** | **Sorghum Flour** |
| F1 | 100% | - | - |
| F2 | 30% | - | 70% |
| F3 | 30% | 20% | 50% |
| F4 | 30% | 35% | 35% |
| F5 | 30% | 50% | 20% |
| F6 | 30% | 70% | - |

**TABLE 2**. Recipe of each Churros formulation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Ingridients** | **Formulas** | | | | | |
| **F1** | **F2** | **F3** | **F4** | **F5** | **F6** |
| Wheat flour | 100 g | 30 g | 30 g | 30 g | 30 g | 30 g |
| Yellow pureed pumpkin | - | - | 20 g | 35 g | 50 g | 70 g |
| Sorghum flour | - | 70 g | 50 g | 35 g | 20 g | - |
| Sugar | 20 g | 20 g | 20 g | 20 g | 20 g | 20 g |
| Egg | 100 g | 100 g | 100 g | 100 g | 100 g | 100 g |
| Salt | 2 g | 2 g | 2 g | 2 g | 2 g | 2 g |
| Butter | 20 g | 20 g | 20 g | 20 g | 20 g | 20 g |
| Milk powder | 20 g | 20 g | 20 g | 20 g | 20 g | 20 g |
| Water | 80 ml | 80 ml | 80 ml | 80 ml | 80 ml | 80 ml |
| Oil | 200 ml | 200 ml | 200 ml | 200 ml | 200 ml | 200 ml |

**Organoleptic Analysis of Churros Snack**

The churros hedonic test was conducted based on the modified research of Lestari & Susilawati (2015) [18]. This test was conducted on color, flavor, taste, and texture by 35 untrained panelists. The assessment criteria were 1 = very dislike, 2 = dislike, 3 = neutral, 4 = like, 5 = very like. Data analysis was carried out using the One-Way Anova method using IBM SPSS 20 software, and if there are significant differences, further analysis will be carried out using DMRT (Duncan Multiple Range Test) at a significance level of α = 0.05 [14].

**Physicochemical Analysis of Churros Snack**

The physical analysis is carried out through hardness testing and fracture level. Chemical analysis carried out on churros is moisture by thermogravimetric method [19], ash content by gravimetric method [19], crude fiber by extraction method [9], fat content by the Soxhlet method [19], and carotenoids by the HPLC method. SPSS testing was carried out independently using the same T-test to compare the results of physical and chemical tests.

**Result and Discussion**

**Organoleptic Analysis of churros**

The results of the organoleptic analysis of each churros can be seen in Table 3. Color is the most essential quality attribute when assessing food. This parameter is the first factor that attracts consumer interest in food products [20]. Based on Table 3, the color parameters of each formula showed no significant difference, except F4 sample. The formulation with the highest level of panelist preference is F4 (30:35:35). In contrast, the lowest panelist preference is F3 (30:20:50). The F4 has a balanced ratio, which is 30% wheat flour, 35% sorghum flour, and 35% yellow pumpkin, that balanced combination of sorghum flour and pumpkin puree is thought to produce a color appeal that panelists prefer.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Formulation** | **Color** | **Flavor** | **Taste** | **Texture** | ***Overall*** |
| F1 | 2.94a**±**0.8 | 2.91bc**±**0.9 | 3.54bc**±**1**.**0 | 3.11b±1.1 | 3.54a±0.7 |
| F2 | 3.17a**±**0,6 | 3.05bc**±**0.8 | 3.25b±0.9 | 2.65ab±0.9 | 3.37a±0.7 |
| F3 | 2.91a**±**1,1 | 3.17c**±**0.9 | 3.54bc±0.8 | 3.97c±0.9 | 3.11a±0.9 |
| F4 | 4.14b**±**0.9 | 4.02d**±**0.9 | 3.82c±1.0 | 4.00c±0.8 | 4.42b±0.7 |
| F5 | 3.02a**±**0.9 | 2.65ab**±**0.8 | 3.11b±0.8 | 3.11b±0.9 | 3.17a±0.8 |
| F6 | 3.25a**±**1.1 | 2.40a**±**1.2 | 2.28a±0.9 | 2.34a±0.9 | 3.11a±1.3 |

**TABLE 3.** Organoleptic Analysis of Churros

The use of yellow pumpkin puree can increase consumer attractiveness due to the pumpkin puree produces a natural color. Yellow pumpkin puree has a yellow to orange color due to the carotenoid pigments content. Carotenoid pigments which exhibit yellow, orange, red and purple colors are natural pigments found in fruits or vegetables [21].



**FIGURE 1.** The color comparision of F1, F2, F3, F4, F5, F6 churros formulation

Carotenoid contained in yellow pumpkin puree support the colors of churros, which causes the color of the churros turn into brownish yellow. Therefore, pumpkin puree can be used as a substitute for synthetic dyes and safer for human health. This is in line with Putri's research (2018), which states that increasing the pumpkin puree concentration, the more brownish the color of the product, so panelists less prefer it [22]. The F4 is the right formulation to produce churros with a bright yellow color. The increasing substitution of sorghum flour also influenced the unattractive color. In this study, increasing the proportion of sorghum flour used, will decrease the color acceptance value of churros. The higher level of sorghum flour used, the paler color produce on churros and resulting the decreasing on panelist attractiveness. Sorghum flour containing tannins that react easily and change color to dull brown [23]. Tannins are polyphenolic compounds that can be oxidized in alkaline atmosphere to produce orthosemiquantionone radicals or orthoquionone molecules, which are highly reactive and produce brown and pale products [24].

Flavor is one of the organoleptic analysis parameters that can be determined using the sense of smell. Based on Table 3, the churros formulation with the highest panelist preference for flavor is F4 sample, while the lowest is F6 sample. Sample F4 has flavor value significantly different from F1, F2, F3, F5 and F6. Sample F4 had flavor preferred by panelists because there was a combination of flavors between wheat flour, sorghum flour and pumpkin puree. The level of flavor acceptance by panelists increased along with the balanced combination of sorghum flour and pumpkin puree. Churros with low pumpkin puree substitution as in F5 and F6 were seen as less flavored by panelists. According to Budiarti et al. (2019) adding pumpkin puree has a specific flavor that can attract consumers [11]. Pumpkin has volatile flavor compounds such as alcohol (eucalyptol, ethanol, 2-heptanol), esters (ethyl acetate, ethyl ether), and alkenes [25]. These volatile compounds cause the churros produced to have a distinctive flavor of pumpkin. In addition, the flavor of F6 of 70% pumpkin puree-substituted churros also less favored by panelists. The increasing use of pumpkin puree can affect the flavor of the churros, because it has a flavor that is too pungent and slightly languorous. According to Montesano et al (2018), pumpkin produces flavortic compounds in the form of a languorous flavor due to the presence of too strong flavonoids [27]. According to Isnaini et al., (2016), the flavor of pancakes with a 10% pumpkin substitution was favored by the panelists because the panelists liked the taste of the pancakes [26]. preferred by panelists because panelists like the smell of pumpkin which is not too pungent. While at 15% pumpkin flour substitution, the results showed more panelists expressed dislike because the smell of pumpkin was sour and very pungent. The sour smell is thought to come from the food fiber component of pumpkin [26, 27].

The fiber component in pumpkin consists of pectin, cellulose, hemicellulose and lignin [28]. Pumpkin contains 40.4% cellulose, 4.3% hemicellulose and 4.3% lignin [22]. The hemicellulose composition has one of the uronic acid monomers which has acidic properties [29]. According to Winarsih (2016), alkaline solutions damage the bonds in lignocellulosic components and the breaking of bonds by heat [30]. The hydrolysis process can convert hemicellulose into pentose sugar, hexose sugar, and hydrolysis uronic acid. Increasing the proportion of sorghum flour was followed by an increase in flavor acceptance by panelists, but when the proportion of sorghum flour reached 50%, flavor acceptance by panelists decreased. Another study revealed that the higher concentration of sorghum flour for wheat substitution in cookies cause a decrease on flavor, texture, and taste acceptance [31]. The flavor of sorghum flour has dusty flavor, woody flavor, and green or plant flavor [23, 30].

The increase in the proportion of sorghum flour given in the churros dough was followed by an increase in taste by the panelists. However, when the proportion of sorghum flour reached 50%, the level of taste acceptance by the panelists decreased. reached 50%, the level of taste acceptance by panelists decreased. According to research Lufiria & Rustanti (2012), the higher percentage level of sorghum flour used will produce a rancid and astringent taste in the mouth of consumers [32]. Sorghum has an astringent taste because of its tannin content [33]. In addition to sorghum flour, the high and low proportion of pumpkin puree is thought to affect panelists perception of taste acceptance. Increasing in the proportion of pumpkin puree in churros, such as in samples F5 and F6, consumers taste acceptance decreased. The taste acceptance value of churros F5, F6 shown a lower value than F4. The more pumpkin puree used in baking will cause a very sweet taste, therefore consumers are less interested in the taste of the product [32, 34].

Texture is an organoleptic analysis parameter that can be determined using the help of the sense of taste and the sense of touch. Based on Table 3, the texture parameter, the formulation with the highest level of panelist preference is F4. Sample F4 is a churros substituted with 35% sorghum flour and 35% pumpkin puree. Pumpkin puree, when steamed, will experience a softening process so that it can provide dough for soft products. The increase in the proportion of pumpkin puree given in the churros dough was followed by an increase in texture by the panelists. However, when the proportion of pumpkin puree reached 50%, the level of texture acceptance by the panelists was lower. The composition of high pumpkin puree made the texture of the product moist, with tight pores, and less fluffy. This was due to the heavier pumpkin puree used, so the more pumpkin puree added to the dough, the more the product could not expand optimally and became tough [35]. In additions, the high and low proportion of sorghum flour affects the perception of texture acceptance. An increase in the proportion of sorghum flour in churros, such as in samples F2 and F3, show a decreased acceptance of texture by consumers. This is due to the addition of sorghum flour resulted in a rough and sandy brownie texture [36]. The rough and sandy nature of churros is caused by the high starch content of sorghum flour, namely (80.42%) [37]. In addition to starch, sorghum's relatively high crude fiber can also give a gritty impression. The higher the substitution of sorghum flour in the product, the grittier the texture will be in the mouth. The water in the dough will be absorbed by the starch, making the starch granules bubble. The starch granules, when heated, will gelatinize and undergo a dehydration process so that the gel forms a solid framework and hard texture because much moisture from the dough is lost.

The overall organoleptic analysis is a parameter that assesses the characteristics of the product in food as a whole and combines testing of the previous parameters, which include color, flavor, taste, and texture. Based on Table 3, the results of organoleptic analysis of overall parameters of churros sample code F4 was significantly different compared to F2, F3, F5, F6. It is concluded that churros with the addition of 30% wheat flour, 35% pumpkin puree and 35% sorghum flour is the most preferred and accepted by consumers.

**Physical Analysis of Hardness and Fracture Levels of Churros**

The results of the physical analysis of each churros formula with the addition of sorghum flour and pumpkin puree can be seen in Table 4. The hardness test results on churros with the addition of sorghum flour and pumpkin puree with samples F1 and F4 are 47.05 N ± 3.93 and 25.50 N ± 0.68. The F1 and F4 samples are 47.05 N ± 3.93 and 25.50 N ± 0.68, respectively. Based on statistical testing carried out using the independent T-Test, the results obtained in the control churros and the best treatment, there are significant differences (>0.05) in the level of hardness. This indicates that using sorghum flour and pumpkin puree can reduce the hardness of the churros. A higher hardness level indicates that the product is less crunchy. The moisture content of the ingredients can influence the difference between the hardness values of the products. The water content in pumpkin puree is very high, so the resulting product is not complex compared to wheat flour [38]. In addition, hardness is also influenced by the thickness of product, the harder the product, the greater the crushing power.

**TABLE 4**. Physics Charateristic of F1 anf F4 Churros

|  |  |  |
| --- | --- | --- |
| **Physical Analysis** | **F1** | **F4** |
| Hardness | 47.05 N ± 3.93 | 25.50 N ± 0.68 |
| Fracture | 2.47 N ± 1.91 | 17.58 ± 14.34 |

According to Suarni & Subagio (2013), products with sorghum flour substitution can produce a texture that is not hard [37]. Texture is influenced by the content of amylose, protein, and amylopectin in flour ingredients. The content of sorghum starch ranges from 56-73% with an average of 69.5%, and amylose is 20% and amylopectin content is around 70-80% [37]. Amylose can give a hard impact on food, while the amylopectin content can cause stickiness in food [39], while amylose in wheat flour is 28% [40]. Amylose in a material can form hydrogen bonds with water. During the cooking process, the water will evaporate and leave space so that the texture will become solid.

Based on Table 4. shows the results of the test of the level of fracture of churros products of F1 and F4 which amounted to 2.47 N ± 1.91 and 17.58 ± 14.34. There is a significant difference (>0.05) in the fracture level. This indicates that the use of sorghum flour and pumpkin puree can increase the percentage of fracture rate in churros products. Sorghum flour can increase the fracture rate thus made the product have a significant level of fracture. The amylose content of the ingredients used also influences the fracture rate. High amylose causes the resulting product to be harder, so the fracture rate on the product is smaller [41].

**Chemical Analysis of Churros**

The results of chemical analysis of churros products adding sorghum flour and pumpkin puree can be seen in Table 5.

**TABLE 5**. Chemical Analysis of F1 and F4 Churros

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Chemical Analysis** | **Result** | |
| **F1** | **F4** |
| 1 | Moisture (%) | 13.08 | 13.31 |
| 2 | Ash content (%) | 0.79 | 1.49 |
| 3 | Crude Fiber (%) | 1.46 | 6.21 |
| 4 | Fat content (%) | 9.27 | 12.4 |
| 5 | Carotenoid (ppm) | 16.45 | 174.35 |

Moisture content is one of the most important components in a food that shows the amount of water content in food ingredients or in food products. The higher the moisture content contained in food, the greater the opportunity for microorganisms to grow in food [17]. Therefore, moisture content can determine the shelf life of the product and affect the quality of a food product. Based on Table 5, the moisture levels of F1 and F4 churros are 13.08% and 13.31%. The churros formulation contains pumpkin puree, which has a very high-water content, so it can affect the water content of churros. The moisture of yellow pumpkin puree is 89.96%, which leads to higher water content in the churros products [42]. While the flour products have water content about 14% [43].

Ash content is one of the chemical components of a food material composed of a mixture of inorganic components or total minerals present in food. Ash content is part of proximate analysis for nutritional evaluation, and it is an important quality attribute for some food ingredients [45]. The results of analyzing ash levels in F1 and F4 were 0.79% and 1.49%. Churros, with the addition of sorghum flour and pumpkin, have more excellent ash content. This is supported by the opinion of DKBM (2005), mineral content in pumpkin, among other things, phosphorus 180 mg/100g; potassium 220,00 mg / 100g; zinc 1,50 mg /100g; calcium 40 mg / 100, and iron 0.70 mg / 100 [46]. Whereas according to the Directorate of Nutrition, Depkes RI (1996), in wheat flour has a mineral content of phosphates 106 mg / 10g; iron 1,2 mg / 10, 100g. and calcium 16 mg / 0g. However, mineral contents in wheat flour range from 0.3 % - 1.5 g. In previous studies, according to Rani & Sood (2021), that there is food use sorghum will conduct a higher ash content due to the contents of minerals in Fe, Ca, P, Mg, and Sodium in sorghum [47]. So, the presence of a concentration of added sorghum flour also enriches the content of mineral products in churros [47].

Crude fiber is a food residue after being treated with alkaline or boiling acid. It is also composed of cellulose, with a small amount of pentose and lignin. Crude fiber is essential as a process that facilitates digestion in the body and smoothes the digestive process in the organism (peristaltic). Also, the contents of this raw fiber can reduce weight in the body [48]. The analysis results of churros crude fiber of F1 and F4 are 1.46% and 6.21%. This is because sorghum flour has a relatively high content of crude fibers. In the study conducted by Anadia (2022), the content of raw fiber of white sorghum flour was 6.3% while the level of fiber wheat flour is 1.92% [9]. The addition of sorghum flour can increase the crude fiber in churros. This is in line with the results of Putri's research (2017), which states that the higher the concentration of sorghum flour added, the higher the fiber content of cookies [22]. The addition of yellow pumpkin puree also affects the increase in crude fiber in churros products. According to Sari & Putri (2018), research stated that the crude fiber content in yellow pumpkins was 8.33% [22]. The higher fiber content in food, the better the impact on digestion. Food products containing high raw fiber are good for the body because they regulate the occurrence of intestinal movement and prevent difficulty urinating [49]. Consumption of foods that contain enough fiber every day can reduce the risk of developing colon cancer by shortening food transit times. The fiber also important for the health of the intestinal microflora, prevents hypertension and gallstones, and prevents obesity [50].

Fat is one of the organic compounds that is insoluble in water but can be soluble in organic solvents such as cholorophoma, ether, and other types of solvent. Fats also serve as a higher source of energy than carbohydrates and proteins, in 1 gram of fat there are 9 kcal as compared to 1 gram of carbs and protein produces less energy that is 4 kcal. The results from the analysis of churros F1 and F4 fat levels were 9.27% and 12.4%. The highest values were obtained in churros with a sample of F4, the subtitation of sorghum flour affects the fat content of a food ingredient. This is because the fat content of sorghum flour is higher than wheat flour [37]. This is in line with a previous study to Nur (2019) stated that the more subtitrated the sorghum flour then there is an increase in the fat content of the bread. The fat content of pumpkin is 4.87%. The high churros fat content is also influenced by the presence of butter, eggs, and other ingredients used in churros butter. Butter plays a role in binding the ingredients used in one paste so that the resulting paste will not be easily broken and more compact. Fats serve as heat carriers in food processing. In addition, fats serve to improve texture, increase calories and enhance the taste of foodstuffs like the use of butter in food making [51].

Carotenoids are natural pigments and have an orange-to-red color. Carotenoid compounds are prone to oxidation caused by light or high temperatures. Carotenoids are stable at 80-100ºC [52]. Carotenenoid is fat-soluble, high-temperature-depleted, benzene, chlorophrome, acetone, and water-insoluble. Carotenoids are also used as an antioxidant in the immune system, which is beneficial in the prevention of cardiovascular, degenerative, and cancer diseases [53]. Carotenoids are aggregate of the intake of five subclasses of carotenoid: α-carotene, β-carotene, beta-cryptoxanthin, lutein, zeaxanthin, and lycopene. Beta-carotene also acts as a precursor of vitamin A, which is beneficial for eye health. The results of carotenoid analysis on samples F1 and F4 were 16.45 ppm and 174.35 ppm. Based on the results, the formulation of churros with the addition of pumpkin puree has higher levels of carotenoids compared to churros using only wheat flour. Yellow pumpkin contained carotenoid of 234.21 - 404.98 ppm [54], whereas in wheat flour does not contain carotenoids. However, in F1 churros has a content of carotenoids because of the use of ingredients such as butter, eggs and milk that have a vitamin A content [55]. Churros with a substitution of sorghum flour and yellow pumpkin puree can be claimed as a high-carotenoid product because it has a carotene content greater than 1.08 mg per 100 g (10.8 ppm) which corresponds to a high food claim of vitamins or minerals according to the provisions of BPOM RI (2011).

**Conclusion**

The most preferred churros formula is F4 with 30% wheat flour, 35% sorghum flour, and 35% pumpkin puree. The F4 churros have a physical characteristic value at a strength parameter of 47,05 N ± 3.93, a breakage rate of 2.47 N ± 1.91, whereas chemical characteristics at a moisture of 13.31%, an ash content of 1.49%, a fat content of 12.4%, a crude fiber of 6.21%, a carotenoid of 174.35%. Churros substituting sorghum flour and yellow pumpkin puree can be claimed as a high-carotenoid product.

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