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Formulation, Nutritional and Sensory Evaluation of Mocaf (Modified Cassava Flour) Noodles with Latoh (*Caulerpa lentillifera*) Addition

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Abstract
Instant noodles gained widespread popularity, resulting in a surge in global wheat consumption. However, concerns about the health implications of wheat-based products spurred the need for alternative ingredients in noodle production. The substitution of wheat flour with local resources, such as mocaf flour, and the enrichment of noodles with latoh (*Caulerpa lentillifera*), provided an opportunity to reduce wheat imports while enhancing the quality and potential health benefits of noodles. This study aimed to determine the optimal formulation, assess the characteristics, and evaluate the functional properties of wheat noodles that were substituted with mocaf flour and supplemented with latoh. The formulation of these noodles was conducted using design expert. The research encompassed a comprehensive analysis of physical, chemical, and organoleptic properties. The presence of latoh, in terms of chemical characteristics, increased the water and protein content in the noodles. On the physical side, it increased the final viscosity, setback, peak time, and elongation, as well as reduced the peak viscosity and breakdown. Meanwhile, the presence of mocaf increased carbohydrate content, peak viscosity, and breakdown value. The variations in noodle formulas only affected consumer acceptance of the appearance of the

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noodles; the noodle formula 99:1 (Mocaf:Latoh) had the most preferred appearance. Based on the sensory test parameters, the elongation value, and the tensile strength, noodles with optimal formulas were obtained, namely mocaf 63%, wheat 36% and latoh 1%. The optimum formula was similar to sample 10 (60:39:1) which exhibited characteristics such as a bright color, a rather smooth appearance with no cracks, a very soft mouthfeel, a bit springiness and elasticity, and a slightly non-sticky texture to the teeth without a fishy aroma. The essential and non-essential amino acids with the highest concentration contained in the Mocaf Noodles' optimum formula were glutamate and leucine. Mocaf noodles with added latoh had low fat content but high carbohydrates and were rich in essential amino acids compared to other noodles. Additionally, they possessed sensory characteristics that were deemed acceptable by the panelists.

Introduction

In recent times, the popularity of instant noodles has surged rapidly, propelling their global consumption to an impressive milestone off 100 billion servings by 2019.[1] The consumption of wheat-based food products, including instant noodles, has led to a significant upswing in wheat imports, a trend that has persisted over the years. However, a decline in the consumption of wheat-based products has been observed due to potential health concerns among certain consumers. Noodles' primary constituents encompass flour, water, and salt.[2] As a strategy to diminish wheat usage and optimize local ingredients, the substitution of local carbohydrate sources into noodle products has garnered attention. Cassava stands out as local ingredients, abundant in carbohydrates. In 2019, Indonesia recorded a cassava cultivation area of 0.63 million hectares, yielding 16.35 million tons. Cassava flour boast numerous advantages over other starch sources, including its starch accumulation capacity, year-round availability, and cost-effectiveness. To enhance the application of cassava flour, physical, chemical, and enzymatic modifications have been undertaken. Modified starch offer several advantages over native starch, especially its superior solubility, hightened stability, and reduced retrogradation tendency.[3] The process of modifying cassava flour (mocaf production) involves biochemical alterations, achieved by encorporating enzymes or enzymes-producing microorganisms. Several studies have demonstrated that mocaf flour can serve as a substitute for wheat flour, with substitution ratios ranging from 20% to100%.[4] By integrating mocaf into noodle dough at a ratio of 70:30 mocaf to wheat flour, along with the inclusion of 20% egg white, a substantial protein content of 15.38% is achieved, meeting Indonesia National Standards (SNI).[5] Additionally, the quality of noodles is internationally regulated under the Codex Alimentarius CXS 249-2006.

Enriching food products with nutrients has become a prevalent practice, aimed at enchancing their functional value for improved health benefits. Among the ingredients conducive to enchancing functional value is latoh (*Caulerpa lentillifera)* commonly known as sea grapes. Latoh, a type of green seaweeds abundant in Indonesia, boasts a nutritional composition comprising 9.22% water content, 41.83% ash content, 7.55% protein content, 0.99% fat content, and 37.76% carbohydrates. Notably, Latoh contains 43.97% dietary fiber, 21.09% soluble dietary fiber, and 22.88% insoluble dietary fibe.[6] Furthermore, studies have revealed latoh's antioxidative potential, featuring a phenolic content of 2.04-5.47 mg GAE/g, and a flavonoid content of 4.93 mg QE/g, with an EC50 antioxidant activity of 2.20 mg/ml.[7]

Latoh can act as a hydrocolloid, playing a pivotal role in enhancing the physical attributes of noodles. Hydrocolloids have multiple functions, including adhesion, water binding, emulsification, gel formation, and thickening and which in turn reduces free water content in food products. Despite its potential availability, seaweed is rarely incorporated into the production of dry noodles. Seaweed addition to dry noodles augments elasticity through macromolecular interactions that facilitate gel formation.[8] Consequently, it becomes imperative to explore the production of noodles through mocaf flour substitution and the incorporation of latoh. Such noodles possess the potential to be functional food, boosting not only palatability but also nutritional fulfillment and potential health benefits supported by scientific research.

Both mocaf flour and latoh have the potential to provide health benefits and enhance the quality of noodles. Therefore, optimizing both ingredients is necessary to obtain the right ingredient ratio for achieving the best noodle quality. The optimization of raw materials for noodle production can be done using mixture design method with the help of design expert. Optimizing the formulation with Design Expert ensures that the noodles not only meet sensory expectations, such as taste, aroma, and appearance but also possess the desired physical attributes that contribute to their overall quality.[9] This approach guarantees that the final noodle formulation is both sensorily pleasing and structurally sound, catering to consumer preferences and market demands. This study aims to ascertain the optimal formulation and evaluate the chemical, physical, and sensory properties of wheat flour noodles substituted with mocaf and enriched with latoh.

Materials and Methods

Materials

The raw materials utilized in noodle production included mocaf flour obtained from Grobogan, Indonesia; Fresh Latoh (*Caulerpa lentillifera)* from Jepara, Indonesia; wheat flour, and water. The chemicals used for analysis were obtained from Sigma-Aldrich (Missouri, USA).

Preparation of Latoh Flour

The preparation of Latoh flour commenced with washing and sorting fresh Latoh directly from farmers. Cleaned latoh was soaked in a salt solution for 3 hours, followed by rinsing and drying using a Cabinet Dryer for 12 hours. The dried latoh was then ground using a grinder and sieved through an 80-mesh sieve.

Preparation of Noodle

The noodle preparation method followed the procedure outlined by Wahjuningsih *et al*.[10] with some modifications. Mocaf flour, wheat flour, and latoh flour were combined in a basin and mixed with water at a dry matter-to-water ratio of 1:0.3 (m/v). The dough was steamed for 15 minutes and then processed through an extruder to form wet noodles. These wet noodles were subquently dried for 12 hours at 50°C to yield dry noodles.

Proximate Analysis

Proximate analysis, encompasing moisture, ash, protein, and fat content adhered to the AOAC guidelines.[11] The carbohydrate content was determined using the following equation:

Carbohydrate (%) = 100% - [Moisture (%) + protein (%) + fat (%) + ash (%)]

Sensory Analysis

The organoleptic evaluation involved both a descriptive test and a hedonic test. The descriptive test aimed to assess the physical characteristics of the noodles, including color, aroma, and texture. These evaluation were conducted on noodle products, involving a panel of previously screened individuals according to Hasanah *et al*.[12] A total of 30 panelists that have been screened participated in this assessment. The panelists were students aged between 20 and 23 years who had studied sensory evaluation. Samples were served with three-digit codes, and the hedonic scale used ranged from 1 to 9, with 1 indicating "very much disliked" and 9 indicating "very much liked." The attributes tested included color, appearance, chewiness, springiness, taste, aftertaste, and overall acceptance. This study was approved by the health research ethics commission Dr. Moewardi General Hospital No. 1.017 / V / HREC / 2023.

Pasting Properties

Sample suspension was prepared by mixing 3 g of starch (dry basis) with water to reach a total weight of 28.0 g. The suspension was allowed to equilibrate at 50°C for 1 minute, followed by heating from 50 to 95°C at a rate 6°C/minute. A holding period at 95°C was maintened before cooling from 95°C to 50°C at 6°C/min, followed by an additional holding phase at 50°C for 2 minutes. The RVA parameters included paste temperature, peak viscosity, breakdown, final viscosity, and setback.

Analysis of Amino Acid Content

The amino acid profile was determined using RP-HPLC with a fluorescence detector. The analytical steps involved protein hydrolysis to release amino acid residues and amino acid derivatization with OPA-MCE. The column utilized was C-18 (250 x 4.6 mm i.d., 5 m). The eluent system consisted of two components and was conveyed in a gradient. Eluent A comprised 0.01 M acetate buffer (pH: 5.9), while eluent B consisted of methanol: 0.01 M acetate buffer (pH: 5.9): tetrahydrofuran (400:75:25 v/v/v). The gradient conditions were as follows: 0-3 minutes, 30% eluent B; minutes 3-25, 30%-100% B; min 25.02 0% eluent B. The eluent flow rate was set at 1.5 ml/min. The fluorescence detector was configured with excitation and emission wavelengths at 340 and 450 nm, respectively.

Noodle formula optimization

The dry noodles with the highest elongation value and preferred by the panelists were selected as the optimal dry noodles. These top-performing noodles then subjected to optimization using a mixture design (design expert 13) to determined the best formula based on overall sensory properties, elongation, and tensile strength value. The mixed starch design formula used for optimization is listed in Table 1.

Table 1: Mixture design applied to optimize mocaf noodles.

Mixtures	Ingredients (g/100 g)		
	Mocaf	Wheat	Latoh
1	86.33	13.67	0
2	88.16	9.67	2.17
3	99	0	1
4	72.33	24.67	3
5	60	39	1
6	99	0	1
7	97	0	3
8	69.67	29.16	1.17
9	78.91	18.92	2.17
10	60	39	1
11	73.67	26.33	0
12	86.33	13.67	0
13	78.91	18.92	2.17
14	84.67	12.33	3
15	60	37	3

Statistical Analysis

Data is presented as mean ± standard deviation (SD). Statistical analysis were conducted using SPSS 25, including analysis of variance (ANOVA), followed by Duncan's multiple range test to identify significant differences at $p < 0.05$.

Results and Discussion

Nutritional Characteristics of Noodle Formula

The chemical composition of the noodle formula is presented in Figure 1. Differences in the concentration of mocaf, wheat flour, and latoh significantly influenced the chemical composition of the produced noodles. Noodle composition containing mocaf, flour, and latoh exhibited total energy levels ranging from 376.27 to 386.[17] Kcal/100 g, with energy from fat ranging from 2.75 to 10.53 Kcal/100 g (Table 2). Carbohydrate content in noodles ranged from 86.85% to 93.22%. Additionaly, the noodles displayed an ash content of 0.45% to 0.78%, moisture content of 4.42% to 6.21%, fat content of 0.31% to 2.20%, and protein content of 1.10% to 5.70%. The concentration of mocaf in the noodle formula positively correlated with carbohydrate content. Higher concentration of mocaf led to increased carbohydrate content in the noodles. Mocaf contained approximately 85% carbohydrates, slightly higher than the carbohydrate content of wheat flour (around 78-80%) and latoh (13.63%) indicating a more significant impact on carbohydrate content than other flours.[13 and14] Furthermore, wheat flour and latoh increased fat and energy from fat in the noodles, as evidenced by samples 16, 1, 4, 9, and 11, which had high fat and energy from fat. Nonetheless, fat content in these noodles remained relatively low.

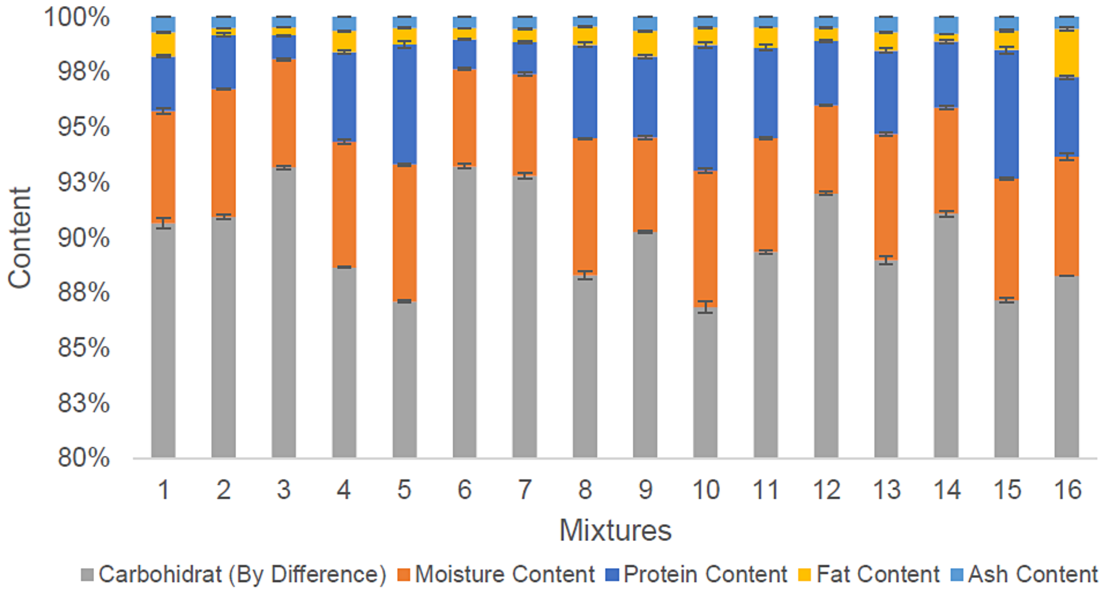

Fig. 1: Chemical composition of noodle formula. The x-axis represents 16 mixtures, and the y-axis represents the percentage of the chemical composition

Table 2: Energy composition of noodle formula

Sample	Total Energy (Kcal/100 g)	Energy from fat (Kcal/100 g)
1	382.18 ± 0.46^{f}	9.68 ± 0.19
2	376.27 ± 0.11^{a}	2.75 ± 0.06^{a}
3	380.39 ± 0.13^{e}	3.29 ± 0.06^{b}
4	379.52 ± 0.59^{de}	8.64 ± 0.25^{i}
5	376.93 ± 0.12^{ab}	6.71 ± 0.19^{e}
6	382.74 ± 0.16^{f}	4.50 ± 0.13^{c}
7	382.52 ± 0.30^{f}	5.58 ± 0.13^{d}
8	377.56 ± 0.04^{bc}	7.52 ± 0.19^{fg}
9	386.17 ± 0.42^{h}	10.53 ± 0.25^{k}
10	377.45 ± 0.32^{b}	7.25 ± 0.19^{f}
11	382.11 ± 0.33^{f}	8.33 ± 0.19^{hi}
12	384.86 ± 0.07^{g}	5.22 ± 0.13^{d}
13	378.35 ± 0.15^{c}	7.43 ± 0.19f^{g}
14	379.43 ± 0.35^{d}	3.11 ± 0.06^{ab}
15	379.78 ± 0.40^{de}	7.92 ± 0.25^{gh}
16	387.18 ± 1.00^{i}	19.80 ± 0.64^{l}

Note: Values are mean ± standard deviation, different superscripts in the column show a significant difference (p<0.05).

The total energy of noodles made with mocaf flour and latoh (Table 2) was similar to composite noodles made from rice, tapioca and soybeans, with a total energy of 378-388 Kcal/100g.[16] In the study by Bayomy and Alamri,[12] noodles made from chickpeas and lentils exhibited a total energy range of 390-400 Kcal/100g. Similarly, Azkia *et al.*[13] reported that noodles made from sorghum, mung beans, and sago had a total energy range of 397-399 Kcal/100gr, with energy from fat ranging from 1.5-2.9 Kcal/100gr. The presence of wheat and latoh in the noodles did not significantly affect the total energy but was reflected in the energy from fat, corresponding to the fat content in the sample.

In comparison, mocaf noodles made with tapioca, corn, and soybeans exhibited protein content of 6-8% and ash content of 0.5-0.6%.[19] Nevertheless, the protein content in the noodle samples in this study was higher, while the ash content was lower than sago noodles in the study conducted by Murtini and Lorenzsa,[16] with a protein content of 0.23% and an ash content of 0.8%. Hou[17] suggests that premium quality noodles typically have low ash content, as higher ash content can lead to a duller and darker appearance. The water content of the noodle samples in this study was similar to that of sorghum, mung bean, and sago noodles in Azkia *et al.*[18] which had a moisture content of 3-6%.

Wheat flour and latoh had no significant effect on the ash content, but both materials tended to increase water and protein content, particularly with the addition of wheat flour. This effect was likely due to the relatively high protein and water content in both wheat flour (with a protein content around 15% and water content of 13.9%) and latoh (with a protein content of 17.8% and varying water content from 9-18%).[22, 23]

Based on the chemical composition results presented in figure 1, noodles made from mocaf, wheat, and latoh starch exhibited low fat content and high carbohydrate content compared to other types noodles. For instance, noodles made from mocaf flour, tapioca, corn, and soybeans, as reported by Violalita *et al.*[15] contained 4-6% fat and 16-27% carbohydrates. Wet noodles enriched with mackerel flour had a fat content of 4-7% and carbohydrate content of 56-59%.[24] In contrast, the fat and carbohydrate levels in sago noodles, according to Murtini and Lorenzsa ,[16] were 0.04% and 85.76%. The inclusion of mocaf flour led to an increase in carbohydrate content. In contrast, the addition of latoh had the opposite effect, reducing carbohydrate levels while leaving fat content unchanged. Calories or energy in food primarily stem from carbohydrates, protein, and fat, so higher carbohydrate, fat, and protein content in noodles correspond to increased calorie or energy content. Ariani and Masdarini 24 reported that mocaf had a fat content of 0.4%, lower than the fat content of wheat flour, which typically ranged from 1.5-2%. Consequently, the addition wheat flour increased the fat content of the noodles. Characteristics of starch gelatinization in composite formulas

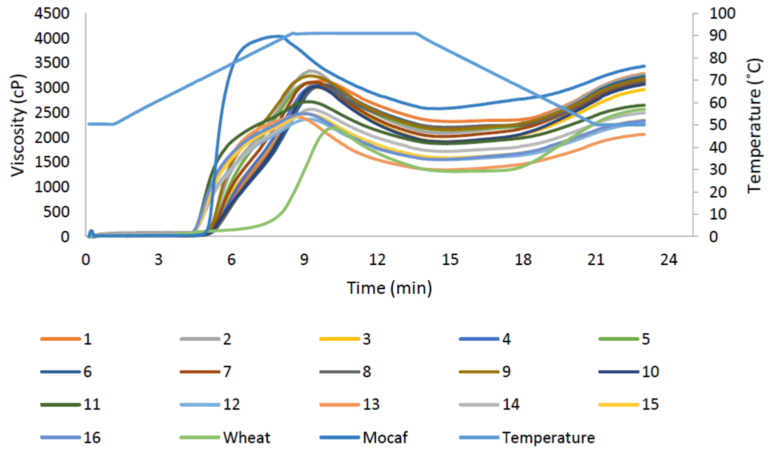

Fig. 2: Starch gelatinization profile of noodle mixtures (samples 1-16, wheat, mocaf) analyzed with Rapid Visco Analyzer (RVA)

In this study, the characteristics of starch gelatinization in the composite formula were analyzed using a rapid visco analyzer (RVA), and the results are presented in Figure 2. Mocaf flour exhibited higher peak viscosity, trough, breakdown, final viscosity, and pasting temperature compared to wheat flour. The concentration of mocaf flour used in this study exceeded that of wheat flour and latoh. When compared to mocaf flour, the 16 noodle formulation in this study demonstrated lower peak viscosity and breakdown values, ranging from 3244 to 5890 and 1293 to 3699, respectively. The final viscosity and sample setback values tended to be higher than those of mocaf flour and wheat flour, ranging from 2012 to 2583 and 187 to 627, respectively. The peak times of the samples fell between those of mocaf flour and wheat flour, ranging from 3.80 to 5.20 minutes. Meanwhile, the trough and pasting temperature values were consistent, averaging around 1811 to 2194 and 71.70 to 72.60°C, respectively.

The starch gelatinization process involves the disruption of molecular order within starch granules, including contaminants, under the influence of temperature, water, and agitation. Heating starch in water causes granules to expand, resulting in increased viscosity, dissolution, and irreversible changes in starch properties.[26] The gelatinization process of each starch produces distinct flexibility and gel strength, directly affecting noodle quality.

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Based on the obtained results, it was observed that increasing concentrations of wheat flour and latoh tended to decrease peak viscosity and breakdown value. Conversely, as the concentration of mocaf increased, peak viscosity and breakdown value also increased. As shown in Figure 2, sample mocaf, 3, and 6 (99 g mocaf; 1 g latoh) exhibited the highest peak viscosity and breakdown value while, samples with high concentration of wheat and latoh such as samples 5, 10, and 15 (value for 15 is not shown in the figure), had the lowest peak viscosity and breakdown value. These findings are consistent with other studies involving mixed starches, such as Ratnawati *et al*.[28], who reported peak viscosity and breakdown values of 2739 and 481, respectively, for a mocaf-soybean starch mixture. The addition of soybean resulted in decrease peak viscosity and breakdown value. In the study by Xu *et al*.[29] a mixture of wheat starch and sorghum had peak viscosity and breakdown value of 2500 and 955, respectively. Peak viscosity can be interpreted as the maximum viscosity of starch to bind water and can provide insight into the final textural properties of product containing starch.[29] Lower peak viscosity results in more broken starch, leading to noodles with increased hardness.[30] An *et al*.[32] noted that starches with lower peak, trough, and final viscosity values produce noodles with slightly lower elongation and springiness values. The breakdown value, on the other hand, represents changes occurring between peak viscosity and viscosity after 15 minutes of heating at a minimum temperature of 95°C. This value reflects the stability of the paste or gel to during heating.[32] Lower breakdown values indicate greater stability against heating,[33] suggesting that the addition of latoh can enhance gel stability.

In this study, the use of latoh as a starch mixture tended to increase the final viscosity and setback of starch. However, the final viscosity and setback values of the samples did not surpass those of mixed mocaf-soybean, mixed grain and sorghum-wheat starches, which exhibited final viscosity values exceeding 2700-4000 and setback value around 491-2500.[9,27, 34] Sinurat and Fadjriah (2019) suggested that Latoh or *Caulerpa lentilifera* is a green seaweed that has a high content of cell-wall sulfated polysaccharides and can serve as a good hydrocolloid agent. Hydrocolloid agents can act as thickening agents and enhance the quality and stabilize the gel properties.[36]

Bashir and Aggarwal [30] described final viscosity as the starch's capacity to form a gel or paste after heating and cooling in the RVA cooling phase. The difference between final viscosity and peak viscosity yields setback viscosity, which can describe retrogradation or syneresis during storage. A high setback value suggests that starch is more prone to retrograde during cooling or storage.[37] Starch mixtures with higher wheat flour concentrations resulted in increased peak time, which represent the time it takes to form a paste or gel.[38] The peak time of mocaf-wheat-latoh starch mixture were not significantly different from those of cassava-rice starch and mixed grain starches.[35]

Meanwhile, latoh had no significant impact on trough viscosity and pasting temperature. The trough viscosity in this study ranged from 1100 to 1500, consistent with the results obtained in studies involving a mixture of sorghum-wheat starch and mixed grain starch, where trough viscosity fell within this range.[9,34] Trough viscosity represents the maximum viscosity under constant temperature in the RVA and assesses paste stability against damage during cooling. Pasting temperature refers to the temperature at which viscosity begins to increase; higher pasting temperatures indicate greater starch resistance to swelling and rupture. Research by Wang *et al.*[42] indicated that starch thermal do not significantly impact the cooking process or the physical characteristics of noodles.

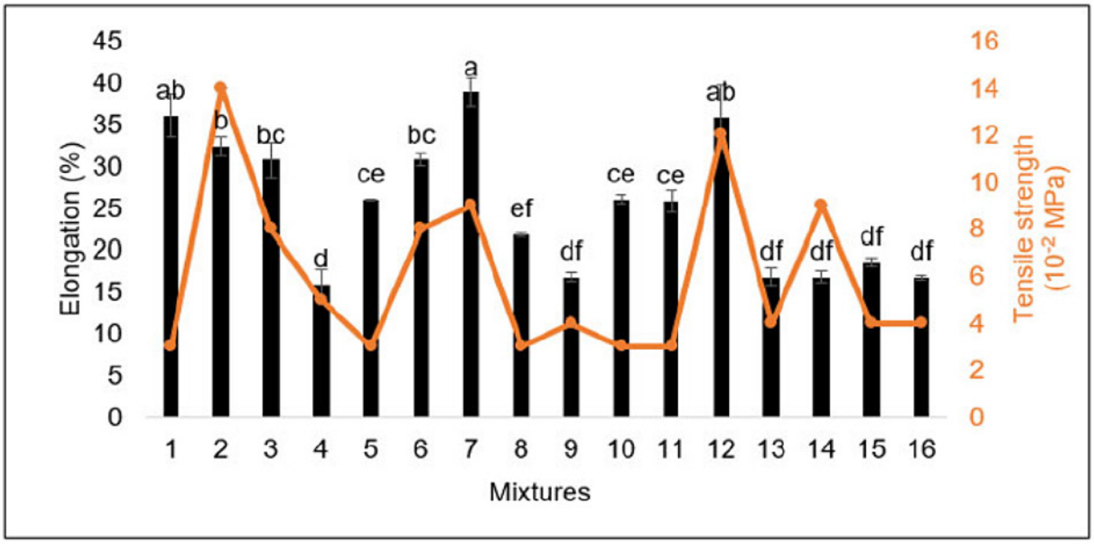

Fig. 3: Elongation value and tensile strength of noodle formula designs. Different letters in the graphics show a significant difference ($p<0.05$)

The Optimization of Noodle

The elongation and tensile strength of noodles with Latoh substitution are presented in Figure 3 (which colour represents which data has to be provided in the figure). The elongation values of the noodles ranged from 15.91% to 38.86%, while the tensile strain values were between 0.03% and 0.14%. From the obtained results, it was observed that the addition of Latoh flour tended to increase the elongation value, while mocaf tended to enhance the tensile strength values. This indicates that each ingredient used in the noodle formula played a role in improving the physical properties and texture of the noodles. Elongation signifies the extent to which the noodle can be stretched before it reaches its breaking point, whereas tensile strength represents the maximum force or strength required for the noodle to breaks.[41,42]

Wheat flour was believed to elevate the gluten content in the noodles. Lower gluten content in noodles typically leads to reduced elongation values. As Lavlinesia[47] noted, wheat flour contains gluten , a protein composed of glutenin and gliadin, when mixed with water, starch molecules form a matrix with gluten, enabling the creation of a three-dimensional structural network with sulfur cross-links between proteins in noodle dough. This results in increased elasticity and noodle strength. The elongation of mocaf noodles with a combination of sago ranged from 15% to 38%.[44] In a study by Wiadnyani and Widarta [51] on noodles made from taro, the tensile strength was measured at 0.014-0.021 mPa. Despite the fact that the reduction of wheat concentration reduced the elongation and tensile strength, the addition of latoh helped to address the issue as explained earlier. Latoh was believed to act as a hydrocolloid, which can help increase the elongation and tensile strain of the noodle.[46] Elongation and tensile strain are attributes of noodles that characterize their texture and elasticity of noodles, with higher values of tensile strain and elongation being preferred by consumers.[47] Elasticity is influenced by the amylose content of the starch used to make the noodles. Elevated amylose content increases intermolecular bonds and the crystal structure of starch, leading to a denser starch structure and increased noodles elongation.[48]

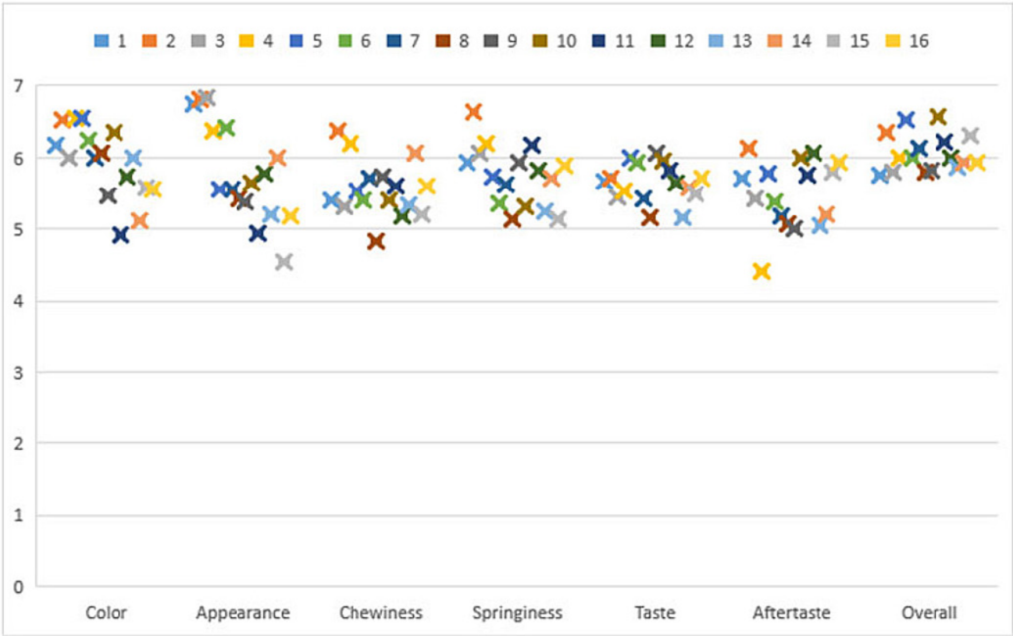

Fig. 4: Sensory evaluation (hedonic score) of noodle formula designs (mixtures 1-16)

In this study, a sensory test was conducted on noodle samples to evaluate consumer acceptance. The success of a noodle product is often gauged by consumers' reaction to the product, and acceptance can be influenced by various factors, including appearance, texture, color, taste, and the authenticity of the raw materials used. The hedonic test, a sensory evaluation method, was employed, where panelists express their preferences for a product in on a preference scale, typically ranging from 1 to 9, representing "very much dislike" to "very much like", the collected were then averaged to assess the overall product acceptance. The results from the hedonic test were subsequently compared with the findings from the descriptive test. Sample 4, which featured the highest concentration of latoh concentration, was the most favored among the panelists, despite having a very dark noodle color. The dark color was attributed to the high levels of green pigments in latoh, such as chlorophyll a and b.[49] Sample 3 exhibited a relatively smooth and uncracked appearance, which was favored by the panelists.

The addition of latoh to the noodles improves the texture, making it smoother and softer, thereby enhancing consumer acceptance. Seaweed posses hygroscopic properties that enable it to absorb significant amounts of water during cooking, resulting in a softer, spongy texture with reduced hardness.[42,50] Sample 2 had the most preferred elasticity, friability, and aftertaste, while sample 9 was favored for taste. Both samples had a relatively soft, somewhat springy, and elastic mouthfeel, and they did not stick excessively to the teeth. Wheat flour played a significant role in determining the acceptance of noodle texture. Although not significantly impactful, the addition of latoh imparted a distinctive aroma and taste to the noodles. The aroma of the noodles became increasingly fishy with higher levels of latoh.

Latoh contains amino acids that, when freshness diminishes, can release ammonia and fatty acids, contributing to a fishy smell.[51]

The optimal noodle formulation, as determined by the overall sensory test parameters, elongation value, and tensile strength, closely resembled sample 10. Sample 10 emerged as the most preferred sample across various parameters. Noodle formulations with the right concentrations of latoh and wheat flour produced noodles characterized by a smooth, soft, elastic texture, vibrant color, and minimal fishy taste or aroma. As previously explained, wheat flour and latoh played pivotal roles in improving noodle texture, while latoh, being seaweed, contributed a unique color, aroma, and taste that enhanced consumer preference.

The optimization of the noodle formulation was based on overall sensory test, elongation values and tensile strength results. The hedonic tests were presented in Figure 4, there are color acceptance, chewiness, texture friability, taste, aftertaste, and overall parameters among the tested noodle samples. Panelists consistently assigned a value within 5-6 score, indicating that mocaf noodles supplemented with flour and latoh were generally acceptable to consumers. To achieve an optimal formula in overall sensory properties, the following regression equation was used:

y= 5.51055A + 8.32333B -7190.38C -3.5298AB + 11074.4AC + 11437.3BC -8179.79ABC + 2.82299AB(A-B) -3869.36AC(A-C) -4328.46 BC(B-C)

The optimization value for elongation (%) was calculated using the following regression equation:

y= 25.59A + 20.4175B -2436.97C + 40.2176AB + 2840.09AC + 2715.31BC -2479.81A2BC -3017.2AB2C + 11319.1ABC2

The optimization value for tensile strength (%) was calculated using the following regression equation:

y= 0.0874207A + 0.0120715B + 0.219151C

Based on completed optimization process, the optimal formula results were determined, comprising 63% Mocaf, 36% Wheat, and 1% Latoh Flour (*Caulerpa lentillifera)*. These findings align with those of sample 10, which received the highest preference score in the overall assessment (6.57). As indicated by the descriptive test results, this sample exhibited characteristics such as bright color, a relatively smooth appearance without cracks, a very soft mouthfeel, slight springiness and elasticity, minimal adhesion to the teeth, and an absence of fishy aroma. As previously explained, it is evident that the appropriate formula successfully enhanced the characteristics and consumer acceptance of mocaf noodles.

Table 3: Amino acids profile of mocaf noodle

Amino Acids	**OF (mg Kg-1)**
L-Alanin	1833.905 ± 0.50
L-Arginin	2555.13 ± 6.18
L-Asam Aspartat	1992.81 ± 0.15
Glisin	2495.40 ± 3.50
L-Asam Glutamat	15489.03 ± 20.94
L-Histidin	1292.01 ± 1.48
L-Isoleusin	1749.94 ± 4.17
L-Leusin	3395.51 ± 4.81
L-Lisin	1358.21 ± 2.64
L-Valin	2124.34 ± 6.98
L-Fenilalanin	2774.68 ± 1.87
L-Prolin	5322.79 ± 12.04
L-Serin	3008.45 ± 3.73
L-Treonin	1842.97 ± 3.83
L-Tirosin	894.28 ± 2.18

*OF means the optimal formula, contains Mocaf 63%, Wheat 36% and Latoh Flour 1%

Amino Acids Profile of Mocaf Noodle

The amino acids contained in noodles with the optimum formula were listed in table 3, comprising 15 amino acids, including essential and non-essential ones. Essential amino acids present in the noodle samples included L-histidine, L-isoleucine, L-leucine, L-lysine, L-valine, L-phenylalanine, and L-threonine. The remaining amino acids were classified as non-essential. Among these, L-Phenylanine and L-Tyrosine belonged to the aromatic amino acid category. In noodles with the optimum formula, the highest concentration of amino acids was found to be L-glutamic acid at 15489 mg/kg, followed by

L-proline at 5322 mg/kg and L-Leusin at 3395 mg/kg. On the other hand, L-Tyrosine had the lowest concentration among the amino acids, at 894 mg/kg.

In total, 15 types of amino acids were identified in these noodles, comprising seven essential amino acids and eight non-essential ones, including two aromatic amino acids, phenylalanine and tyrosine.[52] As explained earlier, the protein contained in the optimum formula noodles was influenced by the protein content of wheat flour and latoh, both of which had relatively high protein levels. It was revealed that *Caulerpa lentillifera* has high-quality protein, with essential amino acids levels nearly equivalent to those found in eggs and soybeans, particulary leucine, valine, aspartate, glutamate, and glycine.[53] The amino acid content in wheat was considered unbalanced due to its deficiency in essential amino acids like lysine, threonine, and methionine. This observation was consistent with Sharma *et al*.'s findings,[73] which emphasized that wheat flour is characterized by a predominant amino acid content of glutamate and proline.

Conclusion

Based on the research that was conducted, it is found that the addition of latoh and mocaf to wheat noodles improved the physical and chemical quality of noodle products and increased consumer acceptance of mocaf noodles. Noodles substituted with mocaf and augmented with latoh had low fat content but high carbohydrates, rendering them suitable as a source of quick energy. Furthermore, based on the gelatinization profile, these noodles exhibited stable and excellent gel characteristics, comparable to other types of noodles. The mocaf noodles with the addition of latoh had a fairly comprehensive content of essential amino acids, comprising 15 types of amino acids, including 7 essential amino acids and 8 non-essential amino acids. Despite the relatively lower elasticity of the resulting noodles due to the reduced wheat flour composition, they were still accepted and preferred by the panelists. The optimum noodle formula was found to be Mocaf 63%, Wheat 36% and Flour Latoh (*Caulerpa lentillifera)* 1%. Based on the explained results, it was concluded that mocaf and latoh can be used to reduce the reliance on wheat for noodle production. For further research, further analysis can be conducted to obtain more information about the physical characteristics and cooking quality of mocaf-latoh noodles.

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Conflict of interest

The authors do not have any conflict of interest.

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