Seagrape (*Caulerpa racemosa*) Flour Combination with Wheat and Sago Affects Physical Characteristics of Dry Noodles

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ABSTRACT

Dry noodles, commonly produced from wheat flour, have been associated with health issues, including obesity, when consumed in excess. Moreover, reliance on imported wheat flour requires local alternatives to enhance its acceptability within the community. This study aimed to evaluate the physical characteristics of dry noodles incorporating a blend of wheat flour, sago flour, and seagrape flour (Caulerpa racemosa). The study involved experimental treatment with varying amounts of added seagrape flour (0, 5, 10, 15, and 20 g). Additionally, the study evaluated the proximate composition of seagrape and sago flour was sourced from Sangihe Islands. The physical attributes analysed in the combined dry noodles included the moisture content, water absorption, cooking loss, and cooking time. Proximate analysis of seagrape flour revealed carbohydrate content of 47.83%, protein 19.78%, ash 17.83%, moisture 12.37%, and fat 2.19%. Sago flour had a proximate content of 87.45% carbohydrates, 11.7% moisture, 0.42% protein, 0.32% ash, and 0.11% fat. The moisture content of the combined dry noodles ranged from 6.83 to 7.83%, water absorption from 72.73 to 90.27%, cooking loss from 8.23 to 13.27%, and cooking time from 7.00 to 7.09 minutes. In conclusion, seagrape flour in the formulation influenced the water absorption and cooking loss of dry noodles prepared from wheat and sago flours. However, the combined dry noodles had no significant impact on the moisture content and cooking time.

Keywords: *noodles, sago, sangihe, seagrape, wheat.*

1. Introduction

Noodles are food products generally made from wheat flour with the addition of other food ingredients, such as chicken eggs, salt, and water (Biyumna et al., 2017). According to the Indonesian National Standard (SNI 8217:2015), noodles are defined as products made from the primary raw material of wheat flour with or without the addition of other food ingredients and permitted food additives through the process of mixing, stirring, sheeting, slitting, with or without steaming, cutting in the form of typical noodles, fried, or dried (BSN, 2015).

Based on the manufacturing process, noodles can be classified as wet, dry, or instant (Koswara 2009). Wet noodles have a slightly wet texture owing to their high moisture content (Billina et al., 2014). Because of their low moisture content, dry noodles with a hard and dry texture have been dried by frying or baking (Supraptiah et al., 2019). Like dried noodles, instant noodles also undergo a drying process but have a higher moisture content than dried noodles (Wicaksono et al., 2022). The moisture content in instant noodles ranges from 10-12% (Sari et al., 2018), whereas in dry noodles, it ranges from 8-10% (Aliya et al., 2016).

Noodles, especially dry and instant noodles, are popular food products in Indonesia. The data show that Indonesia's consumption of dry and instant noodles is the second largest in the world, after China (CNN, 2022). According to the World Instant Noodles Association, the consumption of instant noodles in Indonesia reached 14.26 billion servings in 2022, representing 11.27% of the total global instant noodle consumption of 118.18 billion servings (Annur, 2023).

In addition, noodle consumption increases wheat imports, which are the primary ingredients of wheat flour. Indonesia's wheat imports between 2018 and 2021 ranged from 10.08 to 11.17 million tons (Kahfi, 2022). Excessive imports can harm the Indonesian economy (Astuti & Ayuningtyas, 2018). Excessive noodle consumption can cause health problems such as obesity (Amelia and Nugroho, 2021). Obesity can increase the risk of developing type 2 diabetes as it can cause insulin resistance and disrupt glucose metabolism (Berthiana et al., 2019). This was due to the gluten content of the wheat. Melini and Melini, (2019) reported that excessive gluten consumption can result in weight gain, increased blood sugar, digestive disorders, gluten intolerance, and potential nutritional deficiencies such as B vitamins, fiber, zinc, and iron. Therefore, diversification is needed by combining the manufacture of noodle products with ingredients widely available in Indonesia, especially in North Sulawesi, such as sago and seagrape.

In addition to saving Indonesia's foreign exchange, substituting wheat flour with sago flour could produce healthier noodle products. Sago is reported to contain a high resistant starch content, which cannot be broken down and digested in the human digestive system (Palguna et al., 2014). Sago noodles are reported to have a low glycaemic index, making them suitable for people with diabetes mellitus, as it does not cause a rapid increase in blood glucose levels (Palguna et al., 2013). Diabetes mellitus is a significant health problem in Indonesia, including North Sulawesi. Data show that North Sulawesi ranked fourth in the prevalence of diabetes mellitus at 6.9% in 2013, and in 2018, it increased to 8.5% (Paseki et al., 2021).

The Sangihe Islands commonly consume seagrape and sago (Medellu et al., 2019; Lahaube, 2023). Seagrapes are a popular food in many Indonesian dishes and have several health benefits owing to their high nutritional content (Irene *et al*. 2022). The high fibre content in seagrapes has been reported to help prevent constipation and improve digestive health (Slavin and Jacobs Jr, 2010). Utilising food ingredients commonly consumed by local communities during food diversification will minimise the risk of rejection by local communities (Jamil, 2022). Therefore, this study aimed to determine the physical characteristics of dry noodle combinations of wheat flour substituted with sago flour and seagrape flour (*Caulerpa racemosa*), a local resource of the Sangihe community.

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2. Research Methods

2.1 Research Materials and Tools

The main ingredients used to prepare the combined dry noodles were seagrape (*Caulerpa racemosa*) obtained from the waters of the Sangihe Islands, sago flour made from a suspension of sago pulp, and commercial wheat flour (commercial). Other ingredients used included carboxy methyl cellulose (CMC), salt, eggs, baking soda, vanilla, and mineral water. The tools for making dry noodles are digital scales, blender, stove, steaming pot, oven, spoon, tray, noodle mill, knife, and cutting board. The tools for physical analysis are analytical scales, oven, desiccator, aluminum cup, porcelain cup, and timer.

2.2 Preparation of Seagrape Flour

Seagrapes (*C. racemosa*) were sampled from Enengpahembang Waters, Sangihe Island. Seagrapes were brought to the Fisheries Product Handling and Processing Workshop, Politeknik Negeri Nusa Utara, and washed and soaked in fresh water under running tap for 12 h (Figure 1). Subsequently, the seagrapes were immersed in a 5% CaO solution for 5 h and then rinsed until the rinse water became clear. Boiling was carried out for 5 min. The boiled seagrapes were drained. Subsequently, the seagrapes were oven-dried at 90-100°C for 8-10 hours. The dried seagrapes were pulverised and filtered through a 100-mesh sieve.

Figure 1. Seagrapes (*Caulerpa racemosa*) from the Sangihe Islands

2.3 Preparation of Sago Flour

Sago flour was prepared according to the instructions described by Palawe *et al*. (2021). The finely ground sago (100 g) was washed, and 200 mL water was added to make a slurry in a ratio of 1:2 b/v. The sago pulp was stirred until the starch was fully extracted. The sago pulp starch suspension was then filtered to obtain a starch suspension. The starch suspension was stored in a container for 12-24 hours until it settled like a paste. The paste obtained was then dried in an oven to obtain flour at 90-100 ^{o}C.

2.4 Proximate Analysis of Seagrape and Sago Flour

Seagrape and sago flour were subjected to proximate analysis, namely moisture content, according to Indonesian National Standard (SNI) 01-2354.2-2006 (BSN 2006a). Ash, fat, and protein contents were measured using SNI 01-2891-1992 (BSN 1992). The carbohydrate content followed SNI 01- 3775-2006 (BSN 2006b).

2.5 Preparation of Combination Dried Noodles

The formulations of dry noodles made from a combination of wheat flour, sago flour, and seagrape flour are shown in Table 1.

Table 1. Combination Dry Noodle Formulation

Composition	Treatment of Seagrape Flour Addition				
	A	B	C	D	E
Seagrape Flour (g)	0	5	10	15	20
Sago Flour (g)	75	75	75	75	75
Wheat Flour (g)	75	75	75	75	75
CMC (g)	1.5	1.5	1.5	1.5	1.5
Vanilla (g)	0.5	0.5	0.5	0.5	0.5
Salt (g)	1.5	1.5	1.5	1.5	1.5
Egg (g)	5	5	5	5	5
Baking Soda (g)	1.5	1.5	1.5	1.5	1.5
Mineral Water (mL)	75	75	75	75	75

Notes: Sea grape flour A = 0 g; B = 5 g; C = 10 g; D = 15 g; E = 20 g

A combination of dry noodle dough and sago flour is roasted with pandan leaves until the leaves become brittle. Sago flour is mixed with seagrape flour and mineral water and cooked using low heat until half is cooked. The dough was removed and placed in a plastic container. The dough was then added to wheat flour, vanilla, CMC, salt, baking soda, and eggs, and then mixed until all ingredients were combined to form a smooth noodle dough. Smooth noodle dough was moulded using a noodle mill. The noodles that have been moulded are dusted with a bit of flour to prevent them from sticking. After all noodle dough was moulded, it was steamed for 15-20 minutes. The noodles were dried in an oven at 100-120ºC for 2-4 hours.

2.6 Moisture Content Analysis

The combined dry noodles from each treatment were measured for moisture content using SNI 01-2354.2-2006 (BSN 2006a). The dried noodle samples were pulverised into flour. The oven was then turned on until the temperature stabilised at 105 °C. After the oven temperature was stabilised, the empty porcelain cup was heated for 2 h. The porcelain cup was then removed from the oven and cooled in a desiccator for 30 min until it reached room temperature, and the empty weight was weighed (A). Then, the porcelain cup containing the dried noodle sample was weighed and mashed as much as ± 2 g (B). Subsequently, the porcelain cup containing the sample was placed in an oven at 105ºC for 20-24 hours. The cup was then placed in a desiccator for ± 30 min and weighed (C). Moisture content was calculated using the following equation:

$$\text{Moisture content (\%)} = \frac{B - C}{B - A} \times 100\ \%$$

2.7 Water Absorption Analysis

Water absorption of the combined dry noodles was analysed according to the instructions of Rasper and Deman (1980). The combined dry noodles (5 g) were boiled in 250 mL of water. The noodles were removed and drained after reaching the optimal time (± 5 min). The noodles were then filled with boiled water and drained for 5 min. The noodles were weighed (A) and dried at 105 °C until they reached a constant weight, after which the samples were weighed again (B). Water absorption was calculated using the following equation:

$$\text{Water absorption (\% dry weight)} = \frac{[(A-B)-(\text{Moisture Content} \times \text{Sample Weight})]}{[\text{Sample Weight }(1-\text{Moisture Content})]} \times 100\ \%$$

2.8 Cooking Loss Analyisis

Analysis of cooking loss in combined dry noodles was performed by Oh *et al*. (1985). The combined dry noodles (5 g) were boiled in 150 mL of water. After reaching the optimum boiling time, noodles were removed and drained. The noodles were then filled with boiled water and drained for 5 min. The noodles were weighed and dried at 100°C until a constant weight was achieved. The samples were then weighed again (B). Cooking loss was calculated using the following equation:

$$\text{Cooking loss (\% dry weight)} = \frac{1-(B)}{\text{Sample Weight }(1-\text{Moisture Content})} \times 100\ \%$$

2.9 Cooking Time Analysis

Cooking time analysis of the combined dry noodles followed the instructions of Oh *et al*. (1985). The combined dry noodles were weighed as much as 10 g. It was then placed in boiling water (1000 mL). Cooking time was calculated using a timer. The cooking process was stopped when the centre of the noodle was no longer white.

2.10 Data Analysis

The research was conducted using a completely randomised design (CRD) analysis, with five treatments and three replications. The treatments consisted of the addition of seagrape flour A = 0 g, B = 5 g, C = 10 g, D = 15 g, and E = 20 g. This treatment was based on a study by Aditia *et al*. (2021). The data obtained were statistically analysed using Analysis of Variance (ANOVA). If $F_{count} > F_{table}$, then the analysis is continued with Tukey's test at the 5% level.

3. Results and Discussion

3.1 Proximate of Seagrape Flour

Proximate analysis focuses on determining the major components of a substance such as moisture, ash, protein, fat, and carbohydrates. It provides a general overview of the composition of a substance and is commonly used in the food industry to assess nutritional content. Proximate analysis of seagrape (*Caulerpa racemosa*) flour is presented in Table 2.

Table 2. Proximate of Seagrape Flour

Parameters	Locations				
	Sangihe Islands, North Sulawesi, Indonesia	*Takalar, South Sulawesi, Indonesia	*Sumenep, Madura, Indonesia	St. Martin's Islands, Bangladesh	*Tamil Nadu, India
Moisture (%)	12.37	–	11.40	14.68-16.12	17.04
Ash (%)	17.83	34.44	42.29	11.85-12.68	48.41
Fat (%)	2.19	1.22	2.32	6.54-8.92	1.80
Protein (%)	19.78	19.61	16.24	18.84-20.26	12.64
Carbohydrate (%)	47.83	38.18	39.16	47.74-50.18	–

*Seagrapes are simply dried without washing and soaking
Takalar et al.(Kasmiati et al. 2022); Sumenep (Sanjaya *et al*. 2016); St. Martin's (Bhuiyan *et al*. 2016); Tamil Nadu (Palaniyappan *et al*. 2023)

Table 2 shows that seagrapes from the Sangihe Islands have a high protein content when compared to the research of Jumsurizal et al. (2021); therefore, they have the potential to be added to diversified processed foods. The high protein content in the seagrapes was also due to the low moisture content of the dried seagrape samples. This is due to the ability of food ingredients to bind water, which is inseparable from the involvement of protein, where the more protein contained in a component, the more carboxyl groups so that the more water can be absorbed (Yuarni et al., 2018).

Table 2 also shows a lower ash content compared to seagrapes from Takalar, Sumenep, and Tami Nadu. This result is presumably because the seagrape samples underwent washing, soaking, and boiling to remove impurities and reduce the salt content. The results of this study follow those of Bhuiyan et al. (2016), where seagrape samples were also washed and rinsed repeatedly before analysis. Based on a literature study of seagrape samples from Takalar, Sumenep, and Tami Nadu, there was no more information about the sample treatment process before analysis. The high salt content of the sample can increase the ash content of the seagrapes. The ash content indicates the presence of inorganic or mineral components in food materials (Asriani et al., 2022).

The analysis also showed that the fat content of the seagrapes was low. Previous studies have also reported fat content in fresh seagrapes at approximately 0.16% or approximately 8.68 mg/g. However, seagrapes are usually consumed not for their fat content, but for their protein value and potential health benefits (Puspita et al., 2019). The carbohydrate component of seagrapes is reported to be a mixture of different types, such as glucose, fructose, sucrose, and a variety of dietary fibre components, such as cellulose, hemicellulose, and pectin (Stuthmann et al., 2023).

3.2 Proximate of Sago Flour

The proximate of sago flour measures the percentage of various components in a substance of sago flour, including moisture, ash, fat, protein, and carbohydrates. The proximate analysis of sago flour is presented in Table 3.

Table 3. Proximate of Sago Flour

Parameters	Locations			
	Sangihe Islands, Indonesia	Makassar, Indonesia	Nakhon, Thailand	Sarawak, Malaysia
Moisture (%)	11.7	–	13.1	10.6-14.7
Ash (%)	0.32	1.59	0.19	0.06-0.43
Fat (%)	0.11	0.30	0.01	0.10-0.13
Protein (%)	0.42	1.63	0.04	0.13-0.25
Carbohydrate (%)	87.45	95.99	–	–

Makassar (Gunawan *et al*., 2018); Nakhon (Konuma *et al*., 2012); Sarawak (Ahmad *et al*., 1999)

Table 3 shows that the sago flour made met the SNI 3729:2008 on sago flour (BSN 2008), especially the limits of moisture content (max. 13%), ash content (max. 0.5%), and starch content (min. 65%). A low ash content indicates that the flour has been processed with little contamination from foreign materials, such as soil, stones, or other impurities (Wiandingrum et al., 2005).

3.3 Physical Characteristics of Combination Dried Noodles

In this study, we examined the physical characteristics of dry noodles made from a combination of sago flour and wheat flour with the addition of seagrape (*C. racemosa*) flour. Physical characteristics included moisture content, water absorption, cooking loss, and cooking time. The physical appearance of the dried noodles with the combination of sago flour and wheat flour and the addition of seagrape flour is shown in Figure 2.

A B C D E

Figure 2. Dry noodle combination of sago flour and wheat flour with the addition of seagrape flour (A = 0 g, B = 5 g, C = 10 g, D = 15 g, and E = 20 g)

Moisture content was analysed to ensure that the dried noodles passed the drying process correctly. Figure 3 shows that the moisture content of the combined dried noodles from all treatments met the requirements set by SNI 8217:2015, which is a maximum of 13% (BSN, 2015). The results showed an increasing trend in moisture content with increasing amounts of seagrape flour. However, Tukey analysis showed that adding seagrape flour did not affect the moisture content of the combined dry noodles ($p>0.05$). The moisture content of dry noodles is related to gluten content. Gluten can inhibit the release of water during the noodle-drying process (Putra et al., 2019). Therefore, the addition of sago flour and seagrape flour caused the gluten content of the combined dry noodles to be low; therefore, the increase in moisture content was not significant.

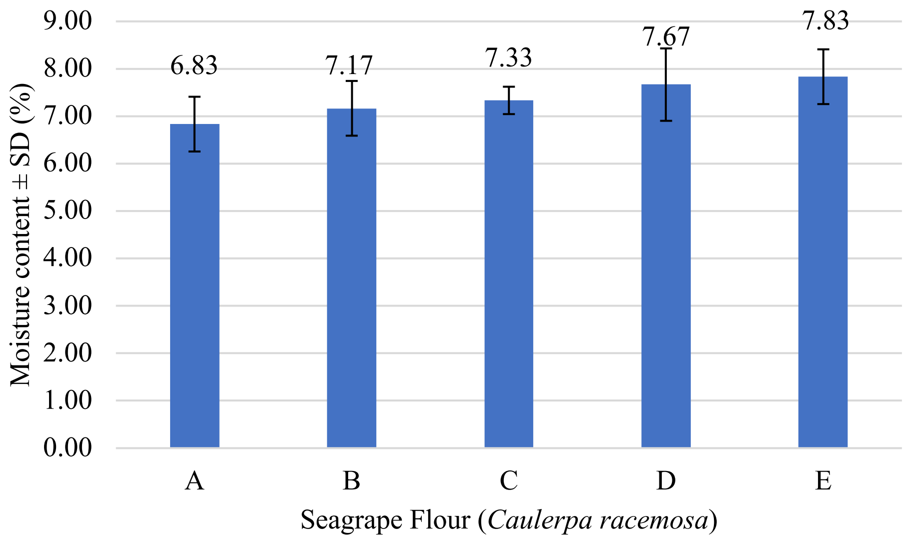

Figure 3. Moisture content of dry noodles combined with sago flour and wheat flour with the addition of seagrape flour (A = 0 g, B = 5 g, C = 10 g, D = 15 g, and E = 20 g)

The water-absorption capacity of dry noodles is the ability to absorb water during boiling until the noodles are fully cooked (Putra et al., 2019). Several factors, such as fibre, water, and protein content, influence the water absorption of noodles. If the water absorption capacity of noodles is higher, more water can be absorbed by the noodles during cooking, resulting in more fluffy noodles (Chang and Wu, 2008). The water absorption of noodles can also affect eating quality because if the water absorption is low, noodles can be produced with a rather hard and rough texture. Conversely, if the water absorption of noodles is too high, then noodles that are too soft and sticky can be produced (Narwal and Yadav, 2022). The results of the water absorption analysis of the combined dry noodles are shown in Figure 4.

Figure 4 shows that the addition of seagrape flour influences the water absorption of the combined dry noodles ($p<0.05$). Tukey's test results showed a difference in the water absorption of the combined dry noodles between the treatments of 0, 5, and 10 g, with the treatment of 15 and 20 g of seagrape flour. Omeire et al. (2014) reported that the water absorption of noodles made from wheat flour was 122.83%. Previous studies have reported

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that the water absorption of dried noodles with the addition of *Kappaphycus alvarezii* seaweed flour ranged from 80.48-95.29%, depending on the amount of seaweed flour used (Hasanah et al., 2021). Gluten is one of the factors that affect water absorption in noodles. Low water absorption in combined dry noodles is due to the low content of gluten in dry noodles made from seaweed flour, causing the mass of the noodles to be less dense, resulting in a low water absorption value (Jeon et al., 2019). Aditia et al., (2021) reported that the addition of seaweed flour to dry noodles can cause a decrease in water absorption. Previous research has also noted that the relationship between water content and water absorption is inversely proportional, meaning that the higher the water content, the lower the water absorption (Nurrohkayati and Khairul, 2020).

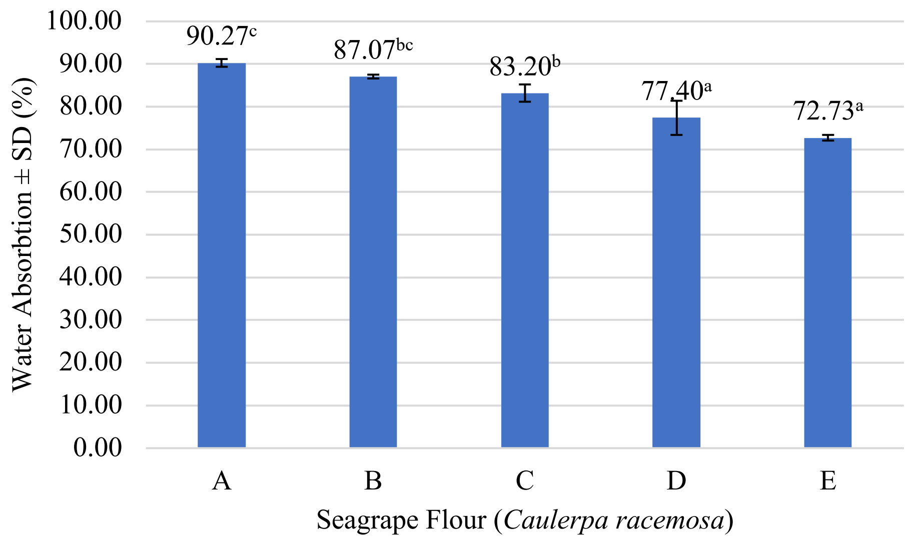

Figure 4. Water absorption capacity of dry noodles containing sago flour and wheat flour with the addition of seagrape flour (A = 0 g, B = 5 g, C = 10 g, D = 15 g, and E = 20 g). Different letters represent groups with statistically significant differences ($p < 0.05$).

The physical parameters used to assess the quality of the dried noodles were cooking loss and cooking time. Cooking loss refers to the amount of solid material lost during the cooking process, whereas cooking time refers to the time taken for the noodles to cook (Subarna et al., 2012). The results of the cooking loss of dried noodles with a combination of sago flour and wheat flour with the addition of seagrape flour are shown in Figure 5.

Figure 5 shows that the addition of seagrape flour influenced the cooking loss of the combined dry noodles ($p<0.05$). Tukey's test results showed a difference in the cooking loss value of the combined dry noodles between treatments of 5, 10, and 15 g, with treatments of 0 and 20 g seagrape flour addition. Cooking loss value is related to the texture and overall quality of the final product. Lower cooking loss values indicate better noodle quality, as noodles tend not to become mushy or lose shape during cooking.

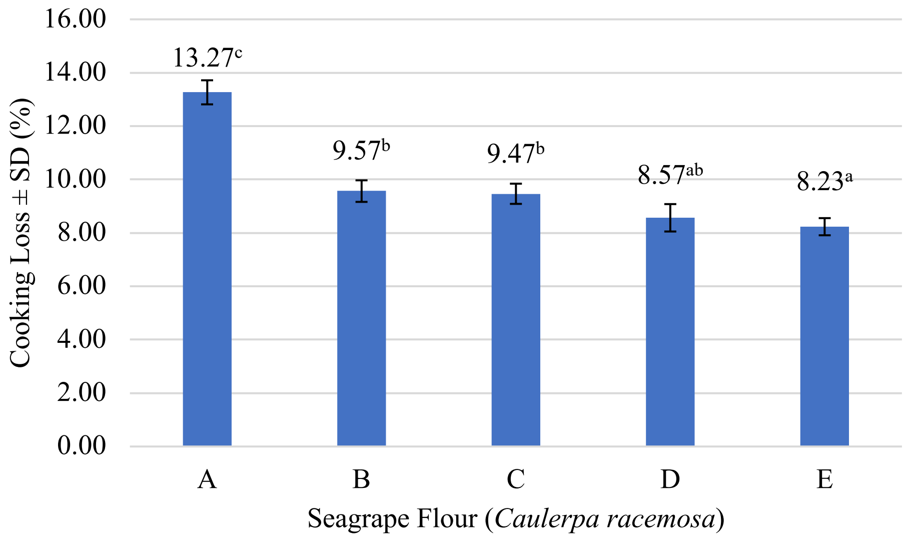

Figure 5. Cooking loss of dry noodles combined with sago flour and wheat flour with the addition of seagrape flour (A = 0 g, B = 5 g, C = 10 g, D = 15 g, and E = 20 g). Different letters represent groups with statistically significant differences ($p< 0.05$).

Cooking loss was influenced by the addition of seagrape. The addition of seaweed can help maintain noodle moisture and reduce water loss during cooking (Jaziri et al., 2018; Nabila, 2023). *Caulerpa racemosa* has water-soluble dietary fibre content that can form a gel by binding water, so it can help maintain the moisture content of the noodles during the cooking process (Nurjanah et al., 2018). The cooking loss value of dried noodles was relatively small; the results of previous research reported that the higher the amount of *K. alvarezii* and *Gracilaria* spp. seaweed flour added to the dried noodle dough, the higher the cooking loss value of the dried noodles (Aditia et al., 2021; Hasanah et al., 2021). In addition Sari and Siqhny, (2022) also reported that the cooking loss value of dried noodles can be influenced by various factors, such as the type of flour used, adding ingredients such as CMC, ascorbic acid, and the drying process

Table 4. Cooking time of dry noodles combined with sago flour and wheat flour with the addition of seagrape flour.

Seagrape Flour (g)	Cooking Time (Minutes)
A (0 g)	7,05±0,12
B (5 g)	7,00±0,11
C (10 g)	7,09±0,08
D (15 g)	7,01±0,09
E (20 g)	7,03±0,08

*with Standard Deviation

The results also showed that the addition of seagrape flour did not affect the cooking time of the combined dry noodles ($p>0.05$) (Table 4). A shorter cooking time is generally preferred because it produces noodles that are smooth and tend to be cooked. Various factors can influence cooking time, such as the type of flour used, addition of ingredients such as baking powder, CMC, and the drying process. The cooking time of dried noodles from wheat flour is approximately 7 min (Narwal and Yadav, 2022), while the cooking time of dried noodles from sago flour is approximately 6 min (Ye and Sui, 2016).

Combining dried noodles from wheat flour and sago flour with seagrape flour could be a healthy alternative for noodle lovers. At the same time, it can reduce dependence on imported ingredients such as wheat flour. The addition of seagrape flour to noodle products can increase the benefits of good nutrition from seagrapes for noodle-loving consumers.

4. Conclusion

The results of this study indicate that the addition of seagrape flour affects the water absorption and cooking loss of dry noodles containing wheat flour and sago flour. However, this did not significantly affect the moisture content or cooking time of the combined dry noodles. This study also showed the potential of fortifying seagrape flour in dry noodle products because it contains a relatively high protein content of 19.78%. In addition, the potential substitution of sago flour for dry noodle products can produce healthier food products. The high nutritional content of sea grapes makes them a potential alternative raw material for noodle-making. Noodles made from sea grapes have the potential to be healthier and more nutritious. In addition, using sea grapes for noodle-making can also be a new business opportunity for the local community, as it can be a unique and authentic local food product. The combination of wheat flour and sago flour with seagrape flour needs to be analysed proximate, especially the content of water-insoluble fibre, which is the main component of seagrape (*Caulerpa racemosa*).

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