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Characteristics of Pasta Substituted with Modified Taro and Yellow Yam Flour

Karakteristik Pasta dengan Substitusi Tepung Talas dan Uwi Kuning Termodifikasi

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Abstract. Heat-moisture treatment (HMT) is a starch modification technique that alters the starch profile from type B to type C, characterized by low swelling power, low solubility, and strong texture stability, making it suitable for pasta production. In addition, HMT can modify physicochemical properties. This study was conducted to evaluate the physicochemical and sensory characteristics of pasta made with HMT-modified taro and yellow sweet potato flour, and to determine the treatment combination that produced the best overall quality. The experimental design used was a Randomized Group Design (RGD) with two factors: type of flour (T) and proportion of flour substitution (P). The physicochemical parameters analyzed included rehydration capacity, color, protein, fat, moisture, ash, and carbohydrate content, along with sensory evaluation. The results showed that the interaction of the two factors significantly affected all sensory parameters. The pasta with the best sensory characteristics was sample T1P3, with the following physicochemical properties: rehydration capacity (55.63%); color L* (18.71); a* (2.51); b* (3.35); protein content (12.99%); fat content (3.63%); moisture content (8.03%); ash content (3.64%); and carbohydrate content (71.71%). Sensory scores included flavor (3.87), texture (3.73), color (3.80), and overall acceptability (3.80).

Keywords: pasta, heat moisture treatment, starch modification, taro flour, yellow yam flour

Abstrak. *Heat moisture treatment (HMT) merupakan metode modifikasi pati yang dapat mengubah profil pati tipe B menjadi pati tipe C yang memiliki daya pembengkakan yang rendah, kelarutan yang rendah, dan kestabilan tekstur yang kuat, sehingga cocok untuk diaplikasikan pada pembuatan pasta. Selain itu, mampu mengubah karakteristik fisikokimia. Penelitian ini dilakukan untuk mengetahui karakteristik fisikokimia dan sensoris pasta dengan substitusi tepung talas dan ubi jalar kuning termodifikasi HMT serta kombinasi perlakuan yang memiliki karakteristik terbaik. Rancangan yang digunakan dalam penelitian ini adalah Rancangan Acak Kelompok (RAK) dengan 2 faktor, yaitu jenis tepung (T) dan proporsi substitusi tepung (P). Karakteristik fisikokimia yang diamati meliputi daya rehidrasi, warna, protein, lemak, air, abu, karbohidrat, dan sensoris. Berdasarkan hasil penelitian, kombinasi kedua faktor tersebut berpengaruh signifikan terhadap semua parameter sensoris. Pasta dengan karakteristik sensoris terbaik adalah sampel T1P3 dengan karakteristik fisikokimia, antara lain daya rehidrasi (55,63%); warna L* (18,71); warna a* (2,51); warna b* (3,35). 35); kadar protein (12,99%); kadar lemak (3,63%); kadar air (8,03%); kadar abu (3,64%); dan kadar karbohidrat (71,71%); rasa (3,87); tekstur (3,73); warna (3,80); dan kesukaan keseluruhan (3,80).*

Kata Kunci: *pasta, perlakuan panas-lembab, modifikasi pati, tepung talas, tepung uwi kuning*

Practical Application: Based on the results of the study, the best formulation that has the best sensory characteristics is pasta with a 30% substitution of HMT modified taro flour. Taro is has high food fiber, meanwhile HMT modification can reduce starch digestibility through the formation of resistant starch due to the heating process. Therefore, this pasta has the potential to be a functional food that is high in fiber and low in glycemic index which is relatively safe for consumption by diabetics.

INTRODUCTION

Pasta is a source of carbohydrates that is currently widely consumed as a substitute for rice. Based on data from the International Pasta Organisation (2022), the amount of pasta production worldwide in 2022 reached 16.9 million tons. Based on SNI 8777:2019, pasta is a product made from semolina or durum wheat flour or other wheat or their mixture as the main raw material, with or without the addition of other food ingredients and food additives (National Standardization Agency 2019). Based on this statement, pasta raw materials are not only limited to semolina flour or durum wheat flour which are quite difficult to obtain in Indonesia. Moreover, Indonesia is ranks second globally of wheat imports, around 11.22 million tons of wheat were

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imported in 2021–2022 (Arifin *et al.* 2024). However, pasta can be made with a mixture of other flours sourced from local food ingredients. Among the many local food ingredients that are sources of carbohydrates, one commodity that has the potential to be developed into flour is tubers.

Tubers are one of the agricultural commodities that have high potential in Indonesia. However, the utilization of tubers by the community is not optimal. In fact, tubers play a significant role in food diversity and can provide adequate nutrition for the community because they contain high vitamins, minerals, and fiber (Rosidah 2014). Tubers also contain various other nutrients and high carbohydrates so that they have an important role in maintaining food security (Estiasih *et al.* 2017). In addition, tubers also have a high starch content, so they have the potential to be made into flour as an effort to diversify wheat flour. Types of tubers that can be processed into flour include taro (*Colocasia esculenta*) and yellow yam (*Dioscorea alata*).

The study conducted by Sonia *et al.* (2019) successfully formulated pasta using taro flour as one of its primary ingredients, but the cooking loss was very high. Similarly, Wuryantoro and Puspitawati (2020), developed a pasta-like food diversification product, namely noodles made from yam flour, but the result has a lower elasticity than conventional noodles. However, tuber-based flours generally contain lower protein levels than wheat flour, resulting in functional limitations. Consequently, pasta and noodle products made from tuber flour exhibit lower elasticity compared to those produced from wheat flour (Winarti *et al.* 2017). Moreover, native starch has several disadvantages, including excessive stickiness, low viscosity, and poor resistance to heat and mechanical processing (Fetriyuna *et al.* 2016), while pasta processing requires heat and mechanical treatment (Zareef *et al.* 2021). To enhance the characteristics of tuber-based flour, modification techniques are required. One promising approach is physical modification, which is considered safer as it does not involve chemical reagents that may leave residues in the final product (Santosa *et al.* 2018).

Heat moisture treatment (HMT) is a starch modification technique capable of altering the structure of starch granules, thereby improving its physical and functional properties (BeMieller and Huber 2015). According to the findings of Putra *et al.* (2016), the application of HMT successfully converted chimp taro starch from type B to type C, reducing its swelling ability and breakdown viscosity, thus making it a promising raw material for pasta production.

This study aims to optimize the utilization of taro and yellow yam tubers by developing local food-based pasta products, integrating the HMT starch modification method to achieve desirable product characteristics that are acceptable to consumers. Specifically, this research seeks to examine the effects of flour type and substitution proportion on the physicochemical and sensory properties of the pasta while identifying the optimal treatment combination based on sensory evaluation data.

MATERIALS AND METHODS

Materials

The materials used in this study were Bungasari semolina flour; New Sakha yellow sweet potato flour cultivated in Trenggalek, East Java; Emil Herbal taro flour cultivated in Wonogiri, Central Java; Tropicana Slim sunflower oil; Dolphin salt; chicken eggs purchased from Rita Supermarket, Purwokerto, Central Java; distilled water purchased from Prima Chemical and Packaging store; and analytical-grade chemicals for analysis.

The experimental design

The experimental design used in this research was a factorial Randomized Group Design with 2 factors, namely the type of flour (T) consisting of taro flour (T1) and yellow yam flour (T2) and the factor of the proportion of substitute flour (P) consisting of 10% (P1), 20% (P2), 30% (P3), 40% (P4), and 50% (P5). The combination of these two factors resulted in 10 treatment combinations, which were repeated 3 times, resulting in a total of 30 experimental units. Grouping was determined based on differences in egg purchase batches, which could potentially have different qualities in each batch. Treatment in each block was carried out randomly using random numbers, so that each treatment had an equal chance of appearing in each block.

Variables and data analysis

The variables observed in this study were physicochemical and sensory characteristics. The physical characteristics analyzed include rehydration capacity and color; while the chemical characteristics analyzed include proximate analysis, which includes moisture content, ash content, protein content, fat content, and carbohydrate content. The sensory characteristics observed include flavor, texture, color, and overall liking for the fettuccine pasta. The characteristics of fetucini pasta with modified tuber flour substitution will be compared descriptively with control pasta made from 100% semolina flour with other ingredients, such as the pasta samples studied, but without substitution, and commercial pasta made through an extrusion process using 100% semolina flour without other ingredients.

Data analysis of physicochemical characteristics used analysis of variance (ANOVA) at a 95% confidence level (α=0.05%), followed by Duncan's multiple range test (DMRT) at a 95% confidence level (α=0.05%). For sensory testing, the Friedman test was conducted, followed by multiple comparison tests at a 95% confidence level (α=0.05%). The best treatment was determined using the De Garmo Effectiveness Test based on sensory parameters.

Modification of taro and yellow yam tubers flour and characterization of HMT modified flour

Modification of flour using heat moisture treatment (HMT) technique by modifying the research method of Putra *et al.* (2016), taro and yellow yam flour were weighed using a Superior Mini Digital Platform Scale type i-2000 (China) conditioned by spraying distilled water until the moisture content reaches 30%. Once this moisture level was reached, the flour was stirred thoroughly to ensure even distribution. The flour was then sieved using a 80 mesh sieve (local Indonesian brand) to further enhance the even distribution of moisture. Afterwards, the flour was transferred into a container and tightly covered with aluminum foil. To even out the moisture, the flour was stored at 4 °C in a refrigerator for 12 h. After this conditioning process, the flour was placed in a baking pan covered with aluminum foil to prevent evaporation, then heated in a drying oven (Tryte Technologies, China) at 110 °C for 10 h. Finally, the aluminum foil was removed, and the flour was further dried at 60 °C for 8 h. After that, 80 mesh sieving to homogenize the particle size, which is less than 180 μm (Siletty *et al.* 2022). Then, characterization of the physicochemical characteristics of modified tuber flour was carried out using standard laboratory apparatus for chemical analysis.

Pasta making

The preparation of fettucine pasta was carried out by modifying the method of Çabuk and Yılmaz (2020), the process began with mixing semolina flour in varying proportions of 90, 80, 70, 60, or 50% of a total of 300 g with 75 g of water, 75 g of eggs, 6 g of salt, and 9 g of sunflower oil until a uniform and homogeneous mixture was achieved. Subsequently, HMT-modified taro or yellow yam flour was incorporated at proportions of 10, 20, 30, 40, or 50% of 300 g. The dough was then kneaded thoroughly and grinded twice through a meat grinder (Hanka type HK028A, Indonesia) to enhance homogeneity and cohesion. Once a consistent texture was obtained, the dough was wrapped in plastic wrap and allowed to rest for 30 min at room temperature to improve its smoothness and elasticity. After resting, the dough was initially flattened using a rolling pin (local brand), followed by further thinning with a pasta grinder. It was then cut into uniform strips using a noddle mold/pasta cutter (local brand). Finally, the prepared fettuccine pasta samples were stored in an airtight container under frozen conditions in a freezer at -18 °C for subsequent analysis.

RESULTS AND DISCUSSION

Raw material characteristics

Heat moisture treatment (HMT) modification which involves the use of high temperature under moist conditions will certainly affect the proximate content of the modified flour, as in Table 1.

Table 1. The proximate content of taro flour and yellow yam flour before and after HMT modification will certainly affect the proximate content of the modified flour

Sample	TN	TM	YN	YM
Protein (%)	5.67	11.03	6.40	9.18
Fat (%)	0.57	0.67	0.78	0.80
Water (%)	13.53	6.39	16.16	7.41
Ash (%)	4.60	4.63	2.66	2.75
Carbohydrate (%)	75.62	77.28	74.01	79.86

Notes: TN = native taro flour; TM = modified taro flour; YN = native yellow yam flour; YM = modified yellow yam flour

HMT causes a decrease in moisture content in taro flour and yellow yam flour. These results are in accordance with the statement of Garnida *et al.* (2019) in their research, namely HMT modification will reduce water content so that the components of carbohydrate compounds (crude fiber), protein, and fat will increase. In addition, the decrease in moisture content of modified flour is thought to occur due to an increase in amylose content after being modified with the HMT technique. Amylose has a straight and tight structure that causes it to easily absorb and release water so that when drying takes place, materials that have high amylose levels will more easily release the water contained in the material, resulting in lower water content Pratama and Nisa (2014). This has an impact on increasing the proportion of ash content in the raw material.

Rehydration

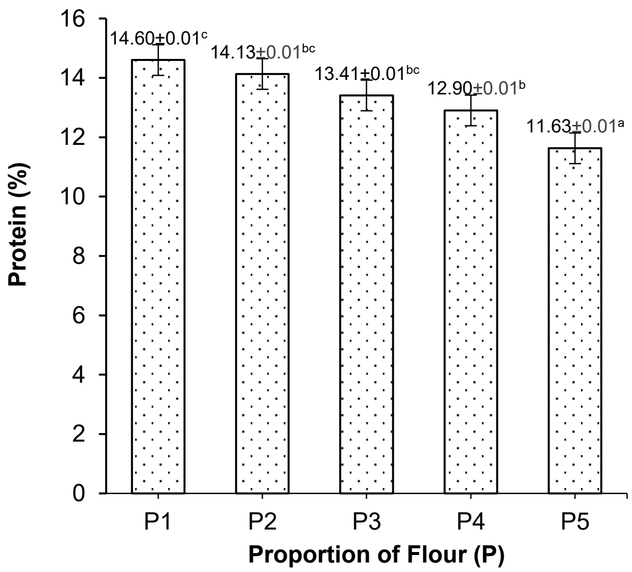
Rehydration capacity is closely related to the content of food fiber and amylose in the raw materials used. Rehydration capacity was significantly affected by types of substitute flour. Pasta with modified taro flour substitution had significantly lower rehydration power (57.35%), compared to pasta with modified yellow yam flour substitution (70.88%). Food fiber has high water absorption and binding capacity, because some of the water will be bound by food fiber (Rismaya *et al.* 2018). The increase in food fiber content in the HMT process causes the absorption or rehydration capacity of the resulting product to be high. In addition, the results of research by Ramadhia *et al.* (2019), showed that yam flour has an amylose content of 29.61%, while taro flour only contains amylose of 13.60%. This is related to the opinion of Komansilan (2015), that the amylose content contains many hydroxyl groups in the starch molecule so that it allows more water to be bound. According to Panjaitan *et al.* (2019), water entering the starch granule will bind more strongly to amylose than to amylopectin, because amylose has more hydrophilic properties than amylopectin. Therefore, amylose has the property of easily absorbing water, while amylopectin has the property of difficult to absorb water (Pradipta and Putri 2015).

Color

The brightness (L*) and redness (a*) of the pasta were not significanly affected by the type of flour, the proportion of substitute flour, and the interaction between the two factors. Meanwhile, yellowness (b*) is only significantly affected by the type of flour (T). According to Asmediana (2017), the b* color value is a measurement of yellow-blue mixed chromatic color, where (b+) is yellow and (b-) is blue. Taro flour substitution (T1) produced a higher b* color value than yellow yam flour substitution (T2). Pasta with modified taro flour substitution had a significantly lower yellowish color (b*) (1.71), compared to pasta with modified yellow yam flour substitution (1.47). This is thought to be due to the length of the drying process during HMT modification of the tuber flour, which is 8 h. As stated by Hawa *et al.* (2020), the longer the drying process, the color of taro flour becomes darker so that there is a decrease in the color value of b*. Meanwhile, yam flour visually looks brownish in color. In addition, this is probably caused by enzymatic browning reactions during heating and drying, another thing that is thought to be one of the factors for the lower yellowish color component in yam flour is the reduced carotene content due to the heating process (Ulyarti *et al.* 2022). This causes the color of yellow yam flour after HMT modification to become darker and brownish, thus giving a significantly lower b* color effect compared to pasta T1.

Protein content

Protein content of pasta was only significantly affected by the proportion of substitute flour, as shown in Figure 1. The protein content of pasta with modified tuber flour substitution ranged from 11.63 to 14.60%, while the control pasta without substitution contained 17.96%. This decrease in protein content was caused by differences in the protein content of the raw materials. Based on the results of preliminary research, the protein content of taro and yellow yam flour modified by HMT has a protein content of 11.03% and 9.18%. Meanwhile, semolina flour contains higher protein levels, around 12% (Garcia-Valle *et al.* 2021). This causes a decrease in protein levels in the product, along with an increase in the proportion of substitute flour used. Based on SNI 2019, the results of analysis in a dry basis (db) of pasta must contain a minimum protein content of 10% (National Standardization Agency 2019). Thus, pasta substituted with modified tuber flour with all treatment combinations still meet the quality requirements of pasta.



Note: Different letters indicate significant differences (α = 0,05); P1 = 10%; P2 = 20%; P3 = 30%; P4 = 40%; P5 = 50%

Figure 1. Protein content of pasta with various proportions of substituted flour (P)

Fat content

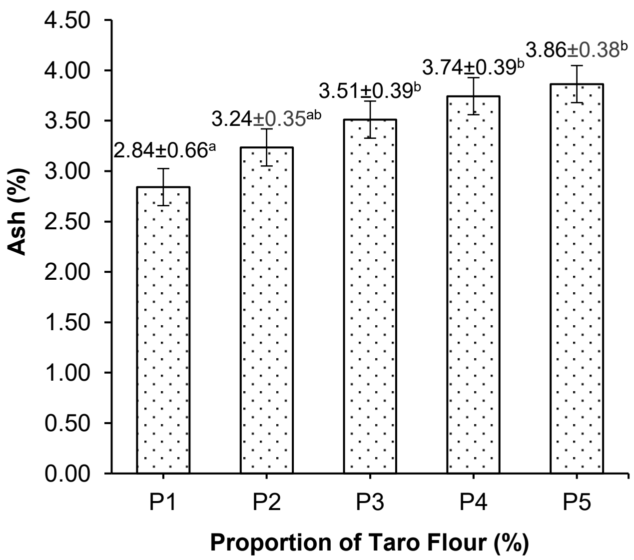
The fat content of the pasta ranged from 2.82–3.65% and was not significantly affected by all factors. This is related to the low-fat content of tuber flours so that it does not significantly affect the fat content of the processed products produced. This is thought to be because both types of flour after HMT modification contain low fat content. The results of stage 2 showed that the fat content of modified taro and yellow yam flour was less than 1%. The low-fat content contained in both causes the combination of flour type treatment and the proportion of substitute flour to have no significant effect on fat content. Meanwhile, the fat content of the control sample was 1.55%.

Moisture content

The moisture content of the pasta was not influenced by all factors. The highest average moisture content was obtained in pasta samples with 10% yellow yam flour substitution (T2P1), which amounted to 8.70%. While the lowest average value of water content, which is 6.99%, is obtained in the pasta sample with 50% yellow yam flour substitution (T2P5). According to Yulianti and Basri (2019), high amylose content will absorb more water. Both taro and yam contain amylose which absorbs water, thus affecting the moisture content of a material. The results of research by Adegunwa *et al.* (2011), showed that yam tubers have a fairly high amylose content, which is 26.67–33.38%. Meanwhile, native taro flour contains amylose of 20-25% Karmakar *et al.* (2016), as well as according to Nurbaya and Estiasih (2013) which is around 17–28%. Moreover, HMT modification can increase the amylose content contained in native flour. As stated by Santosa *et al.* (2018), HMT causes reformation of amylose and amylopectin structures, so that starch granules absorb water more easily. In addition, the low protein content in tuber flour. This results in lower water content, due to the limited availability of various functional groups contained in the protein structure, which can cause proteins to be able to bind water molecules through hydrogen bonds (Trisnawati *et al.* 2020).

Ash content

In addition to protein content, the results showed that the proportion of substituted flour (P) also had a significant effect on ash content (Figure 2). The higher the proportion of modified tuber flour substituted in pasta making, the higher the ash content of the pasta. The lowest average ash content was for the 10% substituted flour proportion (P1) which had a value of 2.84%; while the highest average value was obtained by the sample with 50% substituted flour proportion (P5), which amounted to 3.86%. This is thought to be closely related to the content of dietary fiber in tuber flours. The higher the ash content in food ingredients, the higher the mineral content in the food ingredients (Sofiati *et al.* 2020).



Note: Different letters indicate significant differences (α = 0,05); P1 = 10%; P2 = 20%; P3 = 30%; P4 = 40%; P5 = 50%

Figure 2. Ash content of pasta with various proportions of substituted flour (P)

Carbohydrate

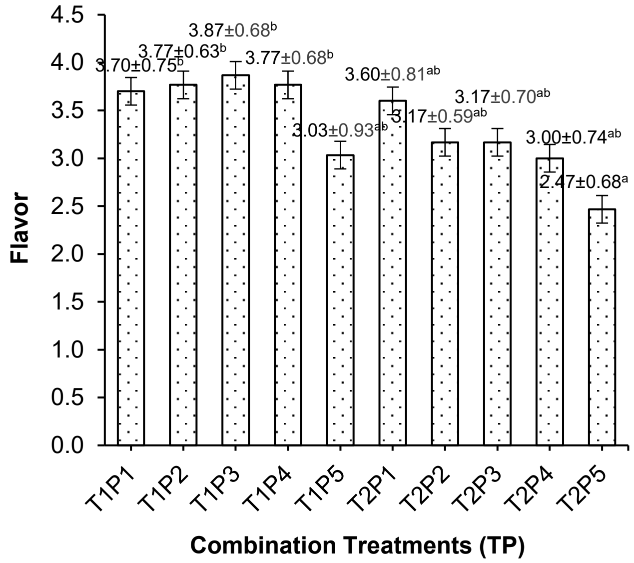
The carbohydrate content of the pasta was around 70.97–74.02%; however, it was not significantly influenced by all factors. The highest carbohydrate content was found in the pasta sample substituted with yellow yam flour by 50% (T2P5), while the sample with the lowest carbohydrate content was found in the treatment combination of modified yellow yam flour substitution by 10% (T2P1). This is thought to be due to the relatively similar carbohydrate content of taro and yellow yam flour. According to Abdulazeez *et al.* (2023), the carbohydrate content is higher than the carbohydrate content of semolina flour, which is only 70.9%, so the higher the proportion of substitution, the higher the carbohydrate content.

Flavor

Based on the research results (Figure 3), sample with 30% modified taro flour substitution (T1P3) got the best flavor value, this is because modified taro flour with a proportion of 30% did not give a significantly less delicious taste to the product. In addition, in the proportion of modified tuber flour substitution with a proportion of 10% (P1) and 20% (P2), the egg flavor was still quite pronounced so that it was considered not as delicious as the product with a proportion of 30% modified taro flour substitution (T1P3). Modified taro flour substitution with this proportion was able to cover the egg flavor without giving a disturbing unpleasant taste so that it was considered the most delicious sample compared to other samples. Meanwhile, modified yellow yam flour has a strong flavor and dominates the taste of the product too much so that the substitution of this flour gives a significant change in taste to the product even in small amounts. The higher the proportion of modified yellow yam flour substitute, the taste of the product was considered increasingly unpleasant by the panelists.

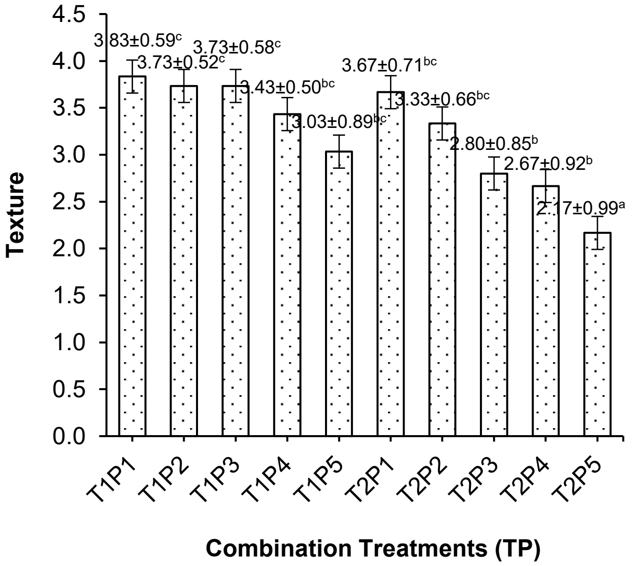
Texture

In the texture parameter, the level of elasticity will decrease along with the increase in the proportion of substitute flour. This is related to the amylose content in tuber flour, especially since HMT modification can increase the amylose content. The more amylose that is dispersed, the more likely the retrogradation process is to occur, thus affecting the increase in hardness texture (Monica *et al.* 2018). Modified taro flour is able to produce products with better elasticity than modified yellow yam flour. The results showed that modified taro flour was able to produce slightly chewy fettuccine pasta up to a proportion of 50% substitute flour; although the level of chewiness decreased as the proportion of substitute flour increased. Meanwhile, modified yellow yam flour could only be substituted up to a proportion of 20% to obtain slightly chewy pasta (Figure 4).



Note: Different letters indicate significant differences (α = 0,05); 1 = very dislike; 2 = dislike; 3 = somewhat like; 4 = like; 5 = very much like. T1 = HMT modified taro flour; T2 = HMT modified yellow yam flour; P1 = proportion of substitution flour 10%; P2 = proportion of substitution flour 20%; P3 = proportion of substitution flour 30%; P4 = proportion of substitution flour 40%; P5 = proportion of substitution 50%

Figure 3. Pasta flavor with various combinations of flour types and proportions of substitute flour (TP)

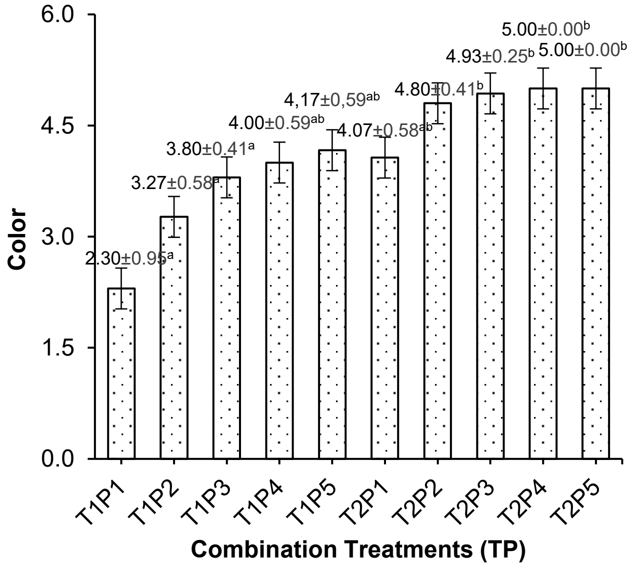


Note: Different letters indicate significant differences (α = 0,05); 1 = very dislike; 2 = dislike; 3 = somewhat like; 4 = like; 5 = very much like. T1 = HMT modified taro flour; T2 = HMT modified yellow yam flour; P1 = proportion of substitution flour 10%; P2 = proportion of substitution flour 20%; P3 = proportion of substitution flour 30%; P4 = proportion of substitution flour 40%; P5 = proportion of substitution 50%

Figure 4. Pasta texture with various combinations of flour types and proportions of substitute flour (TP)

Color

In color parameters, pasta with modified yam flour substitution is considered to have a more brownish color compared to pasta with modified taro flour substitution (Figure 5). Basically, taro flour and yellow yam have a much darker and browner color than semolina flour which is pale yellow. Likewise with the resulting substitution product, the higher the proportion of taro flour or modified yellow yam flour substitution, the browner the color of the product. This is related to the Maillard reaction and caramelization as well as the decrease in carotene content in yellow yam flour which occurs due to the high temperature treatment of the material during HMT.

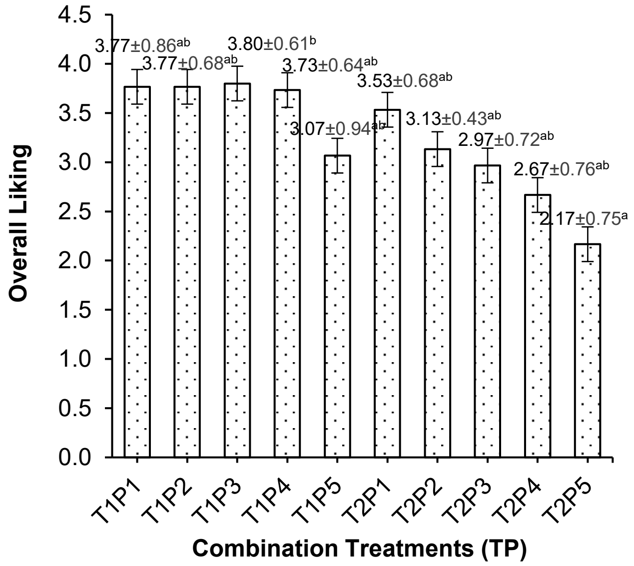


Note: Different letters indicate significant differences (α = 0,05); 1 = very dislike; 2 = dislike; 3 = somewhat like; 4 = like; 5 = very much like. T1 = HMT modified taro flour; T2 = HMT modified yellow yam flour; P1 = proportion of substitution flour 10%; P2 = proportion of substitution flour 20%; P3 = proportion of substitution flour 30%; P4 = proportion of substitution flour 40%; P5 = proportion of substitution 50%

Figure 5. Pasta color with various combinations of flour types and proportions of substitute flour (PT)

Overall acceptability

Based on panelist preferences as shown in Figure 6, the combination of flavor, texture, and color of pasta that was most pre-ferred by panelists overall was T1P3 with a value of 3.80 (like). This pasta was considered the most delicious (3.87) in terms of flavor because the substituted taro flour flavor and the fishy flavor of the eggs did not interfere. This pasta was also considered to have a chewy texture (3.73). Although not as chewy as T1P1 pasta, the difference in the level of chewiness of the two was not significantly different. Meanwhile, from the color parameter, this pasta has a yellow-brown color (3.80) this is due to the bright yellow color of semolina flour mixed with the color of taro flour which has a whitish brown color.



Note: Different letters indicate significant differences (α = 0,05); 1 = very dislike; 2 = dislike; 3 = somewhat like; 4 = like; 5 = very much like. T1 = HMT modified taro flour; T2 = HMT modified yellow yam flour; P1 = proportion of substitution flour 10%; P2 = proportion of substitution flour 20%; P3 = proportion of substitution flour 30%; P4 = proportion of substitution flour 40%; P5 = proportion of substitution 50%

Figure 6. Pasta overall liking with various combinations of flour types and proportions of substitute flour (TP)

Physicochemical and sensory characteristics of pasta with the best treatment combination

The best treatment combination was determined based on the results of an effectiveness index test using the De Garmo method, based on sensory test results conducted by 10 trained panelists aged 20–23 years. In this study, the order of variables was considered most important to least important, namely overall preference, flavor, texture, and color. The results of the effectiveness index test showed that the best treatment combination was pasta with a modified taro flour substitution of 30% HMT (T1P3). The physicochemical characteristics of the best combination of treatment pasta were compared with the control pasta and the SNI 8777:2019 standard which are presented in Table 2.

T1P3 pasta has lower protein and water content than the control pasta, but the values of protein and water content still meet the quality requirements of pasta, namely water content less than 12.5% and protein content more than 10%. However, the ash content of T1P3 pasta does not meet the quality requirements of pasta, because it is more than 1%. The high ash content in T1P3 pasta is related to the high levels of dietary fiber contained. The higher the fiber contained in a product, the higher the ash content of the product.

In terms of sensory characteristics, the best combination pasta compared to the control and commercial pasta, with average values of flavour, texture, color, and overall liking, which are presented in Table 3.

Table 2. Physicochemical characteristics of pasta with the best treatment combination

Variable	T1P3	Control	SNI
Rehydration capacity (%)	55.63	63.61	
Color lightness (L*)	18.71	23.03	
Color redness (a*)	-3.65	-6.06	
Color yellowness (b*)	1.91	15.22	
Protein (%)	12.99	17.96	Min. 10
Fat (%)	3.63	1.55	
Water (%)	8.03	10.29	Max. 12.5
Ash (%)	3.64	1.68	Max. 1.0
Carbohydrate (%)	71.71	68.52	

Note: T1P3 shows pasta with 30% substitution of HMT modified taro flour, control pasta made from 100% semolina flour, SNI regarding pasta quality requirements based on SNI 8777:2019

Table 3. Sensory characteristics of pasta with the best treatment combination

Variable	T1P3	Control	Commercial
Flavor	3.87	3.90	3.80
Texture	3.73	3.40	3.60
Color	3.80	1.00	1.70
Overall liking	3.80	3.40	3.80

Note: T1P3 shows pasta with 30% substitution of HMT modified taro flour, control pasta made from 100% semolina flour, commercial is pasta made from 100% semolina flour without any other ingredients, and is produced through an extrusion process in a factory

The best treatment combination pasta (T1P3) has a value of 3.84 which is higher than commercial pasta in the flavor variable, but lower than the control. This is thought to occur due to differences in the composition used in making pasta. Based on the composition of the ingredients listed on the packaging, commercial pasta is made from durum wheat semolina flour alone without any other additives, while T1P3 and control pasta are made with the addition of eggs and salt which contribute to the formation of the resulting product flavor.

In the texture variable, T1P3 pasta had the highest average value compared to the control and commercial pasta, which was 3.73 (slightly chewy). This was influenced by the composition of the ingredients and the method used in making the pasta. Control and T1P3 pasta are made with the addition of eggs, where the function of eggs in pasta making is as a stabilizer that can improve the consistency and chewiness of the dough (Biyumna *et al.* 2017). In the control pasta, the chewy texture arose due to the high gluten content in semolina flour and the use of eggs which also played a role in increasing the chewiness of the resulting product. However, the level of chewiness is also affected by water absorption. The high-water absorption of the control pasta can cause the chewiness of the product to decrease. Whereas pasta with modified taro flour substitution (T1P3), gluten content from semolina flour, the use of eggs in the manufacturing process, and not too high-water absorption resulted in the highest level of chewiness compared to control and commer-cial pasta based on panelists' preference.

In the color variable, T1P3 pasta was rated as having a yellow-brown color with a value of 3.80 which was much higher than the control and commercial samples. This is an effect of the use of modified taro flour in making T1P3 pasta. Semolina flour has a yellowish white color, while native taro flour has a white-brown color and becomes darker after HMT. HMT is carried out at high temperatures for a long time. Heating at high temperatures can cause browning of the material due to the Maillard reaction, which is the reaction between carbonyl groups of reducing sugars with amino groups of amino acids, peptides, or proteins resulting in the formation of brown color (melanoidin) and flavor due to heating (Anwar *et al.* 2016). As a result, the color of the pasta becomes yellow brown.

The overall liking variable was assessed from the panelists' level of preference for the sensory characteristics of the product which included flavour, texture, and color. Both T1P3 pasta, control pasta and commercial pasta were slightly preferred by panelists. T1P3 pasta and commercial pasta received an average rating of 3.80 (liked), while the control pasta received a lower average rating of 3.40 (somewhat liked). The control pasta received a lower rating. This is thought to be due to the high-water absorption of the sample, resulting in a texture that is not as good as T1P3 and commercial pastas. The control pasta was considered too chewy, resulting in a lower score than the T1P3 pasta. Meanwhile, T1P3 and commercial pasta, which were both liked by panelists, received the same average score, with their respective advantages and disadvantages in terms of flavour, texture, and color.

CONCLUSION

Based on the results, the type of flour substitution (T) significantly affected the rehydration power and yellowish color, while the proportion of substitution (P) significantly affected the protein and ash content. Meanwhile, the interaction of the two factors (TP) not significantly affected all physicochemical characteristics, but significantly affected all sensory parameters. The pasta with the best sensory characteristics was sample T1P3 with physicochemical characteristics, including rehydration power of (55.63%), color L* (18.71), color a* (2.51), color b* (3.35), protein content (12.99%), fat content (3.63%), moisture content (8.03%), ash content (3.64%), and carbohydrate content (71.71%), while the sensory characteristics, namely good flavour (3.87), chewy texture (3.73), yellowish brown color (3.80), and overall liking (3.80).

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REFERENCES

Abdulazeez R, Yusuf H, Suleiman HO, Shehu DM. 2023. Nutritional composition of semolina jaggery diet and its effect on reproductive fitness of harwich strain *Drosophila melanogaster*. *J Appl Sci Environmental Management*. 27 (8): 1639–1643. doi:10.4314/jasem.v27i8.5

Adegunwa MO, Alamu EO, Omitogun LA. 2011. Effect of processing on the nutritional contents of yam and cocoyam tubers. *J Appl Biosci*. 46: 3086–3092.

Anwar MA, Windrati WS, Diniyah N. 2016. Characterization of MOCAF (Modified Cassava Flour) based seasoned flour with the addition of maizena and rice flour. *J Agroteknologi*. 10 (2): 167–179.

Arifin HA, Rahman ANF, Putri TP. 2024. A review of the utilization of modified flour: Local food potential. *BIO Web of Conferences*. 96: 1027. doi: 10.1051/bioconf/20249601027

Asmediana A. 2017. Perubahan komponen rasa gurih dalam cabuk yang mengalami penyimpanan dan pemanasan berulang. *Agroindustrial Technology J.* 1 (1): 1–9.

BeMieller JN, Huber KC. 2015. Physical modification of food strach fucctonalities. *Annual Review Food Sci Technol*. 6 (1): 19–69. doi: 10.1146/annurev-food-022814-015552

Biyumna UL, Windrati WS, Diniyah N. 2017. Characteristics of dry noodles made from bread flour *(artocarpus altilis)* and egg addition. *J Agroteknologi.* 11 (1): 23–34. doi:10.19184/j-agt.v11i1.5440

Çabuk B, Yılmaz B. 2020. Fortification of traditional egg pasta (erişte) with edible insects: nutritional quality, cooking properties and sensory characteristics evaluation. *J Food Sci Technol*. 57 (1): 2750–2757. doi:10.1007/s13197-020-04315-7

Estiasih T, Putri WDR, Waziiroh E. 2017. *Tubers and processing.* Malang: Universitas Brawijaya Press.

Fetriyuna F, Marsetio M, Pratiwi RL. 2016. Effect of Heat Moisture Treatment (HMT) duration to functional properties and the amylograph properties of banten taro starch (*Xanthosoma undipes K. Koch*). *J Food Res.* 1 (1): 44–50. doi:10.24198/jp2.2016.vol1.1.08

Garnida Y, Hervelly, Rahma RN. 2019. Modification of ganyong (*Canna Edulis* Kerr.) flour by heat moisture treatment method at different heating temperature and time and application of flour in cookies making. *Pasundan Food Technol J.* 6 (1): 65–72. doi:10.23969/pftj.v6i1.1508

Garcia-Valle DE, Bello-Pérez LA, Agama-Acevedo E, Alvarez-Ramirez J. 2021. Effects of mixing, sheeting, and cooking on the starch, protein, and water structures of durum wheat semolina and chickpea flour pasta. *Food Chem.* 360: 129993. doi:10.1016/j.foodchem.2021.129993

Hawa LC, Wigati LP, Indriani DW. 2020. Analysis of physical properties and nutritional content of taro flour (*Colocasia esculenta l.*) at different drying temperatures. *Agrointek: J Teknologi Industri Pertanian*. 14 (1): 36–44. doi:10.21107/agrointek.v14i1.6156

International Pasta Organisation. 2022. *Annual Report*. Italia. [Accessed: February, 2nd 2025] https://internationalpasta.org/annual-report/

Karmakar R, Ban DK, Gosh U. 2014. Comparative study of native and modified starches isolated from conventional and nonconventional sources Comparative study of native and modified starches isolated from conventional and non-conventional sources. *Int Food Res J.* 21 (2): 597–602.

Komansilan S. 2015. Pengaruh penggunaan beberapa jenis filler terhadap sifat fisik chicken nugget ayam petelur afkir. *J Zootek.* 35 (1): 106–116. doi: 10.35792/zot.35.1.2015.7107

Monica L, Giriwono PE, Rimbawan. 2018. Pengembangan mi kering berbahan dasar tepung ubi jalar ungu (*Ipomoea batatas* L.) sebagai pangan fungsional tinggi serat. *J Mutu Pangan*. 5 (1): 17–24.

National Standardization Agency. 2019. SNI 8777: 2019 Pasta.

Nurbaya SR, Estiasih T. 2013. Pemanfaatan talas berdaging umbi kuning (*Colocasia esculenta* (L.) Schott) dalam pembuatan cookies. *J Pangan Agroindustri*. 1 (1): 46–55.

Panjaitan N, Ulyarti U, Mursyid M, Nazarudin, N. 2019. Modifikasi pati uwi kuning (*Dioscorea alata*) menggunakan metode presipitasi serta aplikasinya untuk edible film. *J Teknologi Pertanian Andalas*. 23 (2): 196–204. doi:10.25077/jtpa.23.2.196-204.2019

Pradipta IBYV, Putri WDR. 2015. Pengaruh proporsi tepung terigu dan tepung kacang hijau serta subtitusi dengan tepung bekatul dalam biskuit. *J Pangan Agroindustri*. 3 (3): 793–802.

Pratama IA, Nisa FC. 2014. Formulasi mie kering dengan substitusi tepung kimpul *(Xanthosoma sagittifolium)* dan penambahan tepung kacang hijau (*Phaseolus Radiatus L*). *J Pangan Agroindustri*. 2 (4): 101–112.

Putra INK, Wisaniyasa NW, Wiadnyani AAIS. 2016. Optimisasi suhu pemanasan dan kadar air pada produksi pati talas kimpul termodifikasi dengan teknik heat moisture treatment (HMT). *Agritech*. 36 (3): 302–307. doi:10.22146/agritech.16602

Ramadhia M, Purwandani L, Indrastuti E. 2019. Characteristics of kwetiau from rice flour mixed with modified Yam (*Dioscorea alata*), taro (*Colocasia esculenta*) and kimpul (*Xanthosoma sagittifolium*) tuber flour. *Buletin LOUPE*. 15 (1): 1–7. doi:10.51967/buletinloupe.v15i01.23

Rismaya R, Syamsir E, Nurtama B. 2018. Pengaruh penambahan tepung labu kuning terhadap serat pangan, karakteristik fisikokimia dan sensori *muffin*. *J Teknologi Industri Pangan*. 29 (1): 58–68. doi:10.6066/jtip.2018.29.1.58

Rosidah. 2014. Potensi ubi jalar sebagai bahan baku industri pangan. *J Teknologi Busana Boga*. 1 (1): 44–52. doi:10.15294/teknobuga.v1i1.6403

Santosa H, Handayani NA, Fauzi AD, Trisanto A. 2018. Pembuatan beras analog berbahan dasar tepung sukun termodifikasi heat moisture treatment. *J Inovasi Teknik Kimia*. 3 (1): 37–45. doi: 10.31942/inteka.v3i1.2124

Siletty L, Polnaya FJ, Moniharapon E. 2022. Karakteristik kimia tepung umbi talas (*Colocasia esculenta*) kultivar tanimbar dengan lama fermentasi. *Agritekno: J Teknologi Pertanian*. 11 (1): 48–53. doi:10.30598/jagritekno.2022.11.1.48

Sofiati T, Asyari A, Sidin J. 2020. Moisture, ash and carbohydrate content analysis of skipjack sago in morotai island regency. *J Laot Ilmu Kelautan*. 2 (1): 23–30. doi:10.35308/jlaot.v2i1.2359

Sonia S, Julianti E, Ridwansyah R. 2019. The characteristic of taro flour based pasta with addition of modified starch and hydrocolloids. *Indonesian Food and Nutrition Progress*. 16 (1): 27–35. doi: 10.22146/ifnp.45681

Trisnawati W, Sari ARK, Yanti NKAT. 2020. The preference and shelf life of crispy fried onions. *IOP Conference Series: Earth and Environmental Science*. 782 (3). doi:10.1088/1755-1315/782/3/032067

Ulyarti U, Surhaini S, Wahyuni YS, Nazarudin N. 2022. Physico-chemical and functional properties of Yam (*Dioscorea* spp.) flour modified with sauerkraut liquid. *J Teknologi Pertanian*. 23 (1): 73–88. doi:10.21776/ub.jtp.2022.023.01.7

Winarti S, Susiloningsih EKB, Fasroh FYZ. 2017. Karakteristik mie kering dengan substitusi tepung gembili dan penambahan plastiziser GMS (gliserol mono stearat). *Agrointek: J Agricultural Industry Technology.* 11 (2): 53–62. doi:10.21107/agrointek.v11i2.3069

Wuryantoro, Puspitawati IR. 2020. Diversifikasi pangan melalui pemanfaatan sumberdaya lokal ”uwi” sebagai bahan mie instan. *J Agritek: Jurnal Ilmu Pertanian, Kehutanan dan Agroteknologi*. 21 (2): 94–99. doi:10.33319/agtek.v21i2.74

Yulianti Y, Basri BST. 2019. Bubur talas instan dengan penambahan tepung ikan cakalang dan tepung labu kuning. *J Teknologi Industri Pertanian Indonesia.* 11 (2): 53–57. doi:10.17969/jtipi.v11i2.14310

Zareef M, Arslan M, Hassan MM, Ahmad W, Ali S, Li H, Ouyang Q, Wu X, Hashim MM, Chen Q. 2021. Recent advances in assessing qualitative and quantitative aspects of cereals using nondestructive techniques. *Trends Food Sci Technol.* 116 (1): 815–828. doi:10.1016/j.tifs.2021.08.012

JMP-02-25-04-Naskah diterima untuk ditelaah pada 6 Mei 2025. Revisi naskah disetujui untuk dipublikasi pada 4 September 2025. Versi Online: https://journal.ipb.ac.id/index.php/jmpi