Physicochemical and sensory characteristics of granulated rice from sorghum–corn flour with heat-moisture treated cassava starch as binder

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Abstract. Developing rice-like staple alternatives from local crops is crucial for supporting food diversification and functional food innovation in Indonesia. This study evaluated granulated rice produced from composite sorghum–corn flour and heat-moisture-treated (HMT) cassava starch as a binder using a 3×2 factorial design (corn: sorghum ratio of 30:20, 35:25, and 40:30 g; HMT starch of 10 and 12 g). Physical properties (hardness, color, and water absorption capacity/WAC), hedonic acceptance (semi-trained panelists), proximate composition, and selected functional compounds were determined. The best formulation was A3B2 (40:30 g corn: sorghum with 12 g HMT starch), which produced the softest texture (hardness 105.50±2.67 g), acceptable WAC (0.885±0.013 g/g), and the highest overall liking (liked category). The selected best sample contained phenolics (138.706 ppm), showed DPPH radical-scavenging activity of 65.78%, and had low tannin (0.001388%) and phytate (0.017%) levels. Overall, incorporating HMT cassava starch improved granulate integrity and texture, while sorghum–corn composite flour contributed to sensory acceptability and functional potential.

1 Introduction

Food diversification represents a strategic imperative for national food security in Indonesia, where rice consumption dominates dietary patterns with an average per capita consumption of 94.9 kg/year [1]. Excessive dependence on rice creates vulnerability in the food system, particularly given the impacts of climate change on paddy cultivation [2]. An effective diversification program requires the development of alternative food products that maintain cultural acceptability while offering nutritional advantages.

Rice granulated products—artificial rice made from non-rice materials—emerge as a strategic solution because they can be consumed similarly to conventional rice, thus minimizing disruption to established eating habits [3]. Indonesia possesses abundant local carbohydrate sources that remain underutilized. Corn (Zea mays L.) ranks as the second most important commodity after rice, with national production reaching 30 million tons annually [4]. Corn demonstrates superior adaptability to marginal lands and requires 40-50% less water than paddy rice, making it strategically suitable for water-constrained regions [5]. Sorghum (Sorghum bicolor (L.) Moench), though currently limited in production, exhibits remarkable drought tolerance and thrives in areas with rainfall as low as 400-600 mm/year, matching conditions in East Nusa Tenggara and other arid regions of eastern Indonesia [6].

The advantages of corn and sorghum extend beyond food security to health benefits derived from their bioactive compound content. Epidemiological transitions in Indonesia show significant increases in non-communicable diseases (NCDs), including type 2 diabetes mellitus, hypertension, and cardiovascular disease, closely associated with the consumption of simple carbohydrates with high glycemic index, such as white rice [7].

Sorghum is recognized as a functional cereal due to its diverse bioactive compounds. Phenolic compounds in sorghum, including condensed tannins (0.5-2.5%), exhibit strong antioxidant activity that can neutralize free radicals, causing oxidative stress [8]. Research demonstrates that sorghum tannins inhibit the α-amylase and α-glucosidase enzymes, slowing carbohydrate digestion and potentially lowering the postprandial glycemic response, which is beneficial for individuals with diabetes [9]. Flavonoids in sorghum, especially

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anthocyanins in pigmented varieties, possess anti-inflammatory and cardioprotective effects [10]. Phenolic acids such as ferulic acid and p-coumaric acid prevent lipid peroxidation and protect cells from DNA damage [11].

Sorghum has a dietary fiber content of 6-8% in whole grains, which is much higher than that of white rice (0.2-0.5%). This leads to benefits for digestive health, LDL cholesterol reduction, and satiety, all of which help with weight control [12]. Sorghum protein (10-12%) also has a better amino acid composition than rice. Notably, it contains more lysine, a limiting amino acid in cereals [13]. Sorghum is rich in minerals: iron (4.4 mg/100 g), zinc (1.67 mg/100 g), and magnesium (about 165 mg/100 g). These values are much higher than in white rice and play an important role in preventing anemia and micronutrient deficiencies, which are key health problems in Indonesia [14].

Yellow corn is rich in carotenoids, including β-carotene, lutein, and zeaxanthin. Lutein and zeaxanthin are carotenoids found in the macula of the eye's retina, which are involved in the protection against age-related macular degeneration, and are the two major causes of blindness among the elderly [15]. β-carotene is a provitamin A, a vitamin essential for the development of the eye and immune system, as well as growth [16]. Corn also contains bound ferulic acid that may become available during processing, providing an additional antioxidant action [17].

The combination of corn and sorghum in a single product creates nutritional and functional synergy. Carotenoids, which are natural pigments found in corn, and polyphenols, which are plant compounds present in sorghum, work together as antioxidants, protecting against various types of oxidative stress [18]. Complementary amino acid profiles, meaning each grain provides different types of protein building blocks, enhance overall protein quality [19]. Both soluble fiber, which dissolves in water, and insoluble fiber, which does not, from these grains provide optimal digestive benefits [20].

However, despite this promising synergy, corn-sorghum-based rice granulated development faces technological challenges, particularly regarding texture and binding capacity. Corn and sorghum flours lack gluten, necessitating the use of binders to form cohesive granular structures [21]. Native starches often provide insufficient binding for rice granulated applications due to limited water absorption and gel-forming capacity[22].

Heat-moisture treatment (HMT) represents a physical modification method that alters starch properties without chemical additives. HMT involves heating starch at temperatures below gelatinization (90-120°C) with controlled moisture content (10-30%) for specific durations [23]. This treatment induces structural changes in starch granules, increasing crystallinity, thermal stability, and water-binding capacity while maintaining granule integrity [24]. HMT-modified starch demonstrates enhanced binding properties, making it suitable for rice granulated production [25].

This study systematically examined the effects of corn-sorghum flour ratio variations and HMT-modified cassava starch concentration on physicochemical and sensory characteristics of rice analog products. The comprehensive approach included texture evaluation (as a key acceptability parameter), color analysis (affecting visual perception), hedonic testing (consumer acceptance), and characterization of the best treatment through proximate and bioactive compound analysis (nutritional and functional value).

The results of this study are expected not only to produce the optimal formulation for rice granulated products but also to contribute scientifically to the development of food diversification technology based on local carbohydrate sources, support national food security, and provide functional food alternatives that are beneficial to the health of the Indonesian people.

2 Materials and Methods

2.1 Research materials

The main materials used were corn flour, sorghum flour, cassava starch, and water (obtained from East Nusa Tenggara). Chemical reagents for analysis included H_2SO_4 (98%, Merck), NaOH (99%, Merck), HCl (37%, Merck), petroleum ether (Merck), boric acid (Merck), bromocresol green-methyl red indicator (Merck), Folin-Ciocalteu reagent (Sigma-Aldrich), and DPPH (2,2-diphenyl-1-picrylhydrazyl, Sigma-Aldrich).

2.2 Preparation of HMT-modified Cassava Starch

Cassava starch modification followed the method of Suhery et al. [26] with modifications. Cassava starch (100 g) was adjusted to 28% moisture content by adding a calculated amount of distilled water, mixed thoroughly, and equilibrated. The hydrated starch was wrapped in aluminum foil and stored in a refrigerator (4-5°C) for 24 hours to ensure uniform moisture distribution. Subsequently, HMT was performed in an oven at 90°C for 4 hours, followed by drying at 60°C for 6 hours. The modified starch was ground using a Grain Mill and sieved through an 80-mesh sieve (177 µm) to obtain a uniform particle size.

2.3 Rice granulated preparation

The research employed a completely randomized design (CRD) with a 3×2 factorial arrangement with two factors:

a) Factor A: Corn: sorghum flour ratio (A1=30:20 g; A2=35:25 g; A3=40:30 g)
b) Factor B: Modified starch concentration (B1=10 g; B2=12 g)

Rice Granulated production followed the modified method of Antari et al. [18]. Corn flour, sorghum flour, and HMT-modified cassava starch were mixed until homogeneous using a planetary mixer (Getra, Indonesia) at medium speed for 5 minutes. Distilled water (0.55% of total weight) was gradually added while mixing to form a cohesive dough. The dough was wrapped in muslin cloth and steamed for 20 minutes at 100°C. The cooked dough was then granulated using a cold extruder machine with 3 mm diameter holes to form rice-like granules. Granules were dried in a convection oven at 60°C for 7 hours until the moisture content reached approximately 10%. The granulated rice preparation can be seen in Fig. 1.

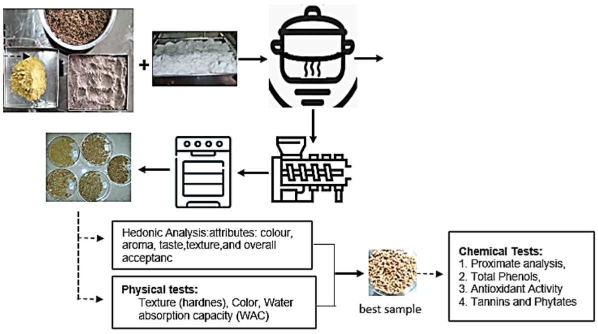

Fig 1. Schematic overview of granulated rice preparation

2.4 Color and Texture Analysis of Granulated Rice

Hardness texture was measured using a penetrometer (mm/g/second). Color was measured using a colorimeter (Konica Minolta CR-400, Japan) calibrated with a white standard plate. The CIELAB color space parameters were recorded: L* (lightness, 0=black to 100=white), a* (redness when positive, greenness when negative), and b* (yellowness when positive, blueness when negative). Chroma (C*) and hue angle (H°) [27]

Water absorption capacity (WAC) was determined using the immersion method [28]. One gram of rice granulated granules (W_0) was placed in a pre-weighed 50 mL centrifuge tube, and 30 mL of distilled water (25°C) was added. The sample was allowed to soak for 30 minutes with occasional gentle swirling. After soaking, excess water was drained through a fine mesh sieve, and the swollen granules were allowed to drain for 5 minutes. The swollen granules were weighed (W_1). WAC was calculated as:

$$\text{WAC (g/g)} = (W_1 - W_0) / W_0$$

where W_0 = initial dry weight of sample (g) and W_1 = weight of sample after water absorption (g). Measurements were performed in triplicate.

2.5 Hedonic analysis (Sensory Evaluation) of Granulated Rice

Sensory evaluation was carried out using a 5-point hedonic test (1 = strongly dislike; 5 = strongly like) with 30 semi-trained panelists. Panelists were selected from students/staff who regularly consume rice and had prior experience participating in sensory tests. Before evaluation, a short orientation session was provided to explain the hedonic scale, attribute definitions (color, aroma, taste, texture, and overall acceptance), and evaluation procedures. Samples were served warm in coded white plates under white fluorescent lighting; water was provided for palate cleansing between samples. Because semi-trained panelists may not fully represent the general consumer population, the results should be interpreted as indicative acceptance and should be confirmed in larger consumer tests.

2.6 Proximate And Functional Analysis

Proximate analysis of the best treatment
Conducted on samples with the best treatment, including moisture content analysis (oven method 105°C), protein (Kjeldahl method), fat (Soxhlet method), crude fiber (gravimetric method), ash content (furnace method 550°C), and carbohydrate (by difference) [28].
Functional analysis:
Total phenol (Folin-Ciocalteu method) [29], antioxidant activity (DPPH method) [30], tannin content was determined using the vanillin-HCl method [31]Phytate content was determined using the Wade reagent method [32], and analysis of crude fiber using the gravimetric method.

2.7 Data analysis

Data were analyzed using two-way ANOVA (α=0.05). If significant effects were found, Duncan's Multiple Range Test (DMRT) was performed to determine differences between treatments.

3 Results and Discussion

3.1 Hedonic test (sensory)

The results of hedonic testing on rice granules from various treatments are presented in Fig. 2.

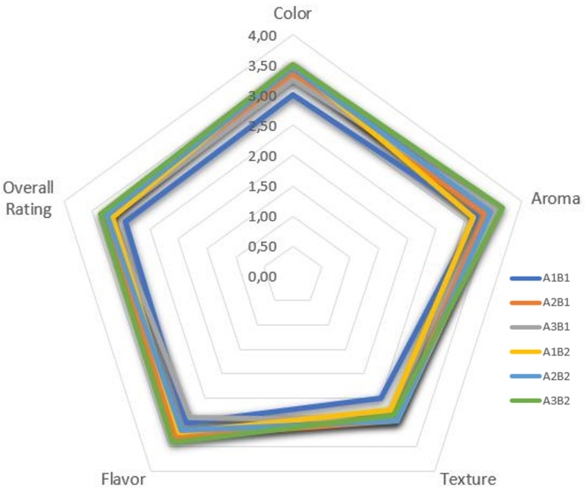

Fig 2. Hedonic profile of rice granulated across different corn-sorghum ratios and modified starch concentrations

Color liking scores indicated that panelists generally accepted the appearance of all formulations (overall in the "somewhat like" to "like" range). Formulations with higher sorghum proportion tended to appear darker (lower L*), which is consistent with the natural pigment content of sorghum flour and the Maillard browning developed during steaming and drying.

Aroma liking was highest for A3B2, suggesting that the balance of corn and sorghum, together with the processing steps (steaming and drying), produced a pleasant cereal-like aroma. Sorghum contributes characteristic volatile notes, while corn provides mild, sweet, and buttery notes that can enhance overall aroma perception.

In addition to contributing to granule binding, HMT cassava starch can influence aroma perception indirectly by modifying moisture retention and surface structure, which may affect the release of volatile compounds during serving.

Texture liking was closely related to physicochemical structure. Increasing HMT starch to 12 g generally reduced hardness and improved perceived softness. This agrees with the physical measurement, where A3B2 had the lowest hardness (105.50 ± 2.67 g). HMT treatment promotes starch re-arrangement and stronger interactions, which can improve granule integrity while providing a softer bite after rehydration/cooking [33].

Taste liking increased with higher corn proportion and adequate binder level. A3B2 received the highest taste score (liked category), likely due to the combined effects of corn sweetness and balanced sorghum cereal flavor. Importantly, textural improvement (lower hardness and adequate WAC) can enhance taste perception by improving mouthfeel and reducing a dry or gritty sensation, as demonstrated in brown rice studies conducted by Liu et al. (2024) [34].

Sorghum phenolics may contribute mild astringency that adds flavor complexity when present at moderate levels; however, excessive tannins could reduce palatability. The low tannin value measured in the best sample (Table 3) indicates that astringency was unlikely to dominate sensory perception.

Because cassava starch has a relatively neutral flavor, its main contribution is functional—forming a cohesive matrix that supports granule structure. This matrix can enhance water uptake during rehydration (WAC) and help achieve a cooked texture that is closer to that of conventional rice.

Overall acceptance reflected the combined effects of appearance, aroma, taste, and texture, and A3B2 showed the best integrated acceptance ("like"). Nevertheless, because the evaluation used semi-trained panelists, broader consumer testing is recommended to confirm market-level preferences.

3.2 Color and Texture Characteristics of Granulated Rice

The results of physical property analyses, including hardness, color parameters, and water absorption capacity, are presented in Table 1.

Table 1. Color and Texture of granulated rice produced from different corn: sorghum flour ratios (A1=30:20 g; A2=35:25 g; A3=40:30 g) and HMT cassava starch levels (B1=10 g; B2=12 g)

Parameter	A1B1	A2B1	A3B1	A1B2	A2B2	A3B2
Texture						
Hardness (g)	124.50±3.21^{c}	113.50±2.85^{e}	197.75±4.56^{a}	160.25±3.89^{b}	119.50±3.12^{d}	105.50±2.67^{f}
Color						
L*	54.50±1.23^{a}	56.20±1.45^{a}	49.58±1.12^{b}	41.82±0.98^{c}	49.47±1.08^{b}	48.61±1.15^{b}
a*	5.67±0.34^{b}	7.22±0.41^{a}	4.67±0.28^{d}	3.67±0.23^{e}	3.48±0.21^{f}	4.94±0.31^{c}
b*	22.89±0.67^{b}	26.84±0.78^{a}	16.97±0.52^{d}	18.67±0.58^{c}	18.97±0.61^{c}	19.55±0.64^{c}
Chroma (C*)	23.58±0.71^{b}	27.79±0.82^{a}	17.60±0.55^{d}	19.03±0.60^{c}	19.29±0.63^{c}	20.16±0.67^{c}
Hue angle (h°)	76.09±2.15^{a}	74.94±2.08^{a}	74.61±2.11^{a}	78.88±2.34^{a}	79.60±2.41^{a}	75.82±2.19^{a}
Water Absorption Capacity						
WAC (g/g)	0.924±0.015^{a}	0.911±0.013^{a}	0.903±0.014^{a}	0.738±0.011^{b}	0.848±0.012^{a}	0.885±0.013^{a}

Different superscript letters indicate significant differences between groups ($p < 0.05$), with values presented as mean ± SD ($n = 3$)

Treatment A3B2 exhibited the lowest hardness value (105.50±2.67 g), indicating the softest texture that most closely approximates the characteristics of conventional cooked rice. For comparison, cooked medium-grain white rice typically exhibits hardness values ranging from 90-130 g depending on variety, cooking conditions, and measurement methods [35]. The hardness value of 105.50 g for A3B2 falls within this range, demonstrating successful texture optimization.

Conversely, treatment A3B1 showed the highest hardness (197.75±4.56 g), nearly twice that of A3B2, indicating that insufficient binder concentration resulted in excessively firm texture. This elevated hardness likely resulted from inadequate starch gelatinization and insufficient formation of a cohesive binding matrix, causing the granules to maintain rigid, compact structures [36].

The trend of decreasing hardness with increasing HMT starch concentration (from B1 to B2) can be attributed to the enhanced water-binding capacity and improved gel-forming properties of HMT-treated starch. Heat-moisture treatment induces partial disruption of crystalline regions in starch granules, increasing the amorphous content and improving hydration properties [37]. According to Hoover, HMT modification increases starch's ability to form elastic gel structures with reduced syneresis compared to native starch, contributing to softer final product textures [38].

L* (brightness) values ranged from 41.82-56.20, with A2B1 being the brightest and A1B2 the darkest. Increasing the sorghum ratio tended to decrease brightness because sorghum has a naturally darker color compared to corn. Positive a* values indicate color tendency toward red, while positive b* values indicate yellow tendency, which is the characteristic color of corn and sorghum-based products. Treatment A3B2 had an L* value of 48.61, still within the range of red rice color (L* 40-55), indicating potential as functional rice with natural color acceptable to consumers. The decrease in lightness with increasing sorghum content results from higher concentrations of pigmented compounds, including tannins (reddish-brown condensed tannins), anthocyanins (in pigmented varieties), and phenolic acids [39]. These compounds absorb light across the visible spectrum, reducing overall reflectance and lightness.

Treatment A2B1 exhibited the highest a* value (7.22±0.41), indicating the strongest red tone, while A2B2 showed the lowest (3.48±0.21). The b* values decreased with increasing sorghum proportion, as the reddish-brown pigments of sorghum partially masked the yellow carotenoid colors. Treatment A2B1 showed the highest b* value (26.84±0.78), indicating the strongest yellow intensity, while A3B1 showed the lowest (16.97±0.52). The yellowness contributed by carotenoids provides not only visual appeal but also nutritional value, as these compounds function as provitamin A precursors (β-carotene) and antioxidants (lutein and zeaxanthin) [40].

Hue angle represents the qualitative color attribute, with 0° indicating pure red, 90° pure yellow, 180° pure green, and 270° pure blue. All treatments showed hue angles between 74.61±2.11° and 79.60±2.41°, indicating colors in the yellow-orange to orange range.

Statistical analysis revealed no significant differences in hue angle among treatments ($p>0.05$), suggesting that while color intensity varied, the fundamental color character remained consistent across formulations. The hue angles confirm that the products maintain attractive yellow-orange colors, which are commonly associated with corn and whole grain products. Water Absorption Capacity (WAC) ranged from 0.738±0.011 to 0.924±0.015 g/g. Statistical analysis revealed that both the corn–sorghum ratio and starch concentration had significant effects on WAC ($p < 0.01$), with a notable interaction effect ($p < 0.05$). The highest value was observed in treatment A1B1 (0.924 ± 0.015 g/g), while the lowest was in A1B2 (0.738 ± 0.011 g/g). Treatment A3B2 exhibited a moderate WAC (0.885±0.013 g/g), which is favorable for cooking applications.

The decrease in WAC with increasing starch concentration (B1 → B2) is attributed to Heat-Moisture Treatment (HMT), which enhances crystallinity and promotes more ordered molecular structures. These structural changes reduce porosity and the accessible surface area for water absorption [99]. The optimal WAC observed in treatment A3B2 (0.885 g/g) offers several advantages: (1) sufficient water uptake for proper softening during cooking, (2) maintenance of structural integrity without excessive swelling, and (3) cooking performance comparable to conventional rice, thereby improving consumer acceptance [41].

3.3 Proximate analysis of best treatment (A3B2)

Based on hedonic and physical property evaluation, treatment A3B2 was designated as the best treatment and continued for complete proximate analysis compared with SNI consumption rice. Analysis results are presented in Table 2.

Table 2. Proximate composition of the best granulated rice formulation (A3B2) compared with the Indonesian standard for milled white rice (SNI 6128:2020; moisture requirement) and typical milled white rice composition reported in the literature.

Parameter	A3B2 (Value, %)	SNI 6128:2020 (milled rice)	Typical milled white rice**
Moisture Content	10.21	≤ 14	12.0–14.0
Ash Content	10.75	–	0.4–0.7
Protein	9.89	–	6.0–9.0
Fat	0.75	–	0.2–0.8
Carbohydrate*	68.45	–	75.0–80.0
Crude Fiber	23.29	–	0.2–1.0

*Carbohydrate was calculated by difference.
*Typical milled white rice ranges are general literature values [42] and provided for contextual comparison; they are not regulatory limits.
**Comparison data from Budi et al.'s research [16]

Moisture content of rice granulated A3B2 at 10.21% meets SNI 6128:2020 requirements (≤14%) and is within the safe range for long-term storage. Low moisture content prevents microorganism growth and maintains product quality during storage [43].

Protein content (9.89%) is higher compared to white rice generally (6-7%), demonstrating the nutritional superiority of this rice. Protein comes from corn (±6.9%) and sorghum (±10.6%), which, when combined, provide a better amino acid profile. These results align with research by Budi et al. [44] reporting protein content of corn-sorghum rice granulated ranges from 8-11%.

The fat content (0.75±0,03%) remains low, consistent with the typical lipid composition of cereal grains, which store energy primarily as carbohydrates rather than lipids. This value falls within the range of whole grain cereals (0.5-1.5%) but is higher than polished white rice (0.3-0.5%) due to retention of the lipid-rich germ fraction [45].

Carbohydrate (68.45%) is the main component functioning as an energy source. Although this value is lower than that of milled white rice, most of the carbohydrates are complex carbohydrates derived from corn and sorghum, which are digested more slowly and may contribute to a lower glycemic index response. Meanwhile, the crude fiber content (23.29%) is substantially higher than that of white rice (±0.2%), providing additional health benefits such as improving digestive function, reducing cholesterol levels, and helping maintain blood glucose control. Sorghum is well-recognized as a good source of dietary fiber [57], supporting the functional advantages of this rice granulated.

Rice granulated A3B2 meets SNI moisture content requirements and has nutritional advantages compared to white rice, especially in higher protein and fiber content. The resulting texture (105.5 g) is within a range approaching consumption rice, demonstrating formulation success in producing products with physical characteristics acceptable to consumers.

3.4 Bioactive compound and functional activity analysis

Results of bioactive compound analysis of rice granulated are presented in Table 3.

Table 3. Bioactive compounds and functional activities of granulated rice formulation (A3B2)

Parameter	Value
Total Phenol	138.706 ppm
DPPH radical-scavenging activity	65.78%
Tannin	0.001388%
Phytate	0.017%

Total phenol of 138.706 ppm indicates that this rice granulate contains phenolic compounds derived from corn and sorghum. Phenolic compounds are natural antioxidants that can scavenge free radicals. Corn contributes additional phenolic acids, particularly ferulic acid, which is predominantly found in bound form within the cell wall matrix [46]. Thermal processing can partially release bound phenolics and increase their bioavailability, but effects depend on food matrix, processing conditions, and phenolic type [47].

The antioxidant activity value of 65.78% indicates moderate antioxidant activity. The lower the IC50 value, the stronger the antioxidant activity. Antioxidant activity originates from phenolic compounds, flavonoids, and phenolic acids present in corn and sorghum. Sorghum is especially rich in tannins and anthocyanins, with high antioxidant activity [48].

Tannin (0,001388%) and phytate (0,017%) content are very low. Tannin and phytate are antinutritional compounds that can inhibit mineral absorption, but in low amounts do not provide significant negative effects. These low levels are likely due to steaming and drying processes that can reduce antinutritional content in food materials [49].

3.5 General discussion

This research successfully developed a rice granulated from a corn-sorghum flour combination with HMT-modified cassava starch. The best treatment A3B2 (corn: sorghum ratio 40:30 with 12g modified starch) produced products with optimal physicochemical and sensory characteristics.

Formulation success is influenced by several factors:

1. **Component material synergy** The corn-sorghum combination provides nutritional balance and functional characteristics. Corn contributes carbohydrate and natural yellow color, while sorghum contributes protein, fiber, and bioactive compounds. The 40:30 ratio provides an optimal balance between taste, texture, and nutrition.
2. **Role of HMT-modified cassava starch.** HMT modification increases starch capacity as a binder through crystalline structure changes. The 12g concentration (B2) proved optimal in producing compact but not overly hard granules. According to Mendes et al. [50]HMT increases the thermal stability and water-binding capacity of starch without damaging granule structure.
3. **Steaming process** Steaming for 20 minutes or under optimal conditions typically causes partial to full starch gelatinization, leading to a denser structure, increased digestibility, and reduced antinutritional compounds. However, the extent of these effects depends on the food type, the presence of fibers or polyphenols, and specific processing parameters [51].
4. **Sensory acceptance.** Overall hedonic value of 3,35 (like) indicates the product can be accepted by consumers. Color, aroma, and taste resulting from the corn-sorghum combination provide organoleptic characteristics that are attractive and different from conventional white rice.
5. **Nutritional and functional value:** Protein 40% higher than white rice, fiber 10 times higher, and it contains bioactive compounds with antioxidant activity. This makes this rice granulated a functional food, potentially providing additional health benefits.

4 Conclusions

The corn-sorghum flour ratio significantly affected sensory acceptance and highly significantly affected rice granulated texture hardness, while modified cassava starch concentration had no significant effect. The best treatment was A3B2 with composition of 40 g corn flour, 30 g sorghum flour, and 12 g HMT-modified cassava starch, producing rice granulated with characteristics: overall hedonic value 3,35 (like), hardness 105,5 g (soft texture), brightness L* 48.61, moisture content 10.21%, protein 9,89%, fat 0,75%, crude fiber 23,29%, total phenol 138.706 ppm, and antioxidant activity IC50 65,78%. This rice granulated meets SNI rice standards regarding moisture content and has nutritional advantages as well as potential as a functional food alternative.

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