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Variation in Colour Attributes of Arrowroot (*Maranta arundinacea*) Flour from Five Different Provinces in Sri Lanka as a Potential Alternative for Wheat Flour

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Abstract

Arrowroot (*Maranta arundinacea*) rhizome flour is a good gluten-free substitute for wheat flour. To evaluate the influence of colour on replacing wheat flour with arrowroot flour, the colour attributes of arrowroot flour from five different Provinces (Western, North-Western, Southern, Sabaragamuwa, and Uva) were compared with the colour of standard wheat flour. Using the colour of wheat flour as a standard, the colours of arrowroot flour samples were determined using a colourimeter (PCE-CSM 2, United States). Flour samples were examined for L* (lightness), a* (redness), b* (yellowness), and ΔE (colour deviation). Yellowness was significantly distinct, although lightness and redness were not statistically different. There were negative moderate correlations between L* and a* (-0.791; $P < 0.05$) and L* and b* (-0.831; $P < 0.05$). While there were some slight variations in the colour characteristics among different arrowroot flour samples, their colours were highly close to the colour of wheat flour.

Keywords: *Arrowroot, Colour evaluation, Colourimeter, L* a* b* values, Maranta arundinacea*

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1. INTRODUCTION

Carbohydrates are an essential constituent in human diets and those are primarily obtained from starch. One of the main sources of carbohydrates in the globe is wheat. Wheat is the oldest and most widely used food crop, and the demand for it is continually rising. The security of the world's food supply is especially dependent on wheat. For products like bread, cake, noodles, pasta, cookies, and confectioneries, among others, wheat flour has been widely used in the bakery industry. It is the main ingredient of the majority of bakery items because it creates an extensible elastic structure that gives bread dough its capacity to hold gas (Riaz, 2004).

Due to people's evolving lifestyles, there is a significant consumption of items made from wheat flour in Sri Lanka, making it the country's biggest agricultural import over time (Jayasinghe, 2018; Dissanayake and Thibbotuwana, 2021). The primary wheat flour-based foods consumed in Sri Lanka are bread and biscuits (Piyasena *et al*., 1996). Due to their cultural traditions, Sri Lankans who reside in estates consume more wheat flour than those who do not (Bandara *et al*., 2021). Even though wheat flour comes in a variety of forms and has a range of nutritious properties, there are some shortfalls and challenges that require it to be enriched, fortified, or even replaced with other cereal grain flours. These issues can include a lack of certain micronutrients, such as vitamins and minerals, or issues with the gluten in wheat, which certain people can lead to a number of allergies and disorders. The best substitutes for wheat flour include almond, arrowroot, barley, buckwheat, maize, millet, oat, potato, quinoa, rice, rye, soybean, spelt, and tapioca (Pourafshar *et al*., 2010).

Arrowroot (*Maranta arundinacea*, Family: Marantacea) is a perennial, herbaceous underutilized tuber crop that is native to south and central America and flourishes in certain tropical nations including Sri Lanka (Firoskhan and Muthuswamy, 2021). Due to a lack of knowledge about the plant's food source and the time-consuming starch extraction technique, the use of arrowroot flour in the food industry is minimum in Sri Lanka. Locally it is known as "Hulankeeriya" or "Aerukka" and is more commonly used in folk and

Ayurvedic medicine than in food preparations. In the food sector, gluten-free extracted flour from arrowroot can be used as a viable substitute for wheat flour.

Arrowroot flour's main industrial purpose is in the bakery industry, although it can also be used as a thickening agent. The colour of the flour is an essential feature that will affect the final appearance of the bakery food products when replacing wheat flour with arrowroot flour or when producing new food products with arrowroot flour because flour is the primary raw ingredient. A consumer's first consideration when evaluating food is its colour (Spence, 2015).

The Colourimeter is a specific instrument that is used to determine the colour attributes of surfaces. Colour coordinates of L*a*b* values are used to express the colour characteristics. L*(L* = 0 for black and L* = 100 for white), a*(-a* for greenness and +a* for redness), and b*(-b* for blueness and +b* for yellowness) is the colour attributes which used to determine the colour in numerical values (Wijesinghe *et al*., 2015).

Background differences (contrast effect), directional differences, observer differences, and size can all influence colour determination in food. A numerical method is utilized as a universal language for determining colours as a remedy to these errors. Colour can be determined as a numerical number using this system's scales for hue, brightness, and saturation. The CIE (International Commission on Illumination) L*a*b* colour space is the most commonly employed when it comes to food because of its uniform colour distribution and because its perception of colour is closest to that of a single human eye (Markovic *et al*., 2013). Lightness, brightness, saturation, hue, chroma, and colourfulness are all determined by readings from L*a*b* (Macdougall, 2002).

L* is a metric that measures brightness and is ranked from black (0) to white (100). a* defines redness or greenness, with +a* starting from red and –a* starting from green. b* determines whether anything is blue or yellow, with +b* starting from yellow and –b* starting from blue. By excluding human errors, the final reading from L*a*b* values indicates the same impression of colour difference (Clydesdale, 1990). This study was undertaken to examine the colour variation of arrowroot flour from five distinct provinces in Sri Lanka.

2. METHODOLOGY

2.1 Sample Collection and Flour Preparation

By encompassing five provinces in Sri Lanka, sixteen locations were selected, namely Gampaha, Divulapitiya, Horana, Mahara (Western Province), Kegalle, Deraniyagala, Rambukkana (Sabaragamuwa Province), Thihagoda, Matara, Galle (Southern Province), Hakgala, Welimada, Badulla (Uva Province), Makandura, Kuliyapitiya, Kurunegala (North Western Province). Arrowroot rhizomes were harvested at correct maturity and flour extraction was performed as described by Nogueira *et al.,* 2018 with slight modifications. Good quality refined wheat flour was purchased from a retail shop. Samples were sifted through 425 µm sieve, sealed in air-tight containers, and stored in the refrigerator (4 °C) until further analysis.

2.2 Determination of Colour Attributes

The Colourimeter (PCE-CSM 2, Unites States) was used to determine the colour of wheat flour and arrowroot flour. With the calibration disc provided, the colourimeter was calibrated and colour coordinates of wheat flour were taken as standard measurements. The samples were put into a watch glass and flattened on their surfaces. Measurements were made by placing the measuring head of the colourimeter on the prepared samples after a clear polythene piece was placed on the sample. Three separate spots on the samples were used to gather measurements. Colour coordinates of L*a*b* values were used to calculate the colour characteristics. L*(L* = 0 for black and L* = 100 for white), a*(-a* for greenness and +a* for redness), and b*(-b* for blueness and +b* for yellowness). Colour deviations from the standard (wheat flour) were recorded as ΔE.

2.3 Statistical Analysis

Colour measurements were done using triplicate samples. The results were analyzed using analysis of variance (ANOVA) and paired T-test at the 0.05 significance level using the Minitab statistical software (version 19).

3. RESULTS AND DISCUSSION

Colour coordinates received for wheat flour were: L* - 95.96, a* - 0.98, b* - 9.16, and it was used as the standard. Table 1 shows the colour attributes of arrowroot flour from five different provinces in Sri Lanka and the deviation of colour coordinates from the colour of wheat flour. There were significant differences in b* but not in L* and a* values among arrowroot flour samples obtained from the five provinces. The flour samples' mean L* (lightness) ranged from 92.39 to 94.55. Southern Province had the highest L* value for flour samples (94.55), while Sabaragamuwa Province had the lowest value. There was no substantial disparity in the lightness of the arrowroot flour samples from different provinces when colour of the wheat flour was used as the standard. It reflects the whiteness of arrowroot flour samples indicating their suitability, in terms of colour, to substitute wheat flour in food products.

The mean a* value ranged from 0.85 to 1.35 when wheat flour was the standard, with the highest a* value recorded by the flour from Uva Province. The redness or greenness of the flour samples is represented by a*. Arrowroot flour samples yielded slightly positive values and it signifies that all samples were in the red zone, although with very low reddish values. Lower redness indicates that all the flour samples are scattered around white colour and it does not differ significantly with the colour of wheat flour. However, lower a* values recorded from the colourimeter redness is not detectable to the naked eye.

The yellowness or blueness of the flour samples is indicated by b* readings. According to the findings, all flour samples were found to be positive. As a result, yellowish colour coordinates can be seen in all of the flour samples. The b* results for five different provinces' arrowroot flour samples demonstrate a considerable variation in b* values when colour of wheat flour was the standard. The highest b* was found in Sabaragamuwa Province (8.55), while the lowest was found in Southern Province (6.32). Sabaragamuwa Province had the highest yellowness of arrowroot flour, while Southern Province had the lowest. The degree of yellowness in arrowroot flour can be different as influenced by the amount of fiber removal, moisture content of the samples, drying temperature and time applied. Yellowness is also responsible for the lightness of the flour samples.

When the overall L*a*b* colour coordinates of arrowroot flour samples from the five provinces of Sri Lanka were considered and compared with colour of wheat flour, they all coordinated around the colour white. Only a minor positive red colour with a slight yellowness was detected in all the samples.

Table 1: Colour attributes of arrowroot rhizome flour from five different provinces in Sri Lanka

Province	L*	a*	b*	ΔE
North Western	92.61 ± 2.32^{a}	1.17 ± 0.51^{a}	7.22 ± 1.35^{ab}	4.46 ± 1.41^{a}
Sabaragamuwa	92.39 ± 1.38^{a}	1.23 ± 0.41^{a}	8.55 ± 0.87^{a}	3.78 ± 1.24^{a}
Southern	94.55 ± 0.35^{a}	0.85 ± 0.15^{a}	6.32 ± 0.40^{b}	3.17 ± 0.45^{a}
Uva	92.92 ± 2.58^{a}	1.35 ± 0.40^{a}	7.31 ± 1.27^{ab}	4.12 ± 1.82^{a}
Western	94.17 ± 2.22^{a}	1.10 ± 0.42^{a}	6.92 ± 2.28^{ab}	4.15 ± 0.66^{a}

Values are Mean ± SD

The same superscript letter in each column represents values not significantly different from each other at p = 0.05.

There were negative moderate correlations between L* and a* (-0.791; $p < 0.05$) and L* and b* (-0.831; $P < 0.05$), indicating that, when a* and b* values increase, the flour sample's L* (lightness) decreases. There was a moderate negative correlation between ΔE and L* (-0.557; $P<0.05$). When the deviation (ΔE) increases, the lightness of the samples tends to decrease. Results revealed that arrowroot flour samples from Sabaragamuwa Province had the highest mean value for yellowness and because of that lowest lightness was recorded from the flour samples from the same province. Redness is not significantly ($P<0.05$) different among the flour samples. Therefore, the yellowness of the flour affects the lightness of the arrowroot flour samples. Deviation of the colour coordinated from the standard (wheat flour) is not significantly different for the arrowroot flour samples from different provinces. Southern Province had the least deviation (ΔE = 3.17) and North Western Province had the highest mean deviation (ΔE = 4.46). The degree of the colour difference increases with increasing ΔE value (Morrison and Laignelet, 1983). The estimation of ΔE indicates how much farther samples' colours deviate from the standard. Deviation of colour of arrowroot flour obtained from five provinces with the colour of wheat flour is presented in Figure 1.

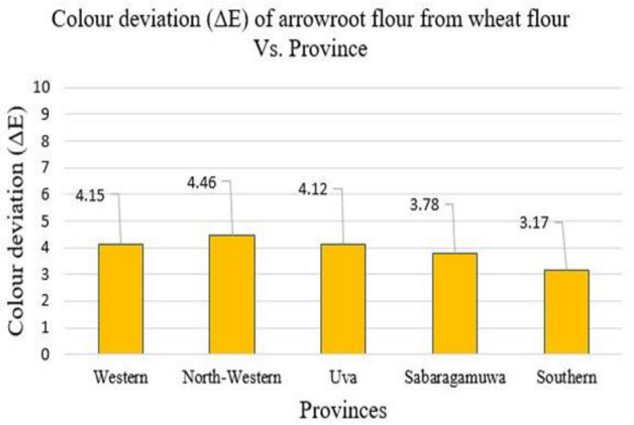

Figure 1: Deviation of colour (ΔE) of arrowroot flour of five provinces in Sri Lanka from the colour of wheat flour (standard)

Similarity level of arrowroot flour colour from five different provinces has shown in Figure 2. The colour coordination had the greatest similarity between North-Western and Uva Provinces, as revealed by the cluster analysis and it was 65.73 %. North Western-Uva cluster and Western Province had the second-highest similarity level (48.12 %). Arrowroot flour has a considerably higher level of colour similarity, indicating that the growing area has less influence on the colour of the flour. Arrowroot flour samples from North Western and Uva Provinces were not significantly different in lightness, redness and yellowness. Arrowroot flour from Southern Province has deviated from other flour samples due to higher lightness, lowest a* and ΔE values. It reflects that arrowroot flour from Southern Province is much similar to colour of wheat flour and somewhat deviated from other arrowroot flour samples.

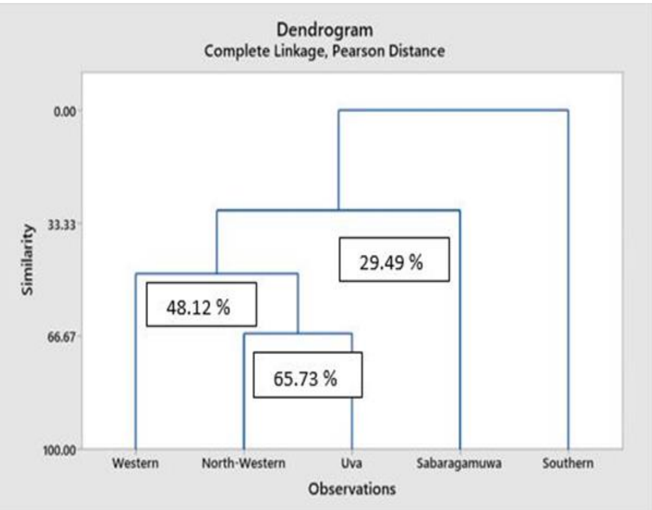

Figure 2: Cluster analysis of colour variation of arrowroot flour samples collected from five different provinces by using L*a*b* and ΔE values (Graphed by Using MINITAB 19 Software)

According to published research, arrowroot flour has a typical white colour, which is supported by its low ΔE value (18.84±0.09). The L* value of arrowroot is lower (75.52±0.12), with greater red tones (a*=0.83±0.01) and lower yellow tones (b*=6.00±0.07). The findings of this investigation and those of Valencia *et al*., 2014 are highly comparable. According to Madineni *et al*., 2012 colour attributes of arrowroot flour in India were L* - 87.5, a*- 1.24 and b* - 6.61. Colour variations may be observed due to compositional changes in the chemical compounds of the flour samples (Valencia *et al*., 2014).

4. CONCLUSION

Colour attributes of arrowroot flour samples from five different provinces in Sri Lanka were determined in L* (lightness), a* (redness) and b* (yellowness) using the colour of wheat flour as the standard. Results revealed that lightness and redness were not significantly different among the flour samples but the yellowness significantly differed (P<0.5). This may be due to the variations in chemical composition. Higher values were obtained for lightness with lower values were gained for redness and yellowness which indicated the closeness of arrowroot flour to the white colour. Correlations indicated that when the redness and yellowness increased lightness decreased. Cluster analysis revealed that there were high similarity levels among all the flour samples from five provinces. This will be a positive point to utilize arrowroot flour from different growing areas in the local food industry. The study reveals that the yellowness of arrowroot flour was influenced by the growing area but not the redness or lightness. Deviation of colour from wheat flour is minimum in arrowroot flour samples. As such, variation of colour attributes among growing areas is minimum when using arrowroot flour in local food industries in Sri Lanka. Thus, arrowroot flour can be used as an effective substitute for wheat flour in terms of the colour attributes.

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