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Evaluating Sensory Quality of Instant Noodles Colored with Carbonized Black Glutinous Rice Straw

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A B S T R A C T

This study investigated the sensory impact of incorporating a liquid black colourant derived from black glutinous rice straw carbon into instant noodles. The colourant was formulated by dispersing fine carbon in fructose syrup and processed through sonication to enhance stability, then added to noodle dough at concentrations ranging from 0% to 6%. A sensory evaluation was conducted with 25 untrained panellists, who assessed colour, aroma, taste, texture, and overall acceptability using a nine-point hedonic scale. Results showed that the 4% concentration achieved the highest sensory scores, offering an appealing colour, a pleasant aroma, a good taste, and a consistent texture. Higher concentrations reduced acceptability due to off-flavor and aroma. These findings support the use of carbonised rice straw as a sustainable, natural colourant in instant noodle production.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-being
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action

1. INTRODUCTION

1.1. Research Background

In recent years, there has been a growing awareness among consumers about the health implications of food additives, particularly synthetic colourants. The growing concern about the potential risks associated with artificial dyes has sparked demand for natural alternatives that are perceived as safer, more sustainable, and compatible with clean-label food trends. Among these natural additives, vegetable carbon, a pigment produced through the carbonisation of plant materials, has garnered interest as a black food colouring agent. Approved for food use in various regions, including the European Union under the E153 code, vegetable carbon is commonly used in a range of food applications such as bakery items, beverages, confectionery, and processed products [1]. Its use caters not only to aesthetic preferences but also to cultural and market demands for novelty and naturality in food presentation.

Indonesia, as one of the world's leading rice producers, generates substantial quantities of rice straw—a biomass often considered agricultural waste. However, rice straw, especially from black glutinous rice, can be converted into high-quality carbon-rich in carbon, offering a local and sustainable source of vegetable carbon. This by-product, known as abu merang, has been traditionally used in Indonesian cuisine to impart a dark colouration to foods such as dawet ireng and kue jongkong, while also contributing to the texture and flavour profile of these products. Its integration into modern food systems, however, remains underutilized. In particular, the application of carbonised rice straw in contemporary processed foods, such as instant noodles, represents a novel and potentially valuable innovation,

aligning with sustainable food development goals and cultural continuity.

Instant noodles are one of the most widely consumed convenience foods globally, particularly in Asia. Their popularity across various demographic segments makes them an ideal vehicle for functional and aesthetic ingredient innovation. The inclusion of natural pigments in instant noodles could not only enhance their visual appeal but also serve as a marketing differentiator in a saturated market. However, to ensure successful integration, it is essential to evaluate how such colorants affect key sensory attributes, which are critical determinants of consumer acceptance.

1.2. Literature Review

Previous studies have demonstrated the functional potential of natural colorants in traditional and modern foods. For example, Alviana [2] and Firsta [3] explored the use of abu merang in local Indonesian confections, showing that carbon incorporation improved both color intensity and texture, likely due to the presence of calcium and other minerals in the carbon. Laila [4] found that black glutinous rice straw produced a darker carbon than other varieties, resulting in superior sensory appeal in kue jongkong. These findings suggest that carbonised rice straw, particularly from black glutinous rice, has strong potential as a natural colourant, making positive contributions to sensory quality. A previous study on the application of rice straw ash as a food colorant was conducted by Rahayu et al. [5] and Murtini et al. [6] demonstrating its potential as a natural pigment in traditional food products.

Despite these insights, challenges remain in adapting abu merang for broader applications. One notable limitation of vegetable carbon is its water-insolubility, which often leads to rapid sedimentation when used in liquid form. This instability presents challenges for food processors, who require uniform colour distribution and long-term stabilityn liquid matrices [7]. To address this, techniques such as sonication have been employed to reduce particle size and improve dispersion. Studies by Bartoli et al. [6] and Fujita et al. [7] have shown that sonicated vegetable carbon particles remain suspended longer and contribute to a more homogeneous appearance in food products. Additionally, suspending carbon in viscous carriers, such as fructose syrup, has proven effective in stabilising dispersion, thereby enhancing its applicability in liquid food formulations.

The integration of black carbon-based colourants into foods, such as noodles, necessitates attention to sensory attributes beyond appearance. While colour is a key visual cue that influences consumer perception, attributes such as aroma, taste, and texture also significantly contribute to overall product acceptability. There is, however, limited research exploring how vegetable carbon affects these attributes in the context of processed food. Existing literature tends to focus more on physical and chemical analyses than on comprehensive sensory evaluations. For instance, Guo et al. [8] investigated the effect of natural additives on the textural properties of noodl, but did not evaluate the impacts on aroma or flavour. Similarly, studies on gluten interactions and noodle rheology often overlook the consumer-oriented dimension of product experience.

This gap highlights the need for a systematic sensory analysis to determine whether natural black colourants, such as carbonised black glutinous rice straw, enhance or compromise the consumer appeal of instant noodles. Since sensory perception is holistic and can be influenced by ingredient interactions, matrix composition, and concentration, it is essential to evaluate each parameter—colour, aroma, taste, texture, and overall acceptability — independently and in relation to one another. The nine-point hedonic scale remains a widely accepted method for capturing these dimensions, particularly in the preliminary stages of product development.

Although the traditional uses of carbonised black glutinous rice straw have been documented, its transformation into a standardised, liquid pigment suitable for industrial use remains largely unexplored. This transformation is not trivial; it involves both physical stabilization and sensory compatibility. The current study addresses these challenges by employing sonication to produce a stable, uniform liquid colorant and testing its application in a highly familiar food product instant noodles. In doing so, it builds upon existing cultural knowledge while advancing technological adaptation for modern food systems.

1.3. Research Objective

Therefore, the objective of this study is to evaluate the influence of liquid black colorant derived from black glutinous rice straw carbon on the sensory characteristics of instant noodles. It aims to determine the concentration at which the pigment produces the most favorable combination of visual appeal, aroma, taste, texture, and overall acceptance. This research is novel in its focus on sensory analysis as the primary evaluative criterion and in its application of sonicated, syrup-based colorant suspensions in a processed food context. The findings are expected to contribute to the broader discourse on sustainable food colourant development, the valorisation of agricultural residues, and consumer-centred product innovation in the food industry.

2. MATERIALS AND METHODS

2.1. Materials and Colorant Preparation

The primary ingredient used in this study was carbonized black glutinous rice straw, which served as the base for the liquid black colorant. The rice straw was first separated from the husk, then subjected to incomplete combustion in an open area at a temperature of 500–600 °C to produce ash. The resulting ash was ground using a ball mill at a speed of 116–118 rpm for 120 minutes. After grinding, the ash was sieved sequentially using 80-, 150-, 250-, and 350-mesh screens. Only the ash that passed through the 350mesh sieve was used as the raw material for this study.

To convert the carbon into a liquid form, the sieved carbon was dissolved in fructose syrup at a ratio of 1:3 (w/v). Fructose syrup was selected as the solvent medium due to its viscosity and stabilizing properties, which help maintain suspension of insoluble carbon particles. This mixture was subsequently processed using an ultrasonic homogenizer with 60% amplitude for 120 minutes. Sonication aimed to reduce particle size and improve the uniformity of dispersion, thereby minimising sedimentation and enhancing the aesthetic appearance of the colourant in food applications. The liquid colourant was then stored in sterilised glass containers at ambient temperature for further use.

2.2. Instant Noodle Preparation

The instant noodles were formulated using a standard base recipe commonly used in small-scale noodle production. The dough was prepared using wheat flour, water, salt, and a small amount of cooking oil. The liquid black colorant was incorporated into the dough formulation at six different concentrations: 0% (control), 1%, 2%, 3%, 4%, 5%, and 6% (v/w of dough). These concentrations were selected based on preliminary tests and literature findings to cover a range from minimal to intense coloration.

Each dough batch was kneaded until homogeneous and then sheeted using a noodle press. The noodles were cut into uniform strands and steamed for 10 minutes, then deep-fried for 1 minute. The resulting dried noodles were stored in airtight containers at room temperature before sensory evaluation.

2.3. Sensory Evaluation Design

The sensory evaluation focused exclusively on the impact of the black colorant on the sensorial properties of the instant noodles. The study employed a hedonic test design using 108 untrained panelists to simulate typical consumer responses.

Each panelist evaluated the seven noodle formulations (including the control) in randomized order to reduce bias. The samples were coded using random three-digit numbers and served warm (approximately 60°C) in identical disposable containers. Between each sample, panellists were instructed to rinse their palates with mineral water to minimise flavour carryover.

2.4. Data Processing and Statistical Analysis

The sensory data were analyzed using the non-parametric Friedman test.

3. RESULT AND DISCUSSION

3.1. Color

Colour is a primary sensory cue in food products, playing a significant role in shaping initial consumer expectations. In this study, colour scores increased in proportion to the concentration of black carbon colourant. The control sample (0%) received the lowest score, averaging 3.54 (Figure 1.), indicating neutrality or slight dislike. In contrast, the 4% treatment achieved the highest average colour score of 3.58, indicating general liking. Beyond this concentration, particularly at 5% and 6%, colour scores declined slightly (3.50 and 3.40, respectively), suggesting a threshold beyond which the intensity of blackness may appear unnatural or unappetizing to consumers.

This trend aligns with findings from Laila [4], who reported that black glutinous rice straw carbon yies a darker colouration in traditional desserts, such as kue jongkong, thereby enhancing their visual appeal. However, over-darkening can counterproductively lead to negative sensory associations, such as burnt or bitter flavours, even before the product is tasted[2]. Therefore, the optimal color appeal was achieved at 4%, offering a deep black hue without compromising visual comfort.

3.2. Aroma

Aroma is a critical sensory parameter that influences the overall acceptability of food, often associated with freshness, flavour anticipation, and hedonic value. The control sample, devoid of colorant, achieved an aroma score of 3.26 (Figure 1.), slightly higher than the lowest concentration (1%), which scored 3.00. Interestingly, the 4% colourant level again showed optimal performance, with a mean aroma score of 3.31, while higher concentrations (5% and 6%) resulted in diminished scores of 3.21 and 3.18, respectively.

The decrease in aroma acceptability at higher concentrations may be attributed to the volatile compounds released from the carbonised carbon, potentially imparting smoky or earthy notes that some panellists found off-putting. This observation is supported by Chandran et al. [9], who noted that carbon-based courants derived from biomass may contain subtle aromatic residues, depending on the combustion conditions. Though generally non-toxic and inert, vegetable carbon can retain olfactory traces from its plant origin, which may become more pronounced as concentration increases.

3.3. Taste

Taste remains one of the most decisive factors in determining the consumer's final preference for a food product. The control noodles scored 3.33 (Figure 1.) on the taste attribute, reflecting a favorable but unremarkable profile. With the addition of black carbon colourant, taste scores followed a similar trend to aroma, peaking at a 4% concentration (3.53) and then declining at 5% (3.43) and 6% (3.49).

The improvement in taste at moderate concentrations may be due to the slight mineral content in the carbon, particularly calcium, which is known to interact with food proteins and alter flavour perception in subtle yepleasing ways [12]. However, as concentration increases, the burnt undertones of the carbon become more apparent, introducing a bitter or carbony aftertaste that detracts from the noodles' palatability. These findings are consistent with Alviana [2], who observed similar effects in traditional swee, where carbonated water enhanced flavour up to a certain concentration but decreased acceptance when used excessively.

3.4. Texture

Texture, or mouthfeel, is especially important in noodle products, as consumers expect a consistent balance of chewiness and elasticity. The texture scores remained relatively stable across treatments, with minor fluctuations. The control scored 3.43 (Figure 1.), and the 4% colorant noodles achieved the highest score of 3.22. The 5% and 6% concentrations showed a modest decline to 3.48 and 3.68, respectively.

These results suggest that the carbon colorant had limited negative impact on the structural integrity of the noodles. In fact, the inclusion of small amounts of mineral-rich carbon may have slightly improved textural attributes by enhancing gluten strength or moisture retention. Based on Firsta [3, it has been demonstrated that the calcium content in carbonised black glutinous rice straw can positively affect gel-based food structures, increasing firmness and elasticity. However, at higher concentrations, the physical presence of carbon particles even when finely suspended could potentially interfere with the smoothness of the noodle matrix, leading to a less desirable mouthfeel.

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3.5. *Overall Acceptability*

The overall acceptability score reflects the cumulative impact of all other sensory attributes and offers the most comprehensive assessment of consumer response. The control sample received a moderate score of 3.52 (Figure 1.), which improved with increasing concentrations of colorant, reaching a peak at 4% with a score of 3.66. Beyond this point, acceptability declined 3.51 at 5% and 3.45 at 6% but remained above the neutral threshold (5.0). This pattern confirms that a 4% concentration of liquid black carbon colorant delivers the best overall sensory performance. The noodles at this level were perceived as having the most appealing colour, a balanced aroma, a pleasant taste, and a satisfactory texture. These findings reinforce the concept of an optimal threshold for novel ingredients, beyond which sensory gains diminish or reverse. The phenomenon aligns with studies on the incorporation of natural pigments in food systems, where visual enhancement must be carefully balanced with flavouneutrality and structural compatibility [13].

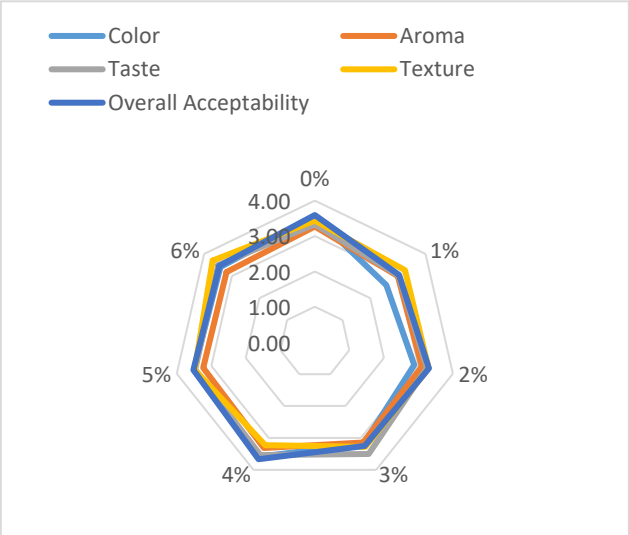

Fig. 1. Sensory evaluation of instant noodles with the addition of liquid black colorant at concentrations of 0%, 1%, 2%, 3%, 4%, 5%, and 6%.

Based on the average, it was confirmed that the 4% treatment group was statistically superior in terms of colour, taste, aroma, and overall acceptability. For texture, the differences among adjacent treatments were more nuanced but still statistically significant at the higher end of the concentration spectrum (5% and 6%).

4. CONCLUSION

This study demonstrated that liquid black colorant derived from black glutinous rice straw carbon can be effectively used to enhance the sensory qualities of instant noodles. Among the tested concentrations, 4% yielded the most favorable results across all sensory attributes, including color, aroma, taste, texture, and overall acceptability. While lower concentrations did not produce the desired visual effect, higher levels negatively impacted aroma and taste due to stronger, earthy, or burnt notes. These findings suggest that rice straw carbon, when processed into a stable liquid form, is a promising, natural, and sustainable colourant for food products. Its application in instant noodles not only improves visual appeal but also aligns with consumer demand for natural ingredients and sustainable food innovation.

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