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Characterization of Coating Flour Based on Local Timor Corn Flour Modified with the Addition of Rice Flour, Tapioca Flour, and Glutinous Rice Flour

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ABSTRACT

The application of pure corn flour (100%) as coating material tends to generate a tough texture, thus requiring an alternative formulation to obtain a crispier result. This research aimed to evaluate the physical, chemical, and sensory characteristics, as well as to determine the optimal coating flour composition. The study was carried out using nine formulations, consisting of varying proportions (%) of corn flour, rice flour combined with tapioca flour, and glutinous rice flour. Formulas involved A (60:35:5), B (60:30:10), C (60:25:15), D (50:45:5), E (50:40:10), F (50:35:15), G (40:55:5), H (40:50:10), and I (40:45:15). The findings indicated that incorporating rice flour, tapioca and glutinous rice to the coating flour significantly affected the physical and chemical properties. The proportion of corn flour 50% by adding rice flour and tapioca 35%, glutinous rice flour 15% gave a higher panelist preference value for crispiness, which was 4.36. Glutinous rice flour was able to change the proportion of amylose and amylopectin so that the texture was crispy and not too hard when the product was cooled. The characteristics of the coating flour included viscosity value of 3.29mP, WHC 152.89%, OHC 107.53%, protein 4.50%, starch 69.41%, amylose 18.47%, and amylopectin 50.94%.

1. INTRODUCTION

One type of local white corn in East Nusa Tenggara (NTT), especially Timor Island, is white stone corn which has a harder texture and when polished it is not easily destroyed and the skin is separated so it is very suitable for Timor typical food product, namely corn bose. White corn kernels can act as an alternative staple food, because of its physical and chemical appearance. White corn in Indonesia has the potential to act as a national food diversification material or as a substitute for rice, flour industry, processed food, and alternative food for people with diabetes mellitus. According to Aini *et al*. (2016), white corn can be an alternative to wheat flour in several flour-based food products. In the future, white corn is expected to develop further not only as a food ingredient but also as a flour industry material that can substitute wheat, especially if the protein quality and production are high.

In NTT, local varieties of white corn, especially in the Timor plains, are used as staple foods in the form of rice-corn, or corn bose which is processed by grinding (Menge & Yohanes, 2017). The use of local corn to be processed into flour has not been widely carried out, but research conducted by Medho *et al*. (2018) concerning the chemical characteristics of local Timor white corn flour modified through fermentation by *Lactobacillus casei* bacteria obtained protein results of 7.82–8.66%, amylose content of 14.93–16.55%. This amylose content is lower than Aini *et al*. (2016), which ranges from 26.9–35.9%. This difference is more due to differences in variety. Amylose contributes to the textural properties of a product. An increase in amylose content results in a denser texture. This occurs because higher amylose levels reduce water absorption capacity and elasticity, thereby increasing hardness.

Research by Medho & Mohamad (2022), has utilized fermented flour made from local Timor corn with 0.2% tape yeast for 24 hours and in making moringa bread with a ratio of 40% corn flour combined with 60% wheat flour, along with the addition of 5% moringa resulting in a specific volume of bread of 3.71 cm^3g^{-1} and with bread elasticity reaching 75.14% and the highest level of sensory acceptance for moringa corn bread. Making cookies using 93–97% Timor local corn composite flour and 3–7% moringa leaves chemically produces cookies that are higher in protein, crude fiber, dietary fiber and have met the cookie requirements according to SNI 2973:2018 (BSN, 2018; Medho & Mohamad, 2024).

Local Timor corn flour can also be used as a coating for fried foods. The main ingredient for fried foods is generally wheat flour. National wheat consumption in 2013 was around 5.15 million tons and increased in 2014 and 2015 to 5.41 million tons per year and continues to increase every year (Hastuti, 2019). The use of wheat for raw materials for fried foods is 5% of national wheat consumption (Razak & Apriyanto, 2014). One of the food products that needs to be made instantly is ready-to-use mixed flour (TCSP) for fried foods (Razak & Apriyanto, 2014). TCSP can also be called coating flour (batter) and is widely used for fried products such as fried bananas, fried tempeh, and fried chicken (Sugiyono *et al*., 2010). So far, coating flour or mixed flour is generally made from the main ingredients of wheat and rice flour to make fried foods. There are several types of mixed flour and seasoned flour on the market derived from several flours such as wheat and rice flour, wheat-tapioca and rice flour, wheat-tapioca, rice-tapioca flour (Shaviklo *et al*., 2013; Permpoon *et al*., 2016, Anwar *et al*., 2016).

Replacing wheat flour in fried food products with corn flour is expected to reduce the use of wheat and increase the use of local commodities such as corn flour. The use of 100% corn flour as a coating for fried food products produces a hard texture after the product has been cooled. This is the basis for the formulation of coating flour or mixed flour from corn flour that has a crunchy texture and is not hard after being cooled.

Starch content is a key determinant influencing the texture and attributes of coating flour. The amylose and amylopectin content of corn flour used in the study by Sugiyono *et al*., (2010) were 27.90% and 31.49%, respectively. Starch with a high amylose content is easily retrograded. Rice flour is a type of flour that is widely used as a coating flour because the amylose content of rice flour contributes to improving the product's crispiness. However, the texture formed becomes very tough and its expansion is lacking (Sugiyono *et al*., 2010). Tapioca is commonly used in making crackers that have good expansion and crispiness. Meanwhile, in fried products, tapioca flour is added to get a crispy, light texture and the crispness lasts long after it cools. Wulandari *et al*. (2016) revealed a lower setback viscosity value in tapioca, namely 735 cP, when compared to the higher setback viscosity value of corn flour, namely 2071 cP. High setback viscosity indicates a stronger likelihood of retrogradation occurring. Setback viscosity is used as a parameter for the ability to form a gel or the tendency of starch to experience retrogradation. Thus, the addition of tapioca to the coating flour formula is expected to reduce the hardness of the product after cooling. Nadhira & Cahyana (2023) also reported that the setback viscosity value has a correlation with the amylose proportion, given that more amylose results in an increased setback viscosity value and the easier it is to experience retrogradation. Conversely, the lower the amylose content, the lower the setback viscosity. Fitriani (2018) also explains that flour with low retrogradation indicates the ability to maintain texture during storage. Elevated setback values signify an increased likelihood of gel formation upon cooling, so a high setback value is less suitable for cakes, cakes, or bread products because after cooling the product will harden, and it is better used as a filler. A low setback value will overcome products that have syneresis or staling problems and can extend the shelf life of these products (Palabiyik *et al*., 2016). This also shows that the addition of glutinous rice flour to the flour mixture can reduce the setback viscosity of corn flour (570 cP).

The formulation of mixed flour made from local Timor corn has never been researched. This applied product is expected to be utilized by the general public, business actors, and local culinary home industries. The aim of this study was to examine the physical, chemical, and sensory properties of the coating flour product and obtain the right formulation of coating flour made from modified local Timor fermented corn flour.

2. MATERIALS AND METHODS

2.1. Materials and Tools

The primary components utilized in the preparation of modified corn flour by fermentation consist of local Timor white stone corn kernels, tape yeast, water, and other materials for analysis. The ingredients for making corn flour-based coating flour were rice flour, glutinous rice flour, tapioca flour, pepper powder, garlic powder, and salt. The ingredients for applying coating flour to fried tempeh were cooking oil, and soybean tempeh obtained from local tempeh craftsmen. The main tools for making modified corn flour were fermentation containers, scales, drying containers, grinders, Tyler sieve 80 mesh. The tools for applying coating flour to fried tempeh are 1 unit of fryer and LPG gas. While the main tools used in the analysis were Soxhlet flasks, Kjeldahl flasks, fat furnace flasks, distillation equipment, pH meters, drying ovens, desiccators, aluminum cups, porcelain cups, aluminum foil, baking sheets, filter paper, and glassware.

2.2. Methods

The research took place during the period March - November 2024. The research was conducted in 3 stages. In the first stage, local Timor corn flour was prepared and modified by fermentation using added tape yeast. Stage II is the formulation of coating flour and application to fried tempeh. Stage III involves characterizing the physical and chemical properties of coating flour products derived from fermented, modified local Timor corn flour.

2.2.1. Making Local Timor White Corn Flour

The production of local Timor white corn flour modified through fermentation was carried out following the stages described in the study of Medho & Mohamad (2024), namely, corn kernels were polished and then fermented with tape yeast at 1 g/kg corn for 24 h. Following fermentation, the corn was drained and subsequently dried. Drying was done naturally under sunlight for about 8 h until dry with a water content below 14%. The next stage was grinding the corn using a grinder and sieving using 80 mesh sieve. Analysis for corn flour included proximate analysis, starch content, amylose content by spectrophotometry, and amylopectin content by difference by calculating the difference between starch and amylose content, and crude fiber (AOAC, 2005; 2012).

2.2.2. Preparation of Coating Flour and Application on Fried Tempeh

The making of coating flour followed Anwar *et al*. (2016), which was modified with modified local Timor white corn flour. The coating flour was added with spices in the form of 3% garlic powder, 1% pepper powder, 4% salt. The making of coating flour formulation used the main ingredients in the form of modified local Timor maize flour, rice flour, cassava starch, and glutinous rice. In addition, food additives such as seasoning was used in the form of pepper, garlic powder and salt according to the seasoning formulation above. The process of making seasoned flour was started by mixing corn flour, rice flour, cassava flour, and sticky rice flour. After that, BTP was added and mixed. The formulated coating flour was applied as coating for fried tempeh. The flour was added with water according to the experimental design (Table 1) then stirred until evenly distributed. The coating flour was then applied to fried tempeh. Sliced tempeh was soaked in a suspension of seasoned flour. The soaked tempeh is lifted and drained for 2–3 seconds and immediately fried for 2 minutes or until all parts are golden brown.

The addition of water in different formulations was done when making the dough by following the amount of corn flour and glutinous rice flour. In the formula for adding 60% corn flour, the water added is more, namely 170-180 mL and decreases with the decrease in the amount of corn flour. Each increase in glutinous rice flour in the same formula for adding corn flour, the water increased. The aim was to get the same viscosity in the dough.

Table 1. Formulation of modified timor local corn flour coating powder

Formula	A	B	C	D	E	F	G	H	I
Corn flour (g)	60	60	60	50	50	50	40	40	40
Rice Flour (g)	17.5	15.0	12.5	22.5	20.0	17.5	27.5	25	22.5
Tapioca Flour (g)	17.5	15.0	12.5	22.5	20.0	17.5	27.5	25	22.5
Glutinous Rice Flour (g)	5	10	15	5	10	15	5	10	15
Water (ml)	170	175	180	155	160	165	140	145	150

2.2.3. Experimental Design

This study was designed completely randomized consisting of nine single factor treatments on the coating flour formula.

For 100 grams the composition or ratio of (corn flour : rice flour and tapioca flour : glutinous rice flour) was formulated as A (60:35:5), B (60:30:10), C (60:25:15), D (50:45:5), E (50:40:10), F (50:35:15), G (40:55:5), H (40:50:10), and I (40:45:15). Each treatment was performed with three replications.

Analysis was conducted on coating flour and fried tempeh. Analysis for coating flour included physical properties (viscosity using RION viscotester VT-03 FT-03) and chemical properties including WHC (ability to retain water), OHC (capacity to absorb oil), starch level, protein content, amylose content, amylopectin content and crude fiber (AOAC,2005). Fried coated tempeh was tested organoleptically to obtain the best coating flour formula.

2.2.4. Viscosity Test (Subagio, 2006)

This analysis used a viscometer, the procedure was as follows: dissolve 8 g in 400 ml of distilled water, and then homogenize the solution using a stirrer rod. Install the spindle needle on the viscometer and adjust the rotation speed (rpm). Measure the viscosity of the sample by reading the scale indicated by the needle.

2.2.5. Water Holding Capacity (WHC) (Zayas, 1997)

The measurement of water holding capacity (WHC) was done by weighing an empty and dry centrifuge tube (A grams). Weigh 0.5 grams of sample (B grams) and add 7 times the weight of the sample to the distilled water and then put it in the tube. Vortex until combined and centrifuge for 5 minutes at 2000 rpm. The supernatant is poured and the sediment is weighed (C grams) then calculated using the formula:

$$WHC\ (\%) = \frac{[(C-A)]-B}{B} \times 100\% \tag{1}$$

2.2.6. Oil Holding Capacity (OHC) (Zayas, 1997)

Oil holding capacity (OHC) measurement was done by weighing an empty and dry centrifuge tube (X grams). Weigh the sample as much as 0.5 grams (Y grams) and add oil as much as 7 times the weight of the sample then put it in the tube. Vortex until combined and centrifuge for 5 minutes at a speed of 2000 rpm. The supernatant was filtered and the sediment was weighed (Z grams) then calculated using the formula:

$$OHC\ (\%) = \frac{[(Z-X)-Y]}{Y} \times 100\% \tag{2}$$

2.2.7. Organoleptic Test (Hedonic Method) (Mabesa, 1986)

The organoleptic test conducted in this study was using a preference test covering color, aroma, taste, crispiness, and overall using 30 untrained panelists. This testing method was carried out randomly using samples that had previously been given a 3-digit random number code. Panelists were asked to determine their level of preference for the samples presented. The test scale of preference for the overall crispness or texture of each sample uses 5 hedonic scales, namely 1 = very dislike, 2 = dislike, 3 = slightly like, 4 = like, 5 = very like.

2.3. Statistical Analysis

The data analysis employed the Friedman test (F test) with a 95% confidence level ($\alpha = 0.05$). When the treatment had a significant influence on the observed parameters, further testing was conducted using Duncan's Multiple Range Test (DMRT) at the same confidence level, to determine which one is significantly different in effect between treatments

3. RESULTS AND DISCUSSION

3.1. Chemical Properties of Modified Timor Local Corn Flour

The characteristic of corn flour is very important to determine the chemical composition as a base ingredient in making coating flour. The chemical composition of Timor local white corn flour is as follow: moisture content (10.02%), protein (5.22%), fat (0.23%), ash (0.31%), starch (68.59%), amylose (18.37%), amylopectin (50.22%), crude fiber (2.51%), carbohydrates (84.11%), energy (348.19 kcal/100g).

Modified Timor local corn flour has a water content of 10.02%, ash content of 0.31%. This value has met the requirements set out in SNI 01-3727-1995 (BSN, 1995) regarding corn flour, namely a maximum water content of 10% bb, a maximum ash content of 1.5%. The crude fiber content of 2.51% does not meet the requirements in SNI where the maximum crude fiber content is 1.5%. This crude fiber content is still lower than the crude fiber content in the study of Fatkurahman *et al*. (2012), who used black rice flour and corn flour substitution in making cookies, namely 6.5451%. However, the higher the fiber content, the better it is for digestion. Products with a relatively high crude fiber content tend to provide fewer calories, sugars, and fats, thereby supporting the prevention of obesity and heart problems. Additionally, the faster passage of high-fiber foods through the digestive tract has been linked to protection against diverticulosis by decreasing pressure on the gut walls (Fatkurahman *et al*., 2012).

The corn flour used has a fat content of 0.23% and a protein content of 5.22%. Starch composition plays a crucial role in defining the texture and properties of coating flour. The corn flour used contains 68.59% starch and is higher than the starch content in the study of Sugiyono *et al*. (2010), which is 59.39% while the amylose and amylopectin content of the corn flour used are 18.37% and 50.22% respectively. The amylose content produced is lower than the amylose content of corn flour in the study of Sugiyono *et al*. (2010), which is 27.90%. Starch with a high amylose content is easily retrograded (Nadhira & Cahyana, 2023).

3.2. Physical and Chemical Properties of Coating Flour

Chemical properties include protein content, starch content, WHC (water holding capacity), OHC (oil holding capacity), along with physical traits, namely viscosity, which are presented in Table 3.

Table 3. Physical and chemical composition of coating flours in various formulations

Formula*	Protein (%)	Starch (%)	Amylose (%)	Amylopectin (%)	WHC (%)	OHC (%)	Viscosity (mP)
A	4.82 ± 0.05 f	69.82 ± 0.19 b	18.78 ± 0.39 d	51.04 ± 0.29 ab	185.49 ± 0.31 i	93.10 ± 0.18 d	3.04 ± 0.01 a
B	4.71 ± 0.06 e	75.10 ± 0.04 f	23.34 ± 0.02 g	51.76 ± 0.03 bc	154.33 ± 0.12 f	106.27 ± 0.03 f	3.19 ± 0.01 b
C	4.47 ± 0.01 c	70.35 ± 0.11 c	17.65 ± 0.02 b	52.70 ± 0.02 c	157.72 ± 0.16 g	106.78 ± 0.15 g	3.64 ± 0.01 i
D	4.37 ± 0.04 ab	73.46 ± 0.12 e	19.60 ± 0.05 e	53.86 ± 0.10 d	148.67 ± 0.11 d	106.57 ± 0.23 fg	3.52 ± 0.01 h
E	4.39 ± 0.02 bc	73.23 ± 0.06 e	18.43 ± 0.09 c	54.80 ± 1.37 d	131.65 ± 0.15 c	100.61 ± 0.07 e	3.48 ± 0.01 g
F	4.50 ± 0.04 d	69.41 ± 0.12 a	18.47 ± 0.03 cd	50.94 ± 0.11 ab	152.89 ± 0.51 e	107.53 ± 0.28 h	3.29 ± 0.01 d
G	4.22 ± 0.05 a	72.25 ± 0.06 d	20.22 ± 0.02 f	52.03 ± 0.08 bc	161.10 ± 0.03 h	85.23 ± 0.05 c	3.33 ± 0.01 e
H	4.26 ± 0.05 a	69.85 ± 0.10 b	19.39 ± 0.05 e	50.46 ± 0.15 a	125.20 ± 0.20 a	84.17 ± 0.10 b	3.44 ± 0.01 f
I	4.35 ± 0.01 b	76.33 ± 0.06 g	16.62 ± 0.02 a	59.71 ± 0.04 e	130.24 ± 0.22 b	71.18 ± 0.02 a	3.24 ± 0.11 c

Note: Values followed by the same letter in the same column and treatment are not significantly different based on DMRT at 5% level. *) Notation for treatments are in accordance to Table 1.

3.2.1. Protein

The protein content in the coating flour is greatly influenced by the corn flour formula. The protein content ranges from 4.26%–4.85% and is highest in formula A with the addition of 60% corn flour, which is 4.85% and the protein content decreases with the lower corn flour formula of 40%. The use of 50% corn flour in formula F resulted in a protein level of 4.50%, attributed to the combination with rice flour, tapioca flour, and 15% glutinous rice flour. Test results from Nuraisyah *et al*. (2018) indicated that rice flour has a protein content of 7.83%, which is consistent with Kraithong *et al*. (2017) at 7.61%. Tapioca and MOCAF flours, on the other hand, provide no more than 1% protein per 100 g (Nuhanifah *et al*., 2020). Tapioca flour is commonly used in making crackers that have good expansion and crispiness. So the increase in protein content in coating flour is highly dependent on modified corn flour and rice flour because tapioca flour is very low in protein.

3.2.2. Starch, Amylose and Amylopectin

Starch consists of 2 fractions, namely amylose and amylopectin. Amylose is a part of starch found in plants, especially in rice, grains and tubers. Starch composition serves as a crucial determinant of coating flour texture and properties. Compared to low and medium amylose flours, high-amylose flour produces a denser, adhesive, and firmer gel (Lin *et al*., 2011). Amylose levels play a significant role in defining the crispness and expansion capacity of food items.

Table 3 along with the variance analysis indicates that the starch content, amylose and amlopectin is greatly influenced by the formulation of coating flour made from local corn flour modified by adding rice flour along with tapioca and glutinous rice flours. It is known that the starch content in modified local Timor corn flour is 68.59% and the starch content of corn flour in the study of Sugiono *et al*. (2010) is lower, namely 59.39%. This difference is not only caused by the corn variety but also the modification process in the process of making corn flour, namely by fermentation using tape yeast. The starch content increased in the coating flour ranging from 69.41%–76.33%. This condition is affected by the incorporation of several types of flour, including rice flour, tapioca flour, and glutinous rice flour, which contribute to increasing starch levels in coating flour. The lowest starch content was observed in formulation F, consisting of 50% corn flour, 35% rice and tapioca flour, and 15% glutinous rice flour. Starch content increased in formulations H and A as the proportion of rice and tapioca flour rose. The highest starch value was obtained in formulation I, containing 45% rice and tapioca flour with 15% glutinous rice flour. Thus, the greater the proportion of rice, tapioca, and glutinous rice flour, the higher the starch content of the coating flour. Reported starch contents were 65.25% for tapioca flour, 67.68% for rice flour, and 63.31% for glutinous rice flour (Imanningsih, 2012).

Table 3 and based on the analysis of variance system also seen between the treatment of significantly different formulations where the formulation of coating flour based on modified Timor local corn flour also strongly influences the amylose and amylopectin levels. The amount of amylose in modified Timor local corn flour is 18.37%. The amylose content in the coating flour is 16.62% in the lowest formulation I by incorporating 40% maize flour, tapioca starch, and rice flour 45% and followed by formulation C even though with the addition of 60% corn flour but the addition of rice flour and tapioca is the lowest at 25% of all formulations with an amylose content of 17.65%. So the difference in the addition of rice flour and tapioca with different proportions of corn flour greatly affects the amylose content. The highest amylose content in formulation B with the addition of 60% corn flour is 23.34%. This indicates that increasing the proportion of corn flour leads to a higher amylose content. The incorporation of rice flour and tapioca flour also contributes to amylose levels, as seen in formulation B, where the use of 30% rice and tapioca flour resulted in a relatively high amylose content, close to formulation G, which contained only 40% corn flour. However, when rice and tapioca flour were added in larger amounts (55%), the amylose level reached 20.22%. In contrast, formulations E and F, both with 50% corn flour, showed moderate amylose contents of 18.43% and 18.47%, respectively, with rice and tapioca flour proportions of 40% and 35%. Imanningsih (2012) reported amylose content in rice flour 11.78%, tapioca flour 8.06% and glutinous rice flour 0.88% is very low compared to corn flour. Therefore, in coating flour derived from corn flour, rice flour, tapioca flour, and glutinous rice flour are incorporated to enhance amylopectin levels. Flours with high amylose generally form harder, stickier, and denser gels compared to those with low or medium amylose content (Lin *et al*., 2011). Amylose content significantly influences the crispiness and expansion of a food product. Amylose contributes to increased hardness compared to amylopectin, so higher amylose levels result in firmer samples with reduced crispiness, while the texture remains crunchy. In contrast, flours with low amylose and high amylopectin contents promote puffing, producing food products that are light, porous, crispy, and crunchy (Hersoelistyorini *et al.*, 2015). Putri *et al*. (2019) also reported that the more gadung (*Dioscorea hispida*) flour substituted in stick production, the higher the hardness level obtained due to the higher amylose content produced. Amylopectin plays a role in increasing crispiness, while amylose increases the firmness of a product, higher hardness values are associated with reduced crispiness, and vice versa, if the hardness value is lower, the crispiness obtained will be higher.

Table 2 shows the amylopectin content in modified Timor local corn flour which is 50.22% lower than the amylopectin content in coating flour with a range of 50.46%–59.71%. The increase in amylopectin content in coating flour is caused by the addition of tapioca flour and rice flour and glutinous rice flour. Coating flour formulation H with the addition of 40% corn flour has a lower amylopectin content of 50.46 and its value is almost the same as formulation A which is 51.04%. The highest amylopectin content is in formulation I through the addition of 45% rice and tapioca flours and and 15% glutinous rice flour. Imanningsih (2012) also showed that the amylopectin content in rice flour was 88.22%, tapioca flour 91.94% and glutinous rice flour 99.11%. These three types of flour provide a high amylopectin contribution. Starches rich in amylopectin tend to generate products that are fragile and crisp, while amylose will produce a texture that is more resistant to being easily broken and contributes to hardness (Putri *et al*., 2019).

3.2.3. Water Holding Capacity (WHC)

Water holding capacity (WHC) measures the ability of flour to absorb and retain water, typically determined through centrifugation. This capacity is influenced by the granule composition and the physical properties of starch after water addition. Water absorption and retention are key functional properties of proteins, and WHC affects the amount of water available for starch gelatinization during cooking. Insufficient water prevents the gel from reaching optimal formation (Aini *et al*., 2016).

Table 3 and based on the analysis of variance show that the coating flour formulation has a significant effect on water absorption capacity. The water absorption capacity value ranges from 125.20–185.49% and increases with each addition of corn flour. The highest water absorption capacity is 185.40% in formulation A corn flour 60% and decreases along with the addition of rice flour and tapioca flour which is decreasing. The water absorption capacity increased again in the F formulation of 50% corn flour with the addition of 35% rice flour and 15% glutinous rice flour. The water absorption capacity also increased in the G formulation of 40% corn flour with the addition of 55% rice flour and tapioca, namely 161.10%. Therefore, in the 60% corn flour formula, more water was given, namely 170–180 ml compared to the 40% and 50% corn flour formulas. This was done to obtain a homogeneous dough. As a comparison, modified corn flour in the study of Aini *et al*. (2016), had a water absorption capacity ranging from 117.8–146.1% dk lower than the coating flour based on modified local Timor corn flour. This difference is caused by the coating flour formulated with the addition of rice flour, tapioca flour and glutinous rice flour. The study of Rauf & Sarbini (2015) also showed that cassava flour provides higher water absorption than wheat flour. Flour mixtures with a larger portion of cassava flour show higher water absorption compared to mixtures with a larger portion of wheat flour. This suggests that the higher the portion of cassava flour, the higher the water absorption of the flour mixture. Flour with low water absorption properties will produce a less than optimal gel during gelatinization, affecting solubility and swelling power. Flour with a high water absorption capacity can improve flour syneresis and produce better product viscosity and texture (Yonata *et al*., 2021). Water absorption capacity also affects the ease of homogenizing the flour dough when mixed with water. Flour with high water absorption tends to be homogenized faster. This homogeneous dough will affect the quality of the steaming and frying results. Homogeneous flour, after being steamed, will experience even gelatinization which is indicated by the absence of white or pale yellow spots on the steamed dough (Aini *et al*., 2016).

3.2.4. Oil Holding Capacity (OHC)

Low Oil Holding Capacity (OHC) or Oil Absorption Capacity (KPM) is required in products processed by frying so that they do not absorb large amounts of natural oil. OHC is the ability to hold the oil it absorbs, so it can affect oil absorption during frying.

Table 3 and based on the analysis of variance shows that the coating flour formulation has a very significant effect on oil absorption capacity and is greatly influenced by protein content. The lowest oil absorption capacity is in the coating flour formulation with the addition of 40% corn flour with a value range of 71.18–85.23%, the value increases in the coating flour formulation with the addition of 50%–60% corn flour with a value range of 93.31–107.53%. The oil absorption capacity of flour is mainly related to the fat content and protein content and when associated with the protein content of the coating flour with the addition of 40% corn flour, the protein content is the lowest with a range of values of 4.22-4.35% and increases in the coating flour formulation with the addition of 50–60% corn flour, namely 4.37–4.82%. The higher the protein content, the greater the oil absorption capacity.

Research by Aini *et al*. (2010) was also demonstrated that an increase in fat or protein content results in higher oil absorption capacity. This is related to the mechanism of oil absorption capacity caused by physical oil trapping with capillary forces and the role of protein hydrophobicity. Sirivongpaisal (2008) also reported that the oil absorption capacity of bambara groundnut flour exceeds that of bambara groundnut starch, as the higher protein and fat contents in the flour can retain more oil. Increased protein levels contribute to greater oil absorption. The hydrophobic properties of proteins are key in this process, since the ability of food components to bind water and oil depends on proteins containing both hydrophilic (water-attracting) and lipophilic (oil-attracting) groups (Astawan & Hazmi, 2016).

According to Zayas (2012), the high oil absorption capacity of flour indicates that flour has a lipophilic part. Oil absorption capacity occurs when oil is retained within the porous starch matrix, either through capillary action or within the helical structures of amylose or amylopectin, resulting from the formation of amylose-lipid complexes, changes from more hydrophobic groups to amylose-lipid complexes due to high temperatures (Ashwar, *et al*., 2016). According to Huang & Rooney (2001), flours high in amylose can help decrease oil absorption due to their film-forming ability.

3.2.5. Viscosity

Table 3 and the variance analysis indicate that corn flour-based coating flour formulations, supplemented with rice flour, tapioca flour, and glutinous rice flour, have a highly significant effect on viscosity. The viscosity of the coating flour is not influenced by the corn flour proportion alone; when 60% corn flour is used, the viscosity ranges from 3.04–3.19 mp, whereas reducing corn flour to 50% and adding 35–45% rice and tapioca flours increases the viscosity to 3.29–3.52 mp. This shows that viscosity rises with higher rice and tapioca flour content. The increase in viscosity is due to the composition of amylose or soluble fractions in starch contributed by rice flour 11.78% from 67.68% starch and tapioca flour 8.06% from 65.26% starch. While glutinous rice flour is only 0.88% of 63.31% starch (Immaningsih, 2012).

3.3. Hedonic test of crispiness or texture of fried tempeh

Texture refers to the feeling of pressure perceived in the mouth during biting, chewing, and swallowing. Food texture can be described as smooth or rough, liquid or solid, and hard or soft (Irmayanti *et al*., 2017). The texture of food can be responded to organoleptically with human senses, and can also use instruments. The results of the texture test are presented in Table 4.

Table 4. Sensory acceptance of coating flour products on fried tempeh texture

Formula	A	B	C	D	E	F	G	H	I
Score	3.60	3.80	3.96	3.96	4.04	4.36	4.16	4.08	4.12

The test results on the texture parameters obtained an average value range of 3.60–4.36. This shows that the panelists gave an assessment of liking to liking the texture of fried tempeh quite a bit. The hedonic score for the crispiness attribute of formulations A, B, C using 60% corn flour was 3.60–3.96, meaning liking quite a bit. However, when the corn flour formula was reduced to 40%–50%, the hedonic score increased with a value range of 3.96–4.36, meaning that the panelists liked this formulation. This shows that the lower the proportion of corn flour, the crispiness of the product can be accepted by the panelists, but with the addition of 35% rice and tapioca flour and 15% glutinous rice flour in formulation F, the panelists' preference value for crispiness was higher, namely 4.36. In formulations with 60% corn flour, the amylose content is higher, contributing to increased hardness and making the sample firmer. Formulations with 40% and 50% corn flour show lower amylose levels. According to Hersoelistyorini *et al.* (2015), higher amylose reduces the crispiness of the product, while flours low in amylose and rich in amylopectin promote puffing, resulting in foods that are light, porous, crispy, and crunchy. Due to the consideration of utilizing more corn flour, in the test of preference for a crispy texture, although the preference value for texture is almost the same in the formulation with the addition of 40% corn flour, formulation F was chosen with the addition of 50% corn flour.

The use of tapioca in small amounts in the dough will also form a crispier final product and less oil absorption. Tapioca and glutinous rice flour contain high amylopectin so that they have the properties of not easily clumping, have high adhesive power, are resistant to breaking or damage, with a relatively low gelatinization temperature ranging from 52 to 64°C (Lekahena, 2016).

In addition to the type of ingredients that make up the formulation, crispiness is affected by the water absorption and retention capacity of the coating flour. Flour that absorbs more water will create empty pores during frying as the water evaporates, some of which are then filled with oil, causing the material to become porous and when eaten it feels crispy (Sejati, 2010). The crispiness of the product also depends on the low amylose-to-amylopectin ratio (Reputra, 2009). Research by Putri *et al*. (2019) shows that the higher the concentration of yam flour substitution in making sticks, the higher the level of hardness obtained and the resulting amylose content, where products with high hardness values will have lower crispiness, and vice versa, if the hardness value is lower, the crispiness obtained will be higher, where the sticks have a crunchy texture.

4. CONCLUSION

The inclusion of rice, tapioca, and glutinous rice flours in coating flour prepared from modified local Timorese corn significantly influences its physical and chemical properties, such as viscosity, water holding capacity (WHC), oil holding capacity (OHC), protein, starch, amylose, and amylopectin. The proportion of 50% corn flour with the addition of 35% rice and tapioca flour, 15% sticky rice flour gives the panelists a higher preference for crispness, namely 4.36. The addition of 15% sticky rice flour in the flour formula. The coating is able to change the proportion of amylose and amylopectin in the coating flour so that the texture is crunchy and not too hard when the product is cooled. In this coating flour formulation, the characteristics of viscosity 3.29 mP, WHC 152.89%, OHC 107.53%, protein 4.50%, starch 69.41%, amylose 18.47%, amylopectin 50.94% are obtained.

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