Influence of Colour on Sensory Attributes of Composite Fruit Powders Produced from Watermelon, Orange and Mango Fruit Varieties

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Abstract: The production of composite fruit powders from watermelon, orange, and mango was evaluated for its sensory and color attributes after different drying processes, specifically freeze drying (FDFP) and spray drying (SDFP). The fruits (watermelon, orange, and mango) were procured locally from Benue State, Nigeria, and processed into purees mixed with maltodextrin as a carrier. Sensory evaluation indicated significant differences in overall acceptability, with the composite puree sample consisting of 50% watermelon, 30% orange, and 20% mango (code: 618) being the most preferred. The freeze-dried fruit powder (FDFP) exhibited better color retention compared to the spray-dried fruit powder (SDFP), with lower color degradation (ΔE of 1.57 ± 0.03 vs. 6.23 ± 0.02, respectively). Color analysis showed that freeze-drying retained higher lightness and Chroma values, whereas spray-drying resulted in a noticeable color shift, likely due to thermal oxidation. The findings suggest that freeze-drying preserves both sensory and color qualities better than spray-drying, with implications for the production of high-quality fruit powders for various applications.

***Keywords**: Freeze-Drying, Spray-Drying, Fruit Powders, Watermelon, Orange, Mango, Maltodextrins*

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I. INTRODUCTION

➢ *Statement of the Problem*

The global demand for fruit powders is on the rise due to their potential use in food, beverages, and nutraceutical products. However, the loss of color and sensory attributes during drying poses a significant challenge. Both spray drying and freeze drying are commonly used for fruit powder production, but the effect of these methods on the sensory and color qualities of composite fruit powders remains underexplored, particularly for blends of watermelon, orange, and mango. The study aims to address this gap by investigating the impact of different drying methods on the quality of composite fruit powders.

➢ *Objectives*

This study aimed to:

- Evaluate the sensory attributes (appearance, aroma, taste, texture, consistency, and overall acceptability) of composite fruit powders produced from watermelon, orange, and mango using spray drying and freeze drying.
- Investigate the color attributes (L*, a*, b*, c*, hue angle, and ΔE) of fresh and dried fruit powders to assess the effects of drying methods on color retention.
- Determine the most acceptable composite fruit powder blend based on sensory and color analysis.

Previous studies have emphasized the importance of color in consumer acceptance of fruit products (Jaya & Das, 2004; Nindo *et al.*, 2003), while other research has explored

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the impact of drying techniques on the sensory characteristics of fruit powders (Fegus *et al.*, 2014). However, limited research has focused on watermelon, orange, and mango composite powders, and this study fills this gap.

II. MATERIALS AND METHODS

A. Materials

➢ *Sources of Raw Materials and Preliminary Handling*

The mango, orange varieties (20kg each), and ten fruits each were procured from the Gboko local market in Gboko Benue State, Nigeria. Watermelon (five fruits of the 'Sugar Baby' variety) was sourced from the Makurdi Railway market in Benue State. All fruits were transported in polyethylene bags to the Joseph Tarka Federal University of Agriculture, Makurdi, Nigeria, for identification. Upon arrival, the fruits were refrigerated for further processing and analysis.

B. Methods

➢ *Sample Preparation*

Each fruit was washed, peeled, and weighed, with the peels also weighed and recorded. The purees were formulated by blending each fruit and adding varying concentrations (15%, 20%, 25%, and 30%) of maltodextrin. The purees were then processed into smoothies before being subjected to spray and freeze drying, based on the method by Mateescu *et al.* (2022). Figures 1 to 4 provide the general flow charts of the puree production process.

➢ *Fruit Puree Production Process*

The preparation of watermelon, orange, and mango purees was based on previous methodologies (Mamadou *et al.*, 2018; Obasi *et al.*, 2017; Labaky *et al.*, 2020) with slight modifications for local conditions. All purees were pasteurized, stored, and prepared for composite formulation.

➢ *Composite Fruit Puree Formulation*

Table 1. Composite Purees Formulation.

Sample code	Puree composition (%)		
	Watermelon	Orange	Mango
573	30	50	20
618	50	30	20
335	20	50	30
804	50	20	30
732	20	30	50
408	30	20	50

The composite purees were prepared as shown in Table 1, with varying proportions of watermelon, orange, and mango. The puree formulation labeled 618 (50% watermelon, 30% orange, 20% mango) was the most preferred in preliminary sensory evaluations and used for drying processes.

➢ *Fruit Powder Production*

C. Sensory Evaluation

➢ *Sample labelling*

The samples were labelled with random 3-digit codes to ensure blind testing and avoid bias during the sensory evaluation process. The reconstituted fruit samples were served at room temperature (~20°C), as temperature fluctuations can influence the perception of taste and aroma (Lawless & Heymann, 2010). The samples were presented in 200ml disposable identical cups that did not influence taste perception (neutral color and odor-free). Consistent portions of 50 mL per sample was used (Lawless & Heymann, 2010).

The sensory evaluation of the fresh composite purees was carried out using trained sensory panel consisting of staff and students of the university of Mkar. The panel consisted of 50 members including male and female members of the University of Mkar, Mkar. All evaluation sessions were held in the Food Chemistry Laboratory of the Food Science and Technology.

➢ *Evaluation*

The sensory evaluation of the fresh samples was carried out four hours after formulation while sensory evaluation of the dried products was after one week of production. The samples were stored at 5°C and taken out three hours before serving. Appearance, aroma, taste, texture, consistency and overall acceptability were evaluated following a nine-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely).

The panelists were thoroughly briefed on how to use the sensory evaluation forms and terminologies of sensory attributes. All samples were presented before the panelists at room temperature under normal lighting conditions in 50 ml cups coded with random, 3-digit numbers to ensure blind testing and avoid bias during the sensory evaluation process. Drinking water was provided for oral rinsing. The average values of the sensory scores (appearance, aroma, taste, texture, consistency and overall acceptability) were used in the analysis as described by Ihekoronyeand and Ngoddy (1985).

The composite puree sample with the highest overall acceptability was subjected to both freeze-drying and spray-drying methods to produce fruit powders. The drying parameters followed established procedures by Camacho *et al.* (2023) for freeze-drying and Jeyanth *et al.* (2020) for spray-drying.

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D. Color Determination

The Hunter color measurement of fresh and reconstituted puree powders were by the method described by Jaya and Das (2004) and also Nindo *et al.* (2003). By this procedure 250 g each of the freeze-dried and spray-dried powders respectively were reconstituted with distilled water to provide 6.143 kg water/kg dry solids similar as the original composite puree. The reconstitution of each powder was carried out by mixing with water at 23 °C in a vortex mixer (Fisher Scientific mini Vortexer, USA) until the powder was completely dissolved. Then 10 ml each of the reconstituted purees and the original test composite puree (fresh composite) were poured into separate Petri dishes, slightly shaken to form a layer of 10 mm thickness and covered with transparent film (Saran TM Wrap, SC Johnson, Racine, WI).

The International Commission on Illumination (CIE) parameters L^*, a^* and b^* were measured with a Minolta Chroma CR-200 color meter (Minolta Co., Osaka, Japan). The colorimeter was calibrated with a standard white ceramic plate (L^* = 95.97, a^* = 0.13, b^* =0.30) prior to reading.

The L^*, a^* and b^*, H^* and C^* values for each puree were immediately measured; they were also used in determining the change in color after the spray and freeze-drying processes.

Hunter Lab Equation

$$\Delta E = \sqrt{(\Delta l^{*2}) + (\Delta a^{*2}) + (\Delta b^{*2})}$$

Where:

L^* indicates lightness and ranges from 0 (black) to 100 (white), a^* Represents the red/green axis (positive values = red, negative values = green and zero a* is neutral, no red or green bias.), b^* represents the yellow/blue axis (positive values = yellow, while negative b* is blue and zero b* is neutral, no yellow or blue bias)

c^* Chroma, showing color saturation or intensity, and *b/a* ratio compares the yellow component (b^*) to the red component (a^*), giving an indication of the dominant color tone. Hue Angle describes the color of an object in terms of its position on the color wheel (e.g., red, green, blue, etc.). It is calculated from the a^* and b^* values, which represent color coordinates. Higher Hue Angles generally indicate a shift toward yellow-green, while lower values trend toward red hues. ΔE (Delta E) measures total color difference between the fresh puree and the dried purees. It quantifies the visual color change. A higher ΔE means a more noticeable color difference

E. Statistical (Data) Analysis

All the experiments were conducted in triplicate samples and the data were the mean of the three replications. All data obtained were statistically analysed using the Analysis of Variance (ANOVA) using SPSS Version 20 and the Duncan Multiple range test to separate means with a significance level p<0.05 (Ihekoronye & Ngoddy, 1985).

III. RESULTS

Table 2. Sensory Attributes of the Fresh Mango-Orange-Water Melon Composite Puree Samples.

Sample Codes	Appearance	Aroma	Taste	Texture	Consistency	Overall acceptability
573	7.000 ± 1.080^{ab}	6.7200 ± 1.243^{a}	6.2800 ± 1.021^{c}	6.3200 ± 1.435^{a}	6.5200 ± 1.530^{b}	7.0800 ± 1.115^{a}
618*	7.7200 ± 1.060^{b}	7.2000 ± 1.251^{ab}	7.2000 ± 1.040^{ab}	7.1200 ± 1.301^{a}	7.3200 ± 1.069^{a}	7.7200 ± 1.208^{a}
335	6.8400 ± 0.943^{b}	7.0000 ± 1.154^{ab}	7.0800 ± 1.222^{ab}	6.4000 ± 2.020^{a}	7.0800 ± 1.382^{ab}	7.2000 ± 1.208^{a}
804	6.8800 ± 1.201^{b}	7.5200 ± 0.770^{b}	7.4800 ± 1.084^{a}	6.7600 ± 1.984^{a}	6.8800 ± 1.268^{ab}	7.5200 ± 1.357^{a}
732	7.2400 ± 1.640^{ab}	6.9600 ± 1.206^{ab}	6.9200 ± 1.288^{abc}	7.0400 ± 1.428^{a}	7.1200 ± 0.781^{ab}	7.6400 ± 1.036^{a}
408	7.4400 ± 1.193^{ab}	6.8400 ± 1.374^{ab}	6.6400 ± 1.350^{ab}	7.1200 ± 0.971^{a}	6.9200 ± 1.037^{ab}	7.1200 ± 1.266^{a}

Values are mean ± standard deviation (SD) of triplicate determinations. Samples with different superscripts within the same column were significantly (p<0.05) different.

Key:

573 = 20% mango, 50% orange, 30% watermelon; *618 = 20% mango, 30% orange, 50% watermelon; 335 = 30% mango, 50% orange, 20% watermelon; 804 = 30% mango, 20% orange, 50% watermelon; 732 = 50% mango, 30% orange, 20% watermelon; 408 = 50% mango, 20% orange, 30% watermelon; ***Most Acceptable (Overall Acceptability)**

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Table 3 Hunter Colour Measurement of Fresh and Dried Puree Powders Obtained from the Different Drying Processes.

Drying method	***L****	***a****	***b****	***c****	***Hue Angle***	***b/a****	**ΔE**
Fresh sample	45.12 ± 0. 02[a]	4.65 ± 0.01[c]	41.78 ± 0.03[a]	41.78 ± 0. 03[c]	83.61 ± 0.01[a]	8.93 ± 0.01[c]	-
FDFP	43.74 ± 0.06[c]	4.69 ± 0.01[b]	40.99 ± 0.23[a]	40.26 ± 0.23[b]	83. 47 ± 0.04[b]	8.73 ± 0.06[d]	1.57 ± 0.03[c]
SDFP	41.59 ± 0.07[e]	3.05 ± 0.01[e]	36.64 ± 0.02[c]	36.77 ± 0.03[a]	85.24 ± 0.02[d]	12.00 ± 0.05[a]	6.23 ± 0.02[b]

ΔE is calculated using the original puree as reference

Superscript letters (e.g., a, b, c, etc.) in the table indicate whether values in a column are significantly different. Different letters mean the values are significantly different, while the same letters indicate no significant difference at $P < 0.05$.

Where:
FDFP = Feeze-Dried Fruit Powder
FDFP = Spray-Dried Fruit Powder

IV. DISCUSSION

➢ *Sensory Evaluation*

The sensory analysis revealed that sample 618 (50% watermelon, 30% orange, 20% mango) had the highest overall acceptability (7.72 ± 1.208), outperforming other formulations in terms of appearance, taste, and aroma (Table 2). This result is consistent with previous studies by Tunde-Akintunde *et al.* (2020), which found that watermelon, with its natural sweetness, contributes to better sensory appeal in fruit blends. In contrast, sample 573 (30% watermelon, 50% orange, 20% mango) showed lower scores for taste, which may be attributed to the higher acidity of orange.

➢ *Color Attributes*

Color analysis (Table 3) indicated that freeze-drying (FDFP) retained better color attributes (L*, a*, b*) compared to spray-drying (SDFP). The ΔE value, which measures the total color difference from the fresh sample, was higher in the SDFP (6.23 ± 0.02), indicating significant color degradation, likely due to thermal oxidation. These findings are consistent with Krokida *et al.* (2019), who suggested that spray-drying can cause more significant color loss due to its high temperatures, whereas freeze-drying maintains better color integrity.

V. CONCLUSION

In conclusion, the composite fruit powder made from 50% watermelon, 30% orange, and 20% mango was the most organoleptically acceptable. Freeze-drying proved superior to spray-drying in retaining both sensory and color attributes of the composite fruit powder. These results are essential for the food processing industry, where maintaining the natural qualities of fruit powders is crucial for consumer acceptance and market success.

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