Clitoria ternatea: A low-cost noble blue tea in India

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ABSTRACT: The study examines the affordability and health effectiveness of blue tea in India with a special focus on pharmacological characteristics and sensory evaluation in comparison to black tea. A mono-method quantitative technique has been utilized to gather information on the health effects of *Clitoria ternatea* (CT) using random sampling techniques and SPSS analytical tool for data analysis. Further, thirty-five untrained panelists have been employed to conduct the sensory analysis. Blue tea made of butterfly pea flower has been identified as a potential source of phytochemical characteristics that can be crucial in addressing human health hazards. Blue tea has several health benefits including antioxidative, anti-inflammatory, anti-stressor, anti-diabetic, and anti-carcinogenic effects. The research has reflected the acceptance of blue tea in the Indian market considering market awareness and its affordability among the population. The average spending of 66 surveyed Indian consumers on tea consumption is less than 300 INR each month and they are most likely to spend the same amount of money on purchasing blue tea. However, its acceptability has been limited in India in comparison to conventional black tea whose acceptability is higher among Indian consumers with better taste and aroma.

Keywords: *Clitoria ternatea* (CT), Blue tea, Black tea, Health effectiveness, Sensory evaluation

INTRODUCTION

There has been a popular trend in new blue product launches, particularly, in terms of drinks (Spence, 2018). This product ranges from beer to tea due to the rarity of naturally blue-colored foods and beverages making it so special and noble to global customers. Blue color attracts the attention of shoppers and adds different nutritional characteristics making the products healthier. Spence, (2021; p1), has shared an anecdote about blue food stating that *"blue food, for instance, is regarded as bizarre and unnatural"* which makes the introduction of blue tea all the more unnatural and unconventional. Considering the experimental nature of individuals, this study has attempted to assess the nobility of blue tea made from *Clitoria ternatea* (CT) or butterfly pea flowers and the health benefits associated with it. The purpose of this research is to evaluate the effectiveness of CT in India on health. This research has further evaluated the economic aspects of using CT as a beverage with extensive health benefits as well as unique socio-cultural characteristics because effectiveness focuses on doing things "in the most economical way" (Lakshmi *et al*. 2014). Pacheco-Coello *et al*. (2020), have associated tea consumption mainly with a low frequency of chronic pathologies such as cancer and cardiovascular diseases. It entails antioxidants and anti-inflammatory effects to enhance endothelial function. High tea consumption is also associated with a high

volume of bioactive ingredients such as polyphenols. It is known as blue tea due to its deep blue color petals traditionally used to make dye and is made from seeping fresh or dried flowers of the butterfly pea flower plant (NDTV Food, 2020). It is also known as pigeonwings or blue pea flowers and can be mostly seen in South East Asian countries. Blue tea is popular in Vietnam and Thailand and is served after dinner with honey and lemon.

Forage cultivation including butterfly pea production is highly feasible in India due to its highly attainable farming system and suitable local ecological circumstances. Selection of appropriate species for forage cultivation is possible which might bring significant changes to the Indian economy. Butterfly pea originated in tropical Asia and has been widely distributed in China, India, South, and Central America, as well as, the East and West Indies (Chakraborthy *et al.* 2018). Butterfly pea has been identified as a member of Fabaceae and sub-members of Papilionaceae. The flower can be observed in 12 varieties; *C. bracteata, C. albiflora, C. coelestris, C. pilosula, C. parviflora, C. ternatensium, C. purpurea, Lathyrus spectabilis, Ternatea vulgaris, T. ternatea, C. philippensis* and *C. ternatea* (Gomez & Kalamani, 2003).

C. purpurea usually entails attractive papilionaceous dark blue flowers which are flat and 6-12 cm long. It has gained popularity in the world as a natural colorant in drinks, foods, and industries and is sensitive to pH changes and temperature (Muhammad Ezzudin & Rabeta, 2018). Butterfly pea has several medicinal effects; analgesic, antipyretic, and anti-inflammatory (Ramli *et al.* 2021; Lijon *et al.* 2017). Consumption of tea in India has increased by approximately 1.1 million kilograms in 2020 due to the high popularity of hot beverages (Tea Board India, 2021a). India has been identified as the second-largest producer of tea after China. The majority of its productivity occurs in the country's northeastern region, particularly in West Bengal and Assam. Tamil Nadu is also a significant producer of tea in the country.

The birth of the Indian tea industry has been triggered by the discovery of the indigenous tea plant in 1823 in Assam by Robert Bush (Sivanesan, 2013). The formation of Bengal Tea Company in Kolkata and Jorhat Company in Assam has marked the growth of the industry. Assam, Tripura, West Bengal, Himachal Pradesh, Tamil Nādu, Karnataka, and Kerala are the most important tea-cultivating states of India. In 2020, the total production of tea has been 1257.56 m.kgs (Tea Board India, 2021b). Tea selling price in India has risen significantly over the years with economic growth and rising demand from both domestic and foreign customers (Shah & Pate, 2016). In 2009, the selling price of tea has been around 100 per kg. Its value increased to 232.60 rupees per kg in 2020 (Tea Board India, 2021c).

Major chemical components of CT have been anthocyanins, flavonoids, alkaloids, ternatins, tannins, saponins, taraxerone, and taraxerol (Muhammad Ezzudin & Rabeta, 2018). CT accounts for 14 types of flavonol glycosides with the use of spectroscopy. These flavonol glycosides are “kaempferol 3-(2G -rhamnosylrutinoside)”, “kaempferol 3-neohesperidoside”, “quercetin 3-(2G -rhamnosylrutinoside)”, “quercetin 3-neohesperidoside”, “kaempferol 3-rutinoside”, “myricetin 3-neohesperidoside”, “quercetin 3- rutinoside”, etc. (Gomez & Kalamani, 2003; Lijon *et al.* 2017; Muhammad Ezzudin & Rabeta, 2018). Thailand has been observed to use extracts of CT in cosmetics for their anti-oxidant activity. According to Gupta *et al.* (2010), CT

paste has even been applied as an antidote for snake bites apart from headaches and eye infections. Research has shown that oxidative stress causes many degenerative and chronic diseases and CT petals have been observed to possess anti-oxidative characteristics in preventing free radical damage. Muhammad Ezzudin & Rabeta, (2018), have acknowledged that CT flowers have antidiabetic characteristics as natural substances of CT reduce glucose levels in the blood. A test conducted on rats reveals that the diabetes rate has reduced after 14 days of CT administration extracted from 150 mg/kg body weight (Gunjan et al. 2010; Verma et al. 2013). Hemolysis occurs when radical damage affects the membrane of red blood cells (RBC) which can be managed by antioxidants. CT exhibits antioxidant activities and phenolic compounds that have an anti-hemolytic effect on the body (Ramli *et al.* 2021). CT flower also exhibits anti-inflammatory activities at the dose level of 200 and 400 mg/kg body weight (Lijon *et al.* 2017).

CT entails a tranquilizing influence on the brain hence it can be used in treating brain weakness, vertigo, syncope, etc. (Lijon *et al.* 2017). Methanolic extract of CT exhibits anxiolytic, antidepressant, and anti-stress activity. Karta et al. (2013), have examined the acute oral toxicity of CT roots which reveals that the mortality rate is 50% at the dose of 15000 mg/kg bw where the "median lethal dose (LD50)" of roots is higher than 15000 mg/kg bw, however, there is no evidence of toxicity in CT flower.

METHOD

Research methodology is an essential part of research that helps in ensuring the consistency of tools, techniques, and underlying beliefs associated with the research (Melnikovas, 2018). This research has adopted a positivist research philosophy as it attempts to understand the social world in an objective way (Žukauskas *et al.* 2018). Crowther and Lancaster (2008), in a study, refer that positivist studies mostly adopt a deductive approach as they focus on facts, while phenomenology philosophy usually adopts an inductive research approach as it concentrates meaning behind the social events. This research has adopted a deductive approach to justify its objectives highlighting CT as a low-cost noble tea in India. This study has adopted a cross-sectional quantitative research approach due to time constraints to conduct research on blue tea consumption.

The research has surveyed Indian populations concerning blue tea consumption. Only close-ended questions have been included in this research to gather demographic and inferential data. 5-Likert scales have been used to gather information on the health effects of CT. The questionnaire has been sent to respondents through social media platforms. The research has adopted a probability sampling method which allows the researcher to randomly select respondents. It provides a strong statistical inference regarding the whole group to ensure the research outcomes are statistically significant (Etikan & Bala, 2017). The research has considered 100 people as its population and 66 responses as its final sample size. Data analysis has been conducted using SPSS analytical tool (IBM SPSS Statistics 26) which helps in providing detailed research through descriptive analysis. The validity and reliability of this research have been measured to ensure the credibility of this research. Cronbach's Alpha test has been used to measure the reliability of this research with its standard range of 0.7 to 1 (Heo *et al.* 2015). KMO and Bartlett's analysis has been done to analyze the validity

of this research which entails a standard value of 0.6 to +1 (Rojas-Valverde *et al.* 2020).

The research has collected consent from respondents to meet the ethical obligations of the research. The respondents have been informed of the importance of this research along with their roles in obtaining a valuable research outcome (Kaewkungwal & Adams, 2019). The gathered responses are stored on the personal computer of the researcher with complex pass-word encryption to protect the privacy and confidentiality of respondents.

For sensory analysis, the butterfly pea flower has been collected from the plant and 250 grams of flowers has been put into the sunlight to dry for 6 hours. The dry pea flowers have been then grided into the blender. To prepare tea, 1 cup or 240 ML of boiling water has been collected, and then 1tsp dried butterfly pea flower or 1 bag of tea has been added to the boiling water. Sugar has been added for taste. The bag has been put into water for 5 minutes to turn the color into bright blues. The black tea has been prepared following the same procedure but with commercially available tea leaves. An untrained panel of 35 individuals ranging from 21-70 years old has been employed for the sensory evaluation. A 15-minute training session for the panelists has been arranged to make them aware of the purpose of the sensory evaluation and afterward, they have been given one sample at a time. They have been asked to express their opinion following a hedonic rating scale with 9 being "like extremely" and 1 being "dislike extremely".

RESULTS AND DISCUSSION

A 66% of response rate has been observed with 70 people participating in the survey to provide responses from 100 populations. The KMO test has helped in analyzing the partial correlation between the factors used in this research. The KMO value of this research is .834 which suggests that the factors are closely related and thus, acceptable (Napitupulu *et al*. 2017). The alpha coefficient value of the ten items selected variables for this research has shown a high internal consistency with a value of .867 which suggests that the Likert scale used in this research is highly reliable (Ravinder and Saraswathi, 2020).

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.834
Bartlett's Test of Sphericity	Approx. Chi-Square	295.069
	df	45
	Sig.	.000

Figure 1: KMO and Bartlett's Test

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.867	.878	10

Figure 2: Cronbach's Alpha test

Research has shown that 40.32% of respondents' income is less than 10,000 INR per month, while 38.71% of respondents earn between 10,000 INR to 30,000 INR. The low income of the general population has, therefore, influenced their purchasing capability of blue tea.

How much money do you spend on monthly tea consumption?	*How much money would you like to spend on blue tea per month?*

Less than 300 INR	*58.5%*	*66.7%*
300 INR-600 INR	*35.4%*	*30.2%*
More than 700 INR	*6.2%*	*3.2%*

Table 1: Average spending of consumers on tea and willingness of consumers to pay for blue tea

58.46% of respondents spend less than 300 INR on their monthly tea consumption, whereas, 35.38% of respondents spend 300-600 INR on their daily tea consumption. Therefore, the majority of respondents do not spend much on tea consumption, and tea prices in the Indian market are quite low. Respondents have shown their willingness to try blue tea as many respondents still don't use the tea for consumption. 66.67% of respondents have acknowledged that they are likely to buy blue tea if the price remains under 300 INR.

The research outcome has highlighted that 47.62% of respondents are aware of the anti-oxidant and anti-cancer characteristics of blue tea while 34.92% of respondents have provided a neutral response on the concerning matter. 53.97% of respondents have been aware of the anti-diabetic effects of blue tea, while 55.56% of respondents have acknowledged the anti-inflammatory and anti-stress effects of blue tea. Gollen *et al.* (2018), have similarly acknowledged the anti-stress and anti-inflammatory activities of CT. Jamil *et al.* (2018), have acknowledged the anti-diabetic characteristics of blue tea which shows the anthocyanin pigment of CT prevents diabetes among consumers. Abbas Eltaib Hamza *et al*. (2021), on the other hand, have catalogued the anti-stress and anti-inflammatory characteristics of CT that enhance the appeal of blue tea to individuals. 47.62% of respondents in this research have been aware that blue tea helps improve the memory and learning capabilities of individuals. Chayaratanasin *et al.* (2015), have similarly acknowledged the use of CT as a traditional memory enhancer medicine supporting the findings of this research. However, very few respondents have a clear idea of the toxicity of blue tea or any adverse effect on health due to overdose as 46.03% of respondents have presented a neutral point of view.

The respondents have acknowledged the sensitivity of blue tea as they find the color-changing techniques of blue tea fascinating. The same has been acknowledged by BAWAR, (2021), as the study observed butterfly pea flowers exhibited a highly sensitive pH balance as the slightest change in acidity transfers their color from blue to a fizzy magenta. The shade blue can be observed in

	Blue tea suits my taste	Blue tea is attractive in color	Blue tea has a pleasant odour	Blue tea is convenient to use	Blue tea is readily available in the market	Blue tea has anticancer and antioxidant effects	Blue tea has antidiabetic effects	Blue tea has anti-inflammatory and anti-stress effects	Blue tea helps in learning and memory improvement	Blue tea has adverse effects on health due to overdosage
Strongly Agree	*6.7%*	*29.7%*	*8.1%*	*11.1%*	*3.2%*	*14.3%*	*12.7%*	*14.3%*	*7.9%*	*7.9%*
Agree	*30.0%*	*50.0%*	*48.4%*	*41.3%*	*30.6%*	*47.6%*	*54.0%*	*55.6%*	*47.6%*	*41.3%*
Neutral	*58.3%*	*17.2%*	*38.7%*	*44.4%*	*22.6%*	*34.9%*	*30.2%*	*30.2%*	*39.7%*	*46.0%*
Disagree	*5.0%*	*1.6%*	*4.8%*	*3.2%*	*35.5%*	*3.2%*	*3.2%*	*0.0%*	*4.8%*	*4.8%*
Strongly Disagree	*0.0%*	*1.6%*	*0.0%*	*0.0%*	*8.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*

Table 2: Health effectiveness of blue tea

pH levels 8 to 4, but it turns into deep purple at pH 3 and carnation pink at pH 2 (Baird, 2015).

The sensory evaluation of both black and blue tea highlights the actual situation of both teas in the Indian market. The average color scores of both teas range from 7.28 to 7.82. The color score of blue tea has been higher in comparison to black tea due to the presence of anthocyanin Delphinidin (Chaiyasut *et al.* 2016). There is no potential aroma in blue tea and it has scored 7.05 in taste which is lesser than black tea with a score of 7.6. The overall acceptability has been noted as higher for black tea indicating that black tea is still considered a preferred beverage for Indian consumers.

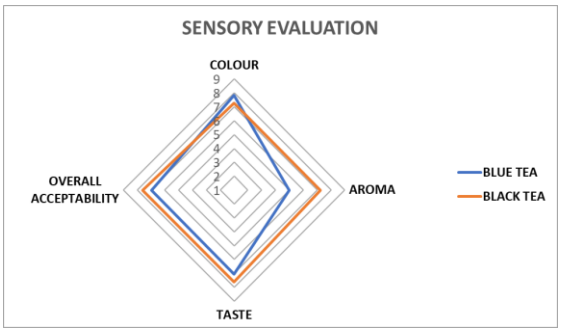

Figure 3: Sensory evaluation of black and blue tea

CONCLUSION

From the quantitative evaluation of CT, blue tea has had several health benefits including antioxidant activity, anti-inflammatory, anti-stressor, anti-diabetic, and anti-carcinogenic but with limited knowledge and understanding among the Indian population. This addresses the objectives of this research concerning the investigation of the health benefits of blue tea and its awareness in India highlighting its pharmacological

characteristics based on consumer perspectives. The study has focused on investigating the affordability of blue tea among Indian populations to promote healthy eating habits which suggest that the majority of Indian consumers spend less than 300 INR each month on tea consumption and they are most like to spend the same amount on purchasing blue tea. Lack of consumer knowledge regarding the health benefits of blue tea has also influenced consumers' willingness to spend money on purchasing blue tea. Individual needs to be aware while consuming blue tea for weight loss purposes and other health benefits to avoid overdose by restricting consumption two times a day since there has been limited research concerning the toxicity of blue tea.

The research has solely focused on understanding the health benefits related to blue tea and the capacity of Indian consumers in affording the tea. The small sample size, however, raises the question of statistical significance. Faber & Fonseca, (2014), have mentioned how a small size can compromise the validity of the conclusion gathered from the research findings. A small sample size often limits the understanding of a valid true or false premise. Further, this research has recorded the responses of consumers rather than marketers or vendors of blue tea which limits the knowledge regarding market acceptance of blue tea within the Indian market. The research has also not taken any clinical approach to experiment with the health benefits of blue tea. Blue tea producers, therefore, should take the initiatives to highlight the health benefits of blue tea to enhance branding opportunities and sales in India.

FUTURE SCOPE

The small sample size has been one of the limitations of this research which prevents it from providing a generalized view of the novelty of blue tea to the Indian population. Therefore, the research can be further explored with large sample sizes. It can further attempt to gather qualitative responses from Indian consumers via interviews or focus groups to understand their affordability and difficulty in adopting blue tea. The study has acknowledged the difficulty in marketing blue tea in the Indian market which can be further explored in future research. Competition with other brands has been identified as another challenge for blue tea acceptability in the Indian market. The survey outcome reveals that black tea and green tea are quite famous in India which makes it extremely difficult for blue tea producers to enter the Indian market. Therefore, the challenges of Indian blue tea producers can be further discussed in future research by taking into account their perspectives on blue tea's health benefits.

Conflict of Interest: Authors have declared that no competing interests exist.

Author contributions: Dr. Sanjukta Kar conceived, and designed the overall manuscript. Puja Barman collected the data and contributed analysis tools, performed the analysis, and wrote the paper. All authors contributed to the final manuscript.

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