Exploring the potential of colorants extracted from refuse green tea as a food applicant

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1. Introduction

Color is the first sensory parameter that meets the eye of the consumer. It plays an important role in determining the overall sensory appeal of a food product (Rajapaksha et al., 2017). Food colorant can be defined as any substance added to food or beverages to change its initial color and to enhance its appearance (Hewamalage et al., 2016). Recently, the use of synthetic food colorants has garnered much attention due to the staggering amount of research done related to the negative health impacts of synthetic food colours. Hence, the demand for the natural food colorants has increased over time. At present, tea extracts have gained popularity as raw material for developing food colorants (Bydoon, 2016). Further, in green tea processing, a considerable amount of wastage is created in the form of refuse tea. A higher percentage of this refuse tea is discarded without making any use of it, despite its potent chemical and therapeutic value. Therefore, this study focuses on developing a natural food colorant from refuse tea generated during green tea manufacturing. The specific objectives of the study are to determine the optimum conditions for extraction procedure; to analyze the stability of the colorant against pH, concentration, and temperature–time combination; to determine the physicochemical parameters of the developed colorant, namely polyphenol content, antioxidant activity, and caffeine content. This could be identified as a novel, low cost and sustainable valorization approach. Also, Sri Lankan tea market can use this method to convert waste materials into cash.

2. Materials and Methods

Refuse tea obtained from Raja-Ela green tea manufacturing factory, Gampola, Sri Lanka was used as the major raw material. Samples were obtained directly from the factory premises. Proximate analysis of the raw material was done according to the AOAC 2000 standard methods on dry weight basis. Extraction was done using the hot water-bath and sonication techniques. For extraction, 5 g of each tea sample was mixed with 25 ml of distilled water. Extraction using the sonication technique was done at room temperature for different time intervals. Extraction using the water-bath was carried out at for different time- temperature combinations as 50 ºC, 60 ºC and 70 ºC for 20 minutes, 30 minutes and 40 minutes respectively, which were determined over a preliminary study. Filtrates were taken using Whatman no: 01 filter paper.

The color intensity and absorbance values of filtrates were measured using KONICA MINOLTA Colorimeter and CT-6400 UV/Vis spectrophotometer at 572nm respectively. Based on the b* values and the absorbance values obtained, sample with highest yellowness and highest absorbance was selected. Afterwards, the selected sample was concentrated until the brix value of the filtrate reached up to 9^0 Bx. Carrageenan (1 - 3 %) was added upon the requirement to enhance the thickness and to stabilize the colorant. Carrageenan samples were collected from Euro food tech, Colombo. Finally, the product was stored in cleaned and dried glass containers at normal refrigerator condition.

The isolated colorant was incorporated with lime juice in different concentrations (1, 1.5, 2, 2.5, 3 % v/v) and structured sensory evaluation with nine point hedonic scale was carried out to study the consumer preference for the colorant. The sensory attributes tested were aroma, taste, colour, appearance, after taste preference and overall acceptability. Sensory data were analyzed using MINITAB 17 statistical package according to non-parametric Friedman test at 5 % level of significance.

The Stability of the selected colorant was determined against concentration (3, 2.5, 2, 1.5, 1, 0.5, and 0.3 % v/v), pH (3, 4, 6, 8, 10, and 12), and time- temperature combinations (30 ºC, 60 ºC and 100 ºC for 3 minutes, 6 minutes, 9 minutes and 12 minutes) and the resulted colors were compared with Munsell color chart. Antioxidant activity (Free radical scavenging activity against DPPH), polyphenol content (ISO 14502 – (1) method), and caffeine content (method described by Jenway bibby scientific) of the colorant were determined.

3. Results and Discussion

According to the results of the proximate analysis, the initial refuse tea sample contained 8 % moisture, 5.58 % ash, 15.51 % crude fiber, 2.06 % fat and 19.68 % of protein. As per the Sri Lanka Tea Research Institute, the moisture content of the sample was well within the limit (Balasooriya et al., 2019). According to the proximate composition, it is evident that refuse tea could be identified as a desirable raw material which could be further improved to be used in various food applications.

Based on the colorimeter values and absorbance values obtained, from both extraction techniques, three samples were selected with the highest yellowness (b* value) and are listed in table 01 and table 02.

Table 01. Results of the sonication extraction technique for refuse tea-based colorant

Time (Minutes)	L^*	a^*	b^*	Absorbance (572nm)
25	31.14	-0.31	3.44	1.424
30	30.88	-0.45	4.13	1.234
35	30.77	-0.21	3.3	1.264

Table 02. Results of the water bath technique for refuse tea-based colorant

Time (Minutes)	Temperature °C	L^*	a^*	b*	Absorbance (572nm)
40	50	29.56	1.08	3.86	1.836
30	70	30.61	0.53	4.29	1.825
40	70	30.29	1.2	4.3	1.76

Among them, using the absorbance value, the sample with highest concentration was identified. Accordingly, water bath extracted sample for 40 minutes in 50 °C was selected as it had the highest absorbance value. Afterwards, 3 % carrageenan was added and finally, gel form of the colorant was obtained.

The sensory profile of refuse tea based colorant is shown in figure 1, According to the results of the sensory evaluation, treatment 472 had higher total scores than other treatments. Addition of the colorant did not have a significant impact on taste and aroma of the food products. However, the use of 2.5 % v/v of the developed colorant was observed as the most suitable amount to be used as a colorant for beverages.

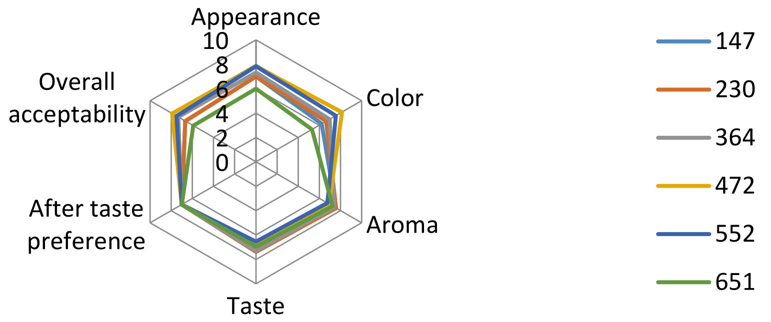

Figure 1. Web diagram of the sensory evaluation for refuse tea-based colorant

pH value	colour	Munsell color code	Concentration% v/v	colour	Munsell color code
3.0		5Y 8/10	0.3		5Y 8/8
4.0		5Y 8/12	0.5		5Y 8/12
6.0		2.5Y 7/10	1.0		2.5Y 8/6
8.0		7.5YR 7/10	1.5		2.5Y 8/8
10		5Y 6/8	2.0		2.5Y 8/10
12		5Y 6/10	2.5		7.5YR 7/8

Figure 2. Stability of colorant against pH and concentration

According to the figure 2, colorant showed yellow hues from 0.3 to 2 % v/v concentration level. Furthermore Yellowness (5 Y8/10 to 5 Y8/12) could be expected in the 3 to 4 pH range in the colorant and there is no significant change in the color from pH 3 to pH 4. Therefore it is intended for food products like Jam, concentrated fruit juice, confectionary food products having an acidic environment. Above pH 8, colorant resulted in hues approximate to commercial caramel color. Within those pH levels, colorant could be used for bakery products which are in high pH conditions.

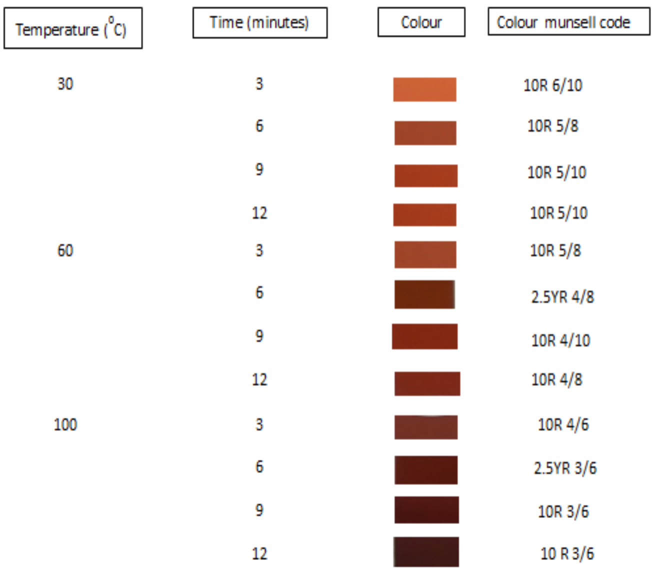

Figure 3. Stability of colorant against Time-Temperature

According to the figure 3, it was observed that the temperature and time harshly affected on the color and with the increase of the temperature darkness of the colorant significantly rises, especially from 60 °C and above, which resulted in a hue approximated to caramel black. Therefore, the colorant could be deemed most suitable for bakery products and confectionery products.

Table 03. Results of the physicochemical analysis

Parameter	Amount
Polyphenol content	192±4.5 mg/100ml
Antioxidant activity	83.24±1.69 µg/ml
Caffeine content	782.8±6.9 ppm

According to table 03, the colorant is found to possess a considerable amount of polyphenol, antioxidant, and caffeine contents. The detected values are in agreement with the values of green tea extracts (Hajiaghaalipour et al., 2016; Reto et al., 2007). Therefore, it can be concluded that colorant possesses a therapeutic effect and health promoting effect against human body. Since refuse tea is a waste product, developed colorant could render positive benefits toward health promotion.

4. Conclusions

According to the results, isolated colorant could be best used in food products in an acidic environment (pH 3-6) which are stored at room temperature or below. Furthermore, the colorant has considerable levels of polyphenol, antioxidant, and caffeine contents. However, further studies are required to improve the stability of the developed colorant.

5. References

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