**Cover Letter for Manuscript Submission to** **International Journal of Agriculture and Biology (IJAB)**

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Prof. Dr. Muhammad Farooq (Sultan Qaboos University, Muscat, Oman)

Editor in Chief International Journal of Agriculture and Biology

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Dear Editorial International Journal of Agriculture and Biology,

We are writing to submit our manuscript entitled, “Physicochemical and Sensory Analysis of Noodles Made from High Beta-Carotene Modified Cassava Flour composed with Corn Flour and Tapioca” for consideration for publication in International Journal of Agriculture and Biology (IJAB). Our findings indicates that mocaf based-noodles show promising potential for noodle application. The noodles were prepared from composite flours contained 80% high beta-carotene mocaf, 5% corn flour and 15% tapioca can be consumed by people with autism and celiac who cannot eat the gluten contained in wheat flour. This topic was of great interest to the scientists, researchers, and lecturer’s in the field of food engineering, food nutritional chemistry and also food processing who read your journal.

This study aimed to investigate physicochemical and sensory characteristics of noodle which made from high beta-carotene modified cassava flour (mocaf)-based composite flours. The mocaf-based noodles can be consumed by people with autism and celiac who cannot eat the gluten contained in wheat flour. Noodles were prepared from composite flours contained 80% high beta-carotene mocaf, 5% corn flour and 15% tapioca. Cooking quality including optimum cooking time, water absorption, cooking loss and volume increase, proximate composition, tensile strength and fracture strength were analyzed and compared with noodles made from 100% of wheat flour. In addition, all noodles were subjected to sensory evaluation. The quality of mocaf composite-based noodles was comparable with wheat flour based-noodles in some properties such as cooking time, cooking loss and fracture strength. Sensory evaluation showed that mocaf composite-based noodles (4.54) had lower acceptability compared to wheat flour noodle (6.8). In proximate properties, the mocaf composit flour based noodles had lower protein content (4.6%), but higher total ash (2.08%) and total fat (7.46%) compared to wheat flour based noodles. It was indicated that the mocaf composite flour based noodles had higher mineral content, beta-carotene and polyunsaturated fatty acid (PUFA) content as antioxidant. The study indicates that mocaf based-noodles show promising potential for noodle application.

This manuscript describes original work and no conflict of interest. It has not been published elsewhere and that it has not been submitted simultaneously for publication elsewhere. All authors approved the manuscript and this submission. Please address all correspondence concerning this manuscript to me at email: [ahmad.fathoni@bioteknologi.lipi.go.id](mailto:ahmad.fathoni@bioteknologi.lipi.go.id) . Thank you for receiving our manuscript and considering it for review. We appreciate your time and look forward to your response.”

Yours Sincerely,

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**Original Research Article**

**Physicochemical and Sensory Analysis of Noodles Made from High Beta-Carotene Modified Cassava Flour composed with Corn Flour and Tapioca**

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**Running title:** Physicochemical and Sensory Analysis of Modified Cassava Flour Noodles

**ABSTRACT**

This study aimed to investigate physicochemical and sensory characteristics of noodle which made from high beta-carotene modified cassava flour (mocaf)-based composite flours. The mocaf-based noodles can be consumed by people with autism and celiac who cannot eat the gluten contained in wheat flour. Noodles were prepared from composite flours contained 80% high beta-carotene mocaf, 5% corn flour and 15% tapioca. Cooking quality including optimum cooking time, water absorption, cooking loss and volume increase, proximate composition, tensile strength and fracture strength were analyzed and compared with noodles made from 100% of wheat flour. In addition, all noodles were subjected to sensory evaluation. The quality of mocaf composite-based noodles was comparable with wheat flour based-noodles in some properties such as cooking time, cooking loss and fracture strength. Sensory evaluation showed that mocaf composite-based noodles (4.54) had lower acceptability compared to wheat flour noodle (6.8). In proximate properties, the mocaf composite flour based noodles had lower protein content (4.6%), but higher total ash (2.08%) and total fat (7.46%) compared to wheat flour based noodles. It was indicated that the mocaf composite flour based noodles had higher mineral content, beta-carotene and polyunsaturated fatty acid (PUFA) content as antioxidant. The study indicates that mocaf based-noodles show promising potential for noodle application.

**Keywords:** Noodle, composite flour, high beta-carotene modified cassava flour, physicochemical and sensory evaluation

**INTRODUCTION**

Noodles are one of the most popular food products on earth and have been globally consumed throughout the world (Fu 2008). In 2017, global consumption of noodles in the world reached up to 100 million servings. Indonesia is the second largest noodles-consuming country after China with consumption rate up to 12.6 million servings (WINA 2018), which means that noodle-based products have promising market potential. Until now, noodles are generally made from wheat flour as the main ingredient due to its component of gluten, a protein contained in wheat flour (Liu *et al.* 2018; Wu *et al.* 2015; Wu *et al.* 2017).

Wheat gluten protein (WGP) is a high quality and inexpensive vegetable protein and is divided into four categories according to their solubility in different solvents: albumin, globulin, prolamin, and glutenin (Li *et al*. 2016; Gasparre and Rosell 2019). Glutenin and gliadin are the main components accounting for 80–85%, which are stabilized by interchain and intermolecular disulphide bonds, and are considered to form a continuous gluten network structure, which has a unique viscoelasticity in wheat flour dough (Inglett *et al.* 2005; Pan *et al.* 2016; Zhang *et al.* 2019; Zhang *et al.* 2020). WGP is also considered safe for use as a dough enhancer, nutritional supplement, processing agent, stabilizer and gelling agent (Pongpichaiudom and Songsermpong 2018; Sofi *et al.,* 2020a). WGP is widely used to reinforce flour with lower protein content as it plays a principal role in noodle quality by providing moisture, cohesiveness, viscoelasticity, and by promoting gas retention in the dough (Patino-Rodriguez *et al.* 2019; Sofi *et al.* 2020b). Gluten gives good elasticity on noodle processing and product (De Mesa‐Stonestreet *et al.* 2010; Srikaeo *et al.* 2018). With the increase of global demand for noodles, demands for wheat flour also increase that put Indonesia as one of the biggest wheat flour importers. On the other hand, Indonesia is rich in bio-resources such as cassava that can be utilized for many purposes including food application.

Cassava is the most important food crop, especially in tropics region. It provides a staple food for more than 600 million people worldwide (Liu *et al.* 2011). In terms of global production, Indonesia is the third largest cassava producer in the world after Nigeria and Thailand (FAO 2016). In Indonesia, cassava recently gets more attention being enzymatically processed to produce high quality cassava flour called modified cassava flour (mocaf) (Subagio *et al.* 2008). Mocaf is a derivative product of cassava flour which is produced using the principle of modified cassava by fermentation of lactic acid bacteria for 12-72 hours (Subagio *et al.* 2008). There have been many applications of Mocaf flour as a substitute for wheat flour. Mocaf can be used as raw material for various types of food products, ranging from noodles, bakery, cookies, semi-wet food and a mixture of other products made from wheat flour with the characteristics of the resulting product not much different from the use of wheat flour (Subagio *et al.* 2008). Additionally, mocaf processing method has been successfully developed to produce high beta-carotene mocaf at Research Centre for Biotechnology, Indonesian Institute of Sciences (LIPI) (Fathoni *et al.* 2016). Compare to non-modified cassava flour, mocaf showed better characteristics such as flavor, texture that makes it more flexible for various usage.

Celiac disease, also known as gluten-sensitive enteropathy, sprue, or celiac disease, is an autoimmune disease in which individuals with certain genetic compositions experience damage to the small intestine if they eat gluten (Milde *et al.* 2018; Padalino *et al.* 2016). Celiac disease is caused by the consumption of foods with gluten, interactions between genes, and other environmental factors. The development of the disease itself is influenced by gastrointestinal infections, infant feeding, and intestinal bacteria. When people with celiac disease eat gluten, the body mounts an immune response that attacks the small intestine (Li *et al.* 2017). These attacks cause damage to the villi that line the small intestine, which are responsible for the absorption of nutrients. When the villi are damaged, nutrients cannot be properly absorbed into the body. People with autism should be on a CFGF (Casein Free Gluten Free) diet (Srikaeo and Sangkhiaw 2014). This means avoiding food sources that contain casein and gluten. Casein is mostly found in milk, while gluten is found in wheat flour (Zhang *et al.* 2019; Zhang *et al.* 2020). Children with autism often have problems digesting gluten and casein. Under normal conditions, most proteins (gluten and casein) are digested into amino acids, the rest into peptides. Gluten and casein proteins have certain combinations of amino acids that are difficult to digest by the digestive system of children with autism. The digestive system is difficult to process it completely into single amino acids, but it is still in the form of peptides that are biologically active (Zhang *et al.* 2019; Zhang *et al.* 2020). The undigested peptides leave the small intestine and enter the bloodstream, which should not be the case. This condition is called leaky gut (increased intestinal permeability). The substitution of wheat flour with mocaf is expected to be a solution to make gluten-free noodles that can be consumed by people with autism and celiac.

The use of mocaf in composite flour ingredient to produce varieties of food products had been applied. Some have demonstrated that mocaf can be used for noodle application in replacement of wheat flour. However, in the absence of gluten in cassava makes noodles from cassava less elastic than the one from wheat flour. Therefore, we need to apply another type of flour to improve cassava-based noodles characters. In this study, we aimed to investigate noodles characteristics made from composite flour comprises high beta-carotene mocaf, corn flour, and tapioca to produce non-wheat flour noodles product.

**MATERIALS AND METHODS**

**Materials**

High beta-carotene modified cassava flour (mocaf) was prepared by Research Centre for Biotechnology, Indonesian Institute of Sciences (LIPI), Cibinong, West Java. Commercial corn flour, tapioca, CMC, STPP and salt (Natrium chloride) were purchased from local market in Boyolali, Central Java.

**Methods**

**Production of high beta-carotene mocaf**

High beta-carotene modified cassava flour was prepared from local Indonesian cassava genotype, Mentega 2, as described in Fathoni *et al.* (2016). One kilogram of peeled Mentega 2 storage roots (10-month-old) were washed, rinsed with tap water, and trimmed into chips-like shape. The cassava chips were soaked for 15 hours in a chamber contained one liter of tap water supplemented with 0.1% lactic acid bacteria (LAB) for fermentation process. About 0.3% sodium meta-bisulfite were then added into a chamber and incubated at ambient temperature for 30 minutes after which the chips were dried at 50 °C for 24 hours. The dried chips were then milled into flour using hammer mills and the flour were sieved using 80-100 µm particle size sieving tool. The fine flour was packaged in aluminum-low density polyethylene bags and stored at room temperature.

**Preparation of noodles**

Ingredients of composite flours for sample noodles were prepared from 80% high beta-carotene modified cassava flour (mocaf), 5% corn flour and 15% tapioca. Composition of 100% wheat flour was used as control. To weigh flour and blend the mixture of composite flour composition, a digital weighing balance (SF-400) and a blender (Philips, HR-2115) were applied.

Noodles were prepared according to Oh *et al.* (1983) with some modifications. A mix of about 50 g of high beta-carotene mocaf and 100 ml tap water was initially pre-gelatinized and heated at boiling temperature for 5 minutes. All other ingredients including corn flour, tapioca, salt, CMC and STPP were then added in the mixture and mixed to make a dough. The dough was incubated for 15 minutes at room temperature. After incubation, the dough was pressed using noodle-making machine (Maksindo) to make dough sheet with 1.5 mm thick. The dough sheet was then cut into 5-mm wide noodle strips. Fresh noodle strips were steamed for 20 minutes and sun dried for 20 h then packed in polyethylene bags for analysis.

**Cooking quality of noodles**

Water absorption, cooking loss, and volume increase of noodles were measured according to the AACC methods 66-50 (2010). The water absorption rate measurement was carried out by cooking 20 g of fresh noodles in 300 ml distilled water for 5 mins, cooling for 1 min in cold water, and removing the water for 30 s. The cooking loss was determined by drying noodles at 105oC for 24 h and it was expressed as percentage of the difference between the solid weight and initial dry matter. The volume increase rate was measured by adding 300 ml distilled water into 20 g of fresh noodles and cooked noodles, respectively. The respective formulas used in the calculations are as follows:

**Sensory evaluation of cooked noodles**

Samples of cooked noodles were subjected to sensory evaluation including color, flavor, texture, mouth feel and appearance. This was carried out by 26 respondents of a semi trained preference test panels from the staff of Research Center for Natural Technology-LIPI, Indonesia. The range of values ​​used is as follows (Carpenter *et al.* 2012):

1. : Deslike extremely
2. : Deslike very much
3. : Deslike moderately
4. : Dislike slightly
5. : Neither like nor dislike
6. : Like slightly
7. : Like moderately
8. : Like very much
9. : Like extremely

**Proximate analysis**

The samples of noodles were analyzed for protein (AOAC 2000), ash (AOAC, 2000), carbohydrate (AOAC 2000), total fat as well as dietary fibers using Kjeltec methods (AOAC 2005), SNI 01‑2891‑1992 point 6.1, 18‑8‑9 /MU/SMM‑SIG, and SNI 01‑2891‑1992 point 8.1, respectively.

**Physical characteristics of noodles**

Tensile strength and fracture strength tests on noodles samples were performed using Zwick SA/ 0.5 Universal Testing Machine with a speed of 10 mm/ min and a sample length of 30 mm.

**Statistical analysis**

All the analyses were conducted in triplicate. Data were expressed by means value ± standard deviation. Statistical analysis was performed using ANOVA followed by Tukey HSD for comparison between means. Different alphabetic letters in the column are statistically differed at 5% level of significant (Snedecor 1980).

**RESULTS**

**Cooking quality of mocaf-composite based noodles**

Optimum cooking time was the time required for the opaque central core of the noodle to disappear when squeezed gently between two glass plates after cooking (Yousif *et al.* 2012). It was shown that mocaf-based noodles had cooking time of 5 minutes in average which is similar with optimum cooking time of wheat flour-based noodles (Table 1). Mean values of cooking time (min), water absorption (%), cooking loss (%) and volume increase (%) are available in table 1.

The water absorption of mocaf-based noodles was significantly lower than that of wheat flour-based noodles. The factors affecting water absorption rate of noodles during cooking are starch gelatinization and protein hydration related to particle size of starch (Lee and Jung 2003; Charles *et al.* 2007). In addition, gluten acts as gelling agent and absorbs more water Cassava flours have lesser protein content and larger granule size than wheat flour which may explain mocaf-based noodles showed lower water absorption rate than wheat flour-based noodles (Cai *et al.* 2016; Chauhan *et al.* 2017). However, we found interesting results in the volume increase rate. It was obtained that the volume increase showing different pattern, where mocaf-based noodles had higher volume increase than wheat flour-based noodles. This finding is contrary than that found in potatoes-based noodles. The water absorption and the volume increase are to be highly associated, meaning that the less water absorption to noodles, the less volume increase in noodles (Kang *et al.* 2017).

The cooking loss of mocaf-based noodles was 5%, which was higher than that of wheat flour-based noodles of 4.29%. However, the value was not statistically significant different. The higher cooking loss in mocaf-based noodles may be due to the absence of gluten in the cassava-based product. This is similar with some other findings in rice flour, corn flour and potatoes starch (Lucisano *et al.* 2012). The cooking loss is one of important properties that determines the quality of noodles. It is related to the structural densities of surfaces, during which the soluble solids are eluted from the surface into the cooking water (Lucisano *et al.* 2012). The quality of noodles became lower when a cooking loss exceeded 12%. In this study, the cooking loss of mocaf-based noodles was 5%, indicating guarantee of quality cooking in terms of water retention after being cooked.

**Sensory evaluation**

Sensory properties are key indicators of potential consumer preferences (Yousif *et al.* 2012), from which will give information on acceptance and preferences of the tested product. Sensory attributes of mocaf-based noodles against control of wheat flour-based noodles are shown in table 2. Overall, wheat flour based-noodles had better acceptance and preferences than mocaf based-noodles. Although there was no significant different in color, but other sensory properties such as chewiness, aroma, appearance, taste and total acceptability of mocaf-based noodles showed statistically significant lower than wheat flour-based noodles. This finding agrees with Abidin, *et al.* (2013) that found cassava flour-based noodles showing lower sensory response than wheat flour-based noodles.

**Proximate properties of mocaf based-noodles**

Proximate composition of noodles from mocaf showed lower protein content but higher content of ash, carbohydrate and fat compared to wheat flour-based noodle (Table 3). Protein content in cassava is originally low, therefore it needs to be blended with other protein sources to increase protein content such as egg and soybean. Compared to other crops such as sweet potato and cocoyam flour, cassava-based noodles generally have lower protein content (Akonor *et al.* 2017). In this study, protein content of composite-based noodles was 4.6%, which is a bit higher than that of the original mocaf. The use of corn flour in composite flours formulation affected protein content in noodles product.

**Mechanical properties of mocaf-based noodles**

The tensile strength and fracture strength are important textural properties in noodle products. The higher tensile strength of noodle product, the better. The tensile strength of mocaf based-noodle was 0,019 MPa lower than wheat flour-based noodle of 0,025 MPa (Table 4). Fracture strength is the ability of a noodle to resist failure and it is designated specifically according to the mode of applied loading, such as tensile, compressive, and bending. The higher the fracture strength value, the better the quality of the noodle product. Mocaf-based noodles had a higher fracture strength (3.05 N) than wheat flour-based noodles (2.15 N) (Table 4). Mocaf-based noodles are relatively not easily broken and damaged because they have a higher fracture point than wheat flour-based noodles.

**DISCUSSION**

Mocaf is a natural raw material that can change the texture and increase the strength of the noodles. The process of production mocaf-based noodles is similar to noodles from other flours, which includes pretreatment, homogenization, kneading, extrusion, freezing, and drying stages. Charles *et al.* (2007) reported that the gelatinization time of cassava starch was 3 minutes and the additives for the production of cassava noodles were as follows: 1.5% salt, 49% water, 5% acetate starch, and 6% pregelatinized starch. The noodles obtained in this way are of good quality and taste.

Wangtueai *et al.* (2020) reported that the optimal condition for improving the quality of gluten-free noodles was mixing 20.5% pregelatinized flour, 5% fish gelatin hydrolyzate and 0.25% transglutaminase from the total base formula. The best composition for gluten-free noodles based on research by Wangtueai *et al.* (2020) consisted of 49.5% composite flour (70% rice flour and 30% cassava flour), pre-gelatinized flour (19.5%), fish gelatin hydrolyzate (3 .8%), transglutaminase (0.19%), sodium carbonate (0.77%), salt (0.77%), rice bran oil (0.77%) and water (24.7%). These gluten-free noodles are sensory acceptable to consumers, provide healthy food products for celiac consumers, and have high antioxidant activity (Wangtueai *et al.* 2020).

Raungrusmee *et al.* (2020) reported that the gluten free noodles prepared by resistant rice starch, xanthan gum (2.5%), inulin, and defatted rice bran (5%) showed low glycemic index and high acceptability by sensory panelists. The addition of defatted rice bran and inulin increased the firmness, cooking time, protein, fiber and ash contents of gluten free noodles.

Mocaf based-noodles showed lower value in chewiness. This may be due to the absence of gluten in the product. In noodles application, gluten plays key role in dough elasticity that make noodle’s processing easier and it makes end product chewier (Abidin *et al.* 2013). The fact that cassava-based product is gluten-free might cause lower chewiness score. Aroma of mocaf based noodles was also low. Main factor affecting this may come from the strong aroma of egg as one of ingredients in the noodle making process (Khouryieh *et al.* 2006). Egg gives the fishy smell in cooked noodles. However, the use of egg is important in noodle making process because it acts as noodle texturizer (Abidin *et al.* 2013; Khouryieh *et al.* 2006). Abidin *et al.* (2013) stated that the taste of noodle products is most likely influenced by particle size of raw material or flour. Compared to wheat flour, cassava flours have bigger particle size which gives the noodle a sandy mouth feeling (Bilgicli 2013).

Composite flour-based noodles had a higher total fat content (7.46%) when compared to wheat flour-based noodles (0.39%). The addition of corn flour in the manufacture of composite flour-based noodles plays an important role in increasing the total fat content. Corn flour contains fatty acids consisting of aclyglycerols (mainly mono-, di-, tri-), 59% poly-unsaturated fatty acid (PUFA), 24% mono-unsaturated fatty acid (MUFA), and 13% saturated fatty acid (SFA) (Kaur *et al.,* 2015). The fatty acid composition of corn flour is oleic acid (19-49%), linoleic acid (34-62%), palmitic acid (8-12%), stearic acid (2.5-4.5%), myristic acid (0.1%), palmitoleic acid (0.1%), linolenic acid (1.2%) (Kaur *et al.* 2015). The high PUFA content in corn flour and beta carotene in mocaf can act as an antioxidant in composite-based noodles to counteract free radicals. Ash content in composite-based noodles was higher than that of wheat flour-based noodles. Total ash content reflects the mineral content in the food products and can be regarded as the general measure of food product quality (Kirk and Sawyer 1991). Therefore, the result indicates that composite based-noodles may contain higher amounts of minerals although it was not specifically analyzed in this study.

Tensile strength in mocaf-based noodles are relatively lower due to the absence of gluten protein in cassava flour. Gluten protein is only contained in wheat flour, so to improve the quality of tensile strength and fracture strength in noodles, it is still necessary to add wheat flour (Balakireva and Zamyatnin 2016; Fu *et al.* 2020). In addition, two main interactions between starch and gluten during heating are derived: a) a competitive hydration between the polymers during their structural changes, and b) a diffusion barrier by the gluten proteins located on the starch granule surface and thus a changed diffusion of water into the starch granules (Pongpichaiudom and Songsermpong 2018; Sofi *et al.* 2020a; Zhang *et al.* 2019; Zhang *et al.* 2020). The dense packing and encapsulation of starch by protein are considered important for the digestion of noodles and the textural attributes (Javaid *et al.* 2018; Kraithong *et al.* 2019). Research has shown that the protein content and quality are known to affect the texture of cooked noodles (Kaur *et al.* 2015; Levent 2017).

Mocaf-based noodles are not only rich in vitamins, minerals, unsaturated fatty acids, starch, and other nutrients, but are also low in fat and low in sugar which are recognized as healthy by nutritionists. The mocaf-based noodles had a natural taste and do not require added flavoring or other food additives. The development of sophisticated processing technology and mechanical production equipment for making mocaf-based noodles can provide an alternative option to wheat flour-based noodles, especially for people diagnosed with celiac disease.

**CONCLUSIONS**

Composite flours based on high beta carotene modified cassava flours (mocaf), corn flour and tapioca showed good potential for noodle application. The quality of mocaf-based noodles was comparable with wheat flour based-noodles in some properties such as cooking time, cooking loss and fracture strength. Sensory evaluation showed that the composite flour based noodles still had lower acceptability, therefore more development is needed to improve these properties. In proximate properties, the composite flour based noodles had lower protein content (4.6%), but higher total ash (2.08%) and total fat (7.46%) compared to wheat flour based noodles. It was indicated that the composite flour based noodles had higher mineral content and polyunsaturated fatty acid (PUFA) content as antioxidant. The study indicates that the mocaf based-noodles show promising potential for noodle application.

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**Conflict of interest statement**

The authors declare that there is no conflict of interest.

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**Table 1.** Mean values of cooking quality of cooked composite-based noodles to control

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Samples | Composition | Optimum cooking time (min) | Water absorption (%) | Cooking loss (%) | Volume increase (%) |
| Wheat Noodle (control) | 100% wheat flour | 5 | 226,34 ± 25,73b | 4,29 ± 0,39a | 109,59 ± 5,43a |
| Mocaf-composite noodle | 80% mocaf, 5% corn flour, 15 % tapioca | 5 | 170,57 ± 5,90a | 5,00 ± 0,15a | 218,96 ± 0,55b |

Data are the mean values ± standar deviation; n = 3; ANOVA analysis followed by Tukey HSD with 95% confidence

**Table 2.** Sensory evaluation of cooked composite-based noodles to control

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Samples | Color | Chewiness | Aroma | Appearance | Taste | General acceptability |
| Wheat flour 100% (control) | 6,40 ± 1,09a | 6,5 ± 0,96b | 6,5 ± 1,09b | 6,5 ± 0,85b | 6,5 ± 0,85b | 6,8 ± 0,58b |
| Composite flour (80% mocaf, 5% corn flour, 15 % tapioca) | 5,45 ± 1,81a | 4,72 ± 1,42a | 4,22 ± 1,57a | 4,95 ± 1,55a | 4,27 ± 1,51a | 4,54 ± 1,26a |

Data are the mean values ± SD; n = 3; ANOVA analysis followed by Tukey HSD with 95% confidence

**Table 3.** Proximate composition of composite based-noodles compared to control

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Samples | Protein (%) | Ash (%) | Carbohydrate (%) | Fat total (%) |
| Wheat flour 100% (control) | 12,32 ± 0,24a | 1,61 ± 0,01b | 76,52 ± 0,26a | 0,39 ± 0,08b |
| Composite flour (80% mocaf, 5% corn flour, 15 % tapioca) | 4,61 ± 0,26b | 2,08 ± 0,25a | 77,23 ± 1,18a | 7,46 ± 1,99a |

Data are the mean values ± SD; n = 3; ANOVA analysis followed by Tukey HSD with 95% confidence

**Table 4.** Mechanical properties of composite based-noodles compared to control

|  |  |  |
| --- | --- | --- |
| Samples | Tensile strength (MPa) | Fracture strength (N) |
| Wheat flour 100% (control) | 0,025 ± 0,001ab | 2,15 ± 0,36a |
| Composite flour (80% mocaf, 5% corn flour, 15 % tapioca) | 0,019 ± 0,004a | 3,05 ± 0,41a |

Data are the mean values ± SD; n = 3; ANOVA analysis followed by Tukey HSD with 95% confidence



**Figure 1.** The mocaf composite based noodles