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# Sensory characteristics of muscovado enhanced with varying levels of turmeric

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**ABSTRACT**

The development of value-added muscovado products offers an opportunity to diversify sugarcane utilization while responding to growing interest in natural and plant-based food ingredients. This study evaluated the sensory characteristics and acceptability of muscovado formulated with varying levels of turmeric. An experimental design was used with four formulations: 0% (control), 1%, 3%, and 5% turmeric. Fifteen faculty members and students from Cagayan State University–Piat Campus evaluated the samples for aroma, flavor, color, and general acceptability using a 9-point hedonic scale. Mean scores were calculated, and differences among treatments were analyzed using analysis of variance at a 5% level of significance. Aroma scores ranged from 6.53 to 7.00, flavor from 6.60 to 6.93, and color from 6.60 to 6.80, with all formulations rated as "like moderately" for these attributes. For general acceptability, the 5% turmeric formulation obtained the highest mean score of 7.87, followed by the 3% formulation at 7.27, both corresponding to "like very much," while the control and 1% formulations scored 7.06 and 6.93, respectively. No significant differences were detected among treatments for color ($p$= 0.90), aroma ($p$ = 0.85), flavor ($p$ = 0.95), or general acceptability ($p$= 0.77). The findings indicate that turmeric can be incorporated into muscovado at concentrations of up to 5% without significantly reducing its sensory acceptability, supporting its potential for further development as a value-added muscovado product.

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## INTRODUCTION

Sugarcane is one of the Philippines' major agricultural commodities and contributes substantially to agricultural production, rural livelihoods, and the local economy, particularly in sugar-producing areas such as Negros Occidental, Batangas, Western Visayas, and Cagayan Valley. The Philippines is among the world's sugar-producing countries, with approximately 400,000 hectares devoted to sugarcane cultivation and annual production exceeding 20 million metric tons. Beyond primary production, the sugar industry provides employment and income to farming communities and supports related processing and marketing activities (Eleazar *et al.*, 2024; Manilay, 2009). Among the products derived from sugarcane, muscovado sugar has gained particular interest because it provides smallholder farmers with opportunities for value addition while responding to consumer demand for natural and less-refined sweeteners (Bokelmann, n.d.; Manilay, 2009).

Muscovado is a non-centrifugal sugar produced by concentrating sugarcane juice without the extensive refining associated with conventional white sugar. This minimal processing allows it to retain natural molasses and various constituents of sugarcane juice. Muscovado and other non-centrifugal sugars have been reported to contain minerals, phenolic compounds, and flavonoids and have attracted interest because of their nutritional and bioactive properties (Ebadi and Azlan, 2021; Nisha *et al.*, 2017). Growing consumer interest in natural and minimally processed foods has also created opportunities for expanding muscovado production and developing value-added products that may strengthen the farm-to-market value chain and provide additional livelihood opportunities for sugarcane producers in the Philippines (Lizada and Tan, 2015; Bokelmann, n.d.).

Turmeric (*Curcuma longa*), another agriculturally important plant, has long been used as a spice, natural colorant, and traditional medicinal ingredient. Its principal bioactive constituents, the curcuminoids, particularly curcumin, have been extensively investigated for their antioxidant, anti-inflammatory, anti-hyperglycemic, hepatoprotective, antimicrobial, and other biological activities (El-Saadony *et al.*, 2022; Dehghani *et al.*, 2020; Marton *et al.*, 2021; Tian *et al.*, 2025; Zhai *et al.*, 2020). These properties have contributed to the increasing use of turmeric and its derivatives in food, pharmaceutical, and other value-added applications. In food products, turmeric is also valued for its distinctive color, aroma, and flavor, making it a potentially useful ingredient in the development of functional and naturally formulated foods.

Combining muscovado with turmeric therefore presents an opportunity to develop a value-added sugarcane product that brings together the distinctive sensory characteristics of muscovado and the food applications of turmeric. However, the incorporation of turmeric may also alter important sensory properties of muscovado, particularly its aroma, flavor, and color. Since sensory acceptance is an important consideration in the development of a new or reformulated food product, determining whether consumers find turmeric-enriched muscovado acceptable is necessary before its potential for wider product development can be considered.

Despite the established uses and reported properties of muscovado and turmeric individually, information on the sensory acceptability of muscovado formulated with different concentrations of turmeric remains limited, particularly in the context of locally developed sugarcane products in the Philippines. It is therefore unclear whether increasing levels of turmeric can be incorporated into muscovado without adversely affecting the sensory characteristics and overall acceptance of the resulting product. Addressing this gap can provide preliminary information for the development of turmeric-enriched muscovado and help identify formulations suitable for further product evaluation.

Accordingly, this study aimed to evaluate the sensory characteristics of muscovado formulated with varying levels of turmeric. Specifically, it assessed the aroma, flavor, color, and general acceptability of muscovado containing 0%, 1%, 3%, and 5% turmeric and determined whether these sensory attributes differed significantly among the formulations. The findings were intended to provide a basis for assessing the sensory feasibility of incorporating turmeric into muscovado as a value-added product and for identifying areas requiring further nutritional, physicochemical, and consumer evaluation.

## MATERIALS AND METHODS

### Research design

An experimental research design was used to evaluate the sensory characteristics and acceptability of muscovado sugar prepared with different levels of turmeric powder. Four formulations were developed, consisting of a control without turmeric and three treatments containing 1%, 3%, and 5% turmeric. The sensory attributes evaluated were aroma, flavor, color, and overall acceptability. Differences among the treatment means were subsequently examined using analysis of variance (ANOVA).

### Treatment formulation

Four treatments were prepared by varying the proportion of muscovado and turmeric. The control treatment (T0) consisted of 100% muscovado without turmeric. The remaining formulations were T1 (99% muscovado + 1% turmeric), T2 (97% muscovado + 3% turmeric), and T3 (95% muscovado + 5% turmeric). These formulations were selected to determine whether increasing the proportion of turmeric influenced the sensory characteristics and overall acceptability of the resulting product.

### Raw materials and preparation

Mature sugarcane, more than eight months old, was used as the principal raw material for muscovado production. The other materials required for processing, including lime and turmeric, were obtained from the local market. The sugarcane was processed into muscovado, after which turmeric was incorporated according to the proportions specified for each treatment. The control was prepared without turmeric, while the other formulations contained 1%, 3%, or 5% turmeric.

### Locale of the study

Product preparation and evaluation were conducted at Cagayan State University–Piat Campus, Philippines. The Integrated Farm of the university was used for the experimental activities because of the availability of the facilities and materials required for the study.

### Sensory panel and sampling procedure

Fifteen faculty members and students from the College of Teacher Education at Cagayan State University–Piat Campus participated in the sensory evaluation. The evaluators were selected purposively based on their availability and willingness to participate in the assessment of the developed products.

### Sensory evaluation

The acceptability of the four muscovado formulations was evaluated using a 9-point hedonic scale. Hedonic testing is widely used in food sensory studies to measure consumers' degree of liking or preference for a product (Lim, 2011). Each evaluator assessed the samples for aroma, flavor, color, and overall acceptability.

To reduce the possibility of identification bias during evaluation, the samples were assigned three-digit codes before being presented to the panelists. Each participant evaluated all four formulations and recorded the degree of liking for each sensory attribute on the evaluation scorecard.

The 9-point scale ranged from 1 = "dislike extremely" to 9 = "like extremely." The scores were interpreted as follows: 8.12–9.00, like extremely; 7.23–8.11, like very much; 6.34–7.22, like moderately; 5.45–6.33, like slightly; 4.56–5.44, neither like nor dislike; 3.67–4.55, dislike slightly; 2.78–3.66, dislike moderately; 1.89–2.77, dislike very much; and 1.00–1.88, dislike extremely.

**Data collection**

Following preparation of the four formulations, sensory evaluation scorecards were distributed to the participating faculty members and students. The panelists independently recorded their ratings for aroma, flavor, color, and overall acceptability. The completed scorecards were collected and the ratings were compiled for statistical analysis.

**Statistical analysis**

Mean sensory scores were calculated for each treatment and sensory attribute. One-way analysis of variance (ANOVA) was used to determine whether the mean ratings differed significantly among the four formulations. Statistical significance was evaluated at the 5% level ($p < 0.05$). A $p$-value greater than 0.05 was interpreted as indicating that there was insufficient evidence of a statistically significant difference among the treatment means.

## RESULTS

**Sensory characteristics of muscovado with varying levels of turmeric**

The mean sensory scores for aroma, flavor, color, and general acceptability of the four muscovado formulations are presented in Table 1.

For aroma, Treatment 4 (5% turmeric) obtained the highest mean score of 7.00, followed by Treatment 3 (3% turmeric) with 6.93 and Treatment 1 (0% turmeric) with 6.87. Treatment 2 (1% turmeric) recorded the lowest mean score of 6.53. Based on the descriptive scale, all four treatments were rated as "like moderately" for aroma.

**Table 1.** Means and adjectival value of the sensory attributes of the different treatments

| Sensory attribute | Treatment 1 (0%) | Treatment 2 (1%) | Treatment 3 (3%) | Treatment 4 (5%) |
|---|---|---|---|---|
| Aroma | 6.87 | 6.53 | 6.93 | 7 |
| Flavor | 6.93 | 6.8 | 6.6 | 6.73 |
| Color | 6.6 | 6.8 | 6.6 | 6.8 |
| General Acceptability | 7.06 | 6.93 | 7.27 | 7.87 |

**Table 2.** Analysis of variance of the different treatments on the parameters tested

| Sensory attributes | F-value | $p$-value | Critical value | Decision |
|---|---|---|---|---|
| Color | 0.20 | 0.90 | 2.77 | Accept Ho |
| Aroma | 0.27 | 0,85 | 2.77 | Accept Ho |
| Flavor | 0.12 | 0.95 | 2.77 | Accept Ho |
| General Acceptability | 0.37 | 0.77 | 2.77 | Accept Ho |

For flavor, the highest mean score was recorded for Treatment 1 (0% turmeric) at 6.93, followed by Treatment 2 (1% turmeric) at 6.80 and Treatment 4 (5% turmeric) at 6.73. Treatment 3 (3% turmeric) had the lowest mean score of 6.60. All treatments were rated as "like moderately" for flavor.

Color scores ranged from 6.60 to 6.80. Treatments 2 (1% turmeric) and 4 (5% turmeric) each obtained a mean score of 6.80, while Treatments 1 (0% turmeric) and 3 (3% turmeric) each recorded a mean score of 6.60. All four treatments were rated as "like moderately" for color.

For general acceptability, Treatment 4 (5% turmeric) received the highest mean score of 7.87, followed by Treatment 3 (3% turmeric) at 7.27. Both treatments were rated as "like very much." Treatment 1 (0% turmeric) and Treatment 2 (1% turmeric) obtained mean scores of 7.06 and 6.93, respectively, corresponding to "like moderately."

**Differences in sensory attributes among treatments**

The results of the analysis of variance for the four sensory attributes are presented in Table 2. For color, the calculated F-value was 0.20, with a $p$-value of 0.90. Aroma had an F-value of 0.27 and a $p$-value of 0.85, while flavor recorded an F-value of 0.12 and a $p$-value of 0.95. General acceptability had an F-value of 0.37 and a $p$-value of 0.77.

For all four sensory attributes, the $p$-values were greater than 0.05. Thus, no statistically significant differences were detected among the four treatments for color, aroma, flavor, or general acceptability.

**DISCUSSION**

The sensory evaluation showed that incorporating turmeric into muscovado at concentrations of up to 5% did not substantially reduce the acceptability of the product. All formulations, including the control, were rated as "like moderately" for aroma, flavor, and color. Although the mean scores varied slightly among treatments, the differences were not statistically significant. This suggests that the sensory profile of muscovado remained generally acceptable as the proportion of turmeric increased. The result is relevant because both muscovado and turmeric have distinctive sensory properties that could influence consumer response when combined in a single product.

For aroma, mean scores ranged from 6.53 to 7.00, with the 5% turmeric formulation receiving the highest numerical rating. The absence of a significant difference among treatments indicates that turmeric addition at the tested levels did not adversely affect aroma acceptability. Turmeric contains volatile compounds responsible for its characteristic aroma and flavor and has long been used as both a spice and functional food ingredient (El-Saadony *et al.*, 2022). At the same time, non-centrifugal cane sugar has its own complex aroma profile. García *et al.* (2017) identified several odor-active compounds in non-centrifugal cane sugar and reported 2-methylpyrazine as an important aroma compound. Similarly, Asikin *et al.* (2016) characterized non-centrifugal cane brown sugar as having predominantly sweet-caramel notes together with nutty-roasted, acidic, and grassy aroma characteristics. These inherent aromatic properties of muscovado may have interacted with the aroma contributed by turmeric, which could partly account for the relatively narrow differences in aroma scores among the formulations.

Flavor scores were likewise similar, ranging from 6.60 to 6.93. Although the control recorded the highest numerical score, all turmeric-containing formulations remained within the "like moderately" category, and no significant difference was detected among treatments. The characteristic flavor of non-centrifugal cane sugar arises partly from its composition and processing. Unlike refined sugar, non-centrifugal cane sugar retains molasses-associated constituents and develops a distinctive flavor and aroma during processing (Jaffé, 2015; Velásquez *et al.*, 2019). Studies of brown and muscovado sugars have also demonstrated the presence of numerous volatile compounds contributing caramel-like, sweet, roasted, and other characteristic notes (Asikin *et al.*, 2016; Liu *et al.*, 2021). Liu *et al.* (2021), for example, identified several key aroma-active compounds in brown sugar and showed that some of these compounds can influence the perception of sweetness. Such characteristics may help explain why the incorporation of turmeric at concentrations of 1–5% did not produce marked differences in flavor acceptance in the present study.

Color scores ranged only from 6.60 to 6.80, and all formulations were classified as "like moderately." Treatments containing 1% and 5% turmeric obtained slightly higher numerical scores than the control and 3% formulation, but these differences were not statistically significant. Turmeric is well recognized as a natural coloring ingredient because curcuminoids, particularly curcumin, impart its characteristic yellow to orange-yellow appearance (El-Saadony *et al.*, 2022). Muscovado itself has a naturally brown appearance, and the color of non-centrifugal cane sugar is strongly influenced by processing conditions. García *et al.* (2017) demonstrated that the color characteristics of non-centrifugal cane sugar are associated with heating during processing, while Alarcón *et al.* (2021) reported that thermal treatment can produce darker non-centrifugal cane sugar and alter its colorimetric properties. Thus, the naturally intense color of the muscovado base may have moderated the visual effect of increasing turmeric concentration. Nevertheless, because instrumental color measurements were not undertaken in the present study, this explanation should be considered only as a plausible sensory basis for the observed ratings.

The most notable numerical difference was observed for general acceptability. The 5% turmeric formulation obtained the highest mean score of 7.87, followed by the 3% formulation at 7.27, and both were classified as "like very much." By comparison, the control and 1% turmeric treatments were rated as "like moderately." This pattern indicates that increasing turmeric to 3% and 5% did not diminish overall product liking and, numerically, the higher concentrations received more favorable ratings. However, the difference in general acceptability was not statistically significant ($p = 0.77$). The higher score obtained by the 5% formulation should therefore be interpreted as a favorable numerical tendency within this panel rather than evidence that the formulation was statistically superior to the other treatments.

The overall acceptability of the turmeric-containing formulations is particularly relevant from a food-product development perspective. Turmeric has attracted considerable attention as a food ingredient because, in addition to its color and flavor, it contains curcuminoids and other bioactive constituents (Gupta *et al.*, 2013; El-Saadony *et al.*, 2022). Non-centrifugal cane sugar also differs compositionally from refined sugar. Jaffé (2015) reviewed the analytical literature on non-centrifugal cane sugar and documented minerals, phenolic compounds, and other constituents retained in these traditionally processed sugars. More recent studies have similarly demonstrated that non-centrifugal cane sugars contain phenolic compounds and that their chemical and physical properties are influenced by processing conditions (Alarcón *et al.*, 2021; Vargas Valencia *et al.*, 2022). These characteristics provide a reasonable basis for exploring muscovado as a carrier for plant-derived ingredients such as turmeric in the development of value-added food products.

The findings also demonstrate the importance of evaluating sensory acceptance alongside the potential functional characteristics of a newly formulated food. The presence of bioactive compounds alone does not establish the practical suitability of a food product if its sensory qualities are unacceptable to consumers. In the present study, turmeric addition did not significantly reduce ratings for aroma, flavor, color, or general acceptability. This is encouraging because sensory attributes are central to consumers' responses to new or reformulated food products. At the same time, the present findings relate specifically to sensory acceptance; no chemical analysis was conducted to determine whether increasing the turmeric concentration actually increased curcumin, antioxidant capacity, or other functional constituents in the finished muscovado product. Claims regarding improved nutritional or functional properties therefore require direct laboratory confirmation.

The results should also be considered in relation to the size and composition of the sensory panel. The evaluation involved only 15 faculty members and students from a single university campus. With a relatively small panel, modest differences among formulations may not be detected statistically, even when numerical differences in mean ratings are apparent. In addition, food familiarity and previous experience can influence hedonic responses to food products. Jaeger *et al.* (2019) demonstrated that familiarity with foods can affect sensory acceptability, highlighting the importance of consumer background when interpreting hedonic evaluations. The present findings should therefore be regarded as preliminary evidence of acceptability rather than a definitive measure of broader consumer preference.

The results demonstrate that incorporating 1–5% turmeric into muscovado maintained acceptable sensory characteristics. None of the turmeric concentrations significantly altered aroma, flavor, color, or general acceptability compared with the control. Among the formulations, the 5% turmeric treatment achieved the highest numerical score for general acceptability while maintaining comparable ratings for the remaining sensory attributes. Taken together, these findings support further evaluation of turmeric-enriched muscovado as a value-added product. Larger consumer studies, together with physicochemical, nutritional, antioxidant, storage-stability, and market-acceptance assessments, would be useful for determining whether the favorable sensory response observed here can be reproduced in a broader population and translated into a commercially viable product.

## CONCLUSION

The study demonstrated that muscovado formulated with varying levels of turmeric was generally acceptable in terms of aroma, flavor, color, and general acceptability. All formulations were rated as "like moderately" for aroma, flavor, and color, indicating that the addition of 1–5% turmeric maintained the sensory acceptability of the product. Although numerical differences were observed among the treatments, no significant differences were found for any of the sensory attributes evaluated ($p > 0.05$).

Among the formulations, muscovado containing 5% turmeric obtained the highest numerical score for general acceptability (7.87), corresponding to "like very much," followed by the 3% turmeric formulation (7.27). However, because the differences among treatments were not statistically significant, these higher scores should not be interpreted as evidence that the 5% formulation was superior to the other formulations. Rather, the findings indicate that turmeric can be incorporated into muscovado at concentrations of up to 5% without significantly reducing its sensory acceptability.

These findings provide preliminary support for the development of turmeric-enriched muscovado as a value-added product. Further studies involving larger and more diverse consumer panels are needed to confirm consumer acceptance. Additional analyses of nutritional composition, curcumin content, antioxidant activity, physicochemical and microbiological properties, storage stability, and economic and market feasibility would also be valuable in establishing the functional quality and commercial potential of the product.

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