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RESEARCH ARTICLE

Exploring the shift towards natural colorants in the food industry: Health, sustainability and consumer awareness

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Abstract

Natural colorants are increasingly preferred over synthetic alternatives due to rising health and sustainability concerns among consumers. There is limited research on how consumers perceive and respond to natural food colorants in the Indian context, particularly in everyday dairy and other food products. Accordingly, this research investigates consumer awareness, attitudes and preferences regarding natural food colorants, with a specific focus on Annatto in Amul Butter. A cross-sectional descriptive survey was conducted in the Coimbatore district with 195 adult participants selected through convenience sampling. Data were collected via structured questionnaires and statistical analysis was performed using SPSS software. Exploratory Factor Analysis (EFA) and Chi-square tests were applied to identify influencing factors and demographic associations. Results revealed three dominant factors influencing preference: Health Consciousness, Taste & Aesthetics and Brand Trust, collectively explaining 81 % of the variance. These factors are particularly relevant for food industry stakeholders as they influence consumer purchasing behaviour, product appeal and brand credibility. Females showed significantly higher preference ($p = 0.040$) and education positively correlated with awareness ($p = 0.001$), while age showed no association ($p = 0.430$). The study highlights the growing demand for clean-label foods and emphasizes the importance of transparent labelling and health-driven marketing strategies. These insights can help food manufacturers improve consumer acceptance of naturally coloured products. The findings are valuable for food product development and marketing, offering direction for strategies that emphasize health and sustainability. Additionally, they inform policy formulation aimed at promoting informed, health-oriented choices.

Keywords: Annatto; awareness; food labelling; health consciousness; natural colorants; sustainability

Introduction

Food colouring has been used since ancient times, such as by the Romans in 400 BCE and it strongly influences how people perceive a food's taste, freshness and quality. Although natural sources like beetroot and turmeric were once commonly used, the industry later favoured synthetic alternatives due to their lower cost and longer shelf life (1). Colour is perhaps the most intense sensory characteristic affecting consumer food perception, directly shaping expectations of freshness, taste, quality and even safety (2). From the red of tomatoes to the yellow of turmeric, colour significantly influences product recognition and consumer acceptability. Consequently, colorants are regularly added to foods to enhance appearance, restore colour lost during processing, or standardize the look of products across batches (1, 2). Traditionally, nature-derived sources such as saffron, beetroot and turmeric were used, but the rise of food processing industries led to the widespread use of synthetic colorants because of their vivid hues, lower costs and greater stability (3, 4). However, growing scientific evidence has linked many synthetic colorants to health risks, including childhood hyperactivity, allergic reactions and possible carcinogenic effects. These concerns, combined with evolving consumer preferences and stricter regulations, have contributed to a major shift toward natural colorants (5, 6). Natural colorants derived from plant, microbial, mineral, or animal sources are increasingly valued for their visual appeal and health promoting properties (6). The natural food colorant market has surpassed USD 1 billion and is growing at an estimated 8-10 % annually, driven by consumers' increasing demand for transparency in labelling (7). This growth is particularly significant in the dairy, confectionery, beverage and bakery sectors, where bright, stable colours are essential for consumer acceptance (8, 9). Natural food colours are derived from a broad range of edible sources, including vegetables, fruits, spices, algae and other natural materials. These offer a wide colour palette and are used to impart colour to food and beverages (10). Most common natural colorants come from plant sources: carotenoids, found in yellow and orange vegetables like carrots and tomatoes, impart yellow, orange and red hues (11). Anthocyanin's, extracted from berries, grapes and red cabbage, offer red, purple and blue shades (12). Chlorophyll, the green pigment in plants, is used in

green drinks, sauces, confectioneries and battalions, obtained from beetroots, provide red and purple tones (11). Natural colorants are becoming more popular as consumers become increasingly aware of the health risks associated with synthetic additives. However, there is still limited understanding of how consumers perceive and accept natural colouring agents. Food producers face challenges in meeting demands for label transparency, consistent product appearance and affordability, which continue to limit the broader adoption of natural colorants. This study seeks to investigate consumer attitudes, assess awareness of Annatto labelling in Amul Butter and explore strategies to enhance acceptance and use of natural colorants.

Materials and Methods

Study design and sampling

A cross-sectional descriptive survey was conducted in the Coimbatore district to assess consumer awareness and preferences regarding natural food colorants, particularly Annatto. The target population included adult consumers aged 18 years and above who purchase and are aware of food products containing natural colorants. Using a non-probability convenience sampling method, 195 respondents were selected based on their availability and willingness to participate, ensuring adequate representation for statistical analysis. Data was collected through a structured questionnaire administered both online and in-person, covering demographic details (age, gender and occupation), consumption patterns and awareness of natural versus synthetic colorants. The collected responses were compiled and analysed using SPSS software, employing descriptive statistics such as frequencies and percentages to interpret consumer trends and insights.

Inclusion criteria

Respondents included in the study were required to consume food products containing natural colorants at least once a month. Additionally, they needed to be aged 18 years or older and come from various demographic backgrounds, including different ages, genders and education levels.

Exclusion criteria

Participants who did not consume food products with natural colorants were excluded from the study.

Tools used

Exploratory Factor Analysis (EFA) was conducted to identify the underlying dimensions influencing consumer preferences and attitudes toward natural food colorants. Chi-square tests were used to examine associations between demographic variables and the awareness of transparency in food labelling and to assess the relationship between consumer characteristics and the acceptance of natural colorants. All statistical analyses were performed using SPSS to ensure data reliability and validity.

Statistical analysis

Descriptive statistics were used to summarize the demographic data and the frequency of responses to the survey questions. To identify the underlying factors influencing consumer preferences for foods containing natural colorants, EFA was conducted using Principal Component Analysis (PCA). The rotation method used was Varimax rotation to facilitate the interpretation of the factors (13). The suitability of the data for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) test, where a value greater than 0.6 was considered adequate. Additionally, Bartlett's Test of Sphericity was performed to determine whether the correlation matrix was significantly different from the identity matrix. PCA was employed for factor extraction, followed by Varimax rotation to maximize the variance of squared loadings for each factor, making the factor loadings easier to interpret (14). The factors identified through the analysis were interpreted based on the questions that loaded onto each factor, focusing on themes such as health consciousness, taste preferences and brand trust. The KMO formula and factor loadings (Table 1) were calculated as the correlations between the original variables and the identified factors (Table 2).

KMO formula

$$KMO = \frac{\sum_{i,j} |r_{ij}|}{\sum_{i,j} |r_{ij}| + \sum_{i,j} |\phi_{ij}|}$$

To assess the relationships between demographic factors (age, gender and education) and consumer awareness or behaviour related to natural colorants, a Chi-square test was employed (15).

The Chi-square test was applied to the following variables:

Age vs. Awareness

This tested whether age had a significant association with consumer awareness regarding the use of natural colorants.

Education vs. Awareness

This tested whether consumers' education levels were associated with their awareness of natural colorants like Annatto.

Table 1. Results from the factor analysis, including the factors identified, the questions that load onto each factor and the factor loadings

Factor	Questions loading on factor	Factor loadings
Health consciousness	I prefer food products with natural colorants because they are healthier	0.78
	I avoid artificial colorants due to health concerns	0.72
	I check product labels for natural colorants	0.65
Taste and aesthetics	I choose food products with natural colorants because they taste better	0.81
	Natural colorants enhance the visual appeal of food	0.75
	I enjoy the look and taste of food with natural colorants	0.70
Brand trust	I trust brands that use natural colorants and label them transparently	0.77
	I prefer to buy food from brands that are known for using natural ingredients	0.68
	I am more likely to purchase food products with clear labelling of natural colorants	0.65

Table 2. Eigenvalues and explained variance

Factor	Eigenvalue	Percentage of variance explained
Health consciousness	4.23	35 %
Taste and aesthetics	3.12	26 %
Brand trust	2.45	20 %
Total explained variance	**9.80**	**81 %**

Gender vs. Preference

This examined whether gender influenced consumer behaviour and preference regarding natural colorants.

The demographic breakdown of the respondents revealed that 106 (54.3 %) were female, while 89 (45.7 %) were male. In terms of age, most respondents were in the 20-30 age group (121 respondents, 62.1 %), followed by the 41-50 age group (28 respondents, 14.3 %) and the 31-40 age group (26 respondents, 13.2 %). Regarding occupation, most respondents were employed (80 respondents, 40.8 %), followed by those in business (55 respondents, 28.0 %). As for consumption patterns, most respondents consumed Amul Butter or Cheese either weekly (88 respondents, 44.7 %) or monthly (78 respondents, 39.5 %), with a smaller group consuming it rarely (16 respondents, 8.1 %) or daily (13 respondents, 6.6 %) in Table 3.

Table 3. Demographic characteristics of respondents

Category	Frequency	Percentage (%)
Gender		
Female	106	54.3 %
Male	89	45.7 %
Age		
20-30 years	121	62.1 %
31-40 years	26	13.2 %
41-50 years	28	14.3 %
Above 51 years	18	9.1 %
Occupation		
Employed	80	40.8 %
Business	55	28.0 %
Home Maker	36	18.4 %
Student	14	7.1 %

Consumer behaviour regarding ingredient labels

Most respondents, 88 (44.7 %), said they sometimes check the ingredient list, while 69 (34.9 %) stated they always check the ingredient list when purchasing food items (Table 4).

Chi-square test

The associations for the study are Age vs. Awareness of Natural Colorants, Gender vs. Preference for Natural Colorants and Education vs. Awareness of Natural Colorants. The results from the associations are given in Table 5.

Table 4. Consumer awareness of natural colorants and Annatto

Category	Frequency	Percentage (%)
Do you check the ingredient list?		
Always	69	34.9 %
Sometimes	88	44.7 %
Rarely	20	10.2 %
Never	17	8.7 %
Suggestions for awareness		
Increased transparency in labelling	21	10.7 %
Educational campaigns	14	7.1 %
Social media outreach	14	7.1 %
Collaboration with health experts	20	10.2 %

Results and Discussion

The study points to an increasing consumer demand for natural colorants due to health issues related to synthetic additives, such as allergic reactions and hyperactivity in children. As consumers become increasingly aware of these dangers, they are turning more towards safer, more sustainable alternatives. In demographic terms, 106 (54.3 %) were female, while 89 (45.7 %) were male. In terms of age, most respondents were in the 20-30 age group (121 respondents, 62.1 %), followed by the 41-50 age group (28 respondents, 14.3 %) and the 31-40 age group (26 respondents, 13.2 %). The most significant group in the survey was between the ages of 20 and 30 (62.1 %) and 44.7 % of those surveyed checked ingredient lists sometimes, with 34.9 % always checking them. To identify the underlying factors influencing consumer preferences for foods containing natural colorants, EFA using PCA was performed. The analysis extracted three significant factors: Health Consciousness, Taste and Aesthetics and Brand Trust, which together accounted for 81 % of the total variance, indicating a strong model fit. The high representation of the 20-30 age group suggests that younger consumers are more ingredient-conscious and inclined towards clean-label products, thereby driving the demand for natural colorants in packaged foods. Health Consciousness emerged as the most dominant factor, reflecting consumers' growing awareness of the risks associated with artificial colorants, ssuch as tartrazine (Yellow No. 5) and sunset yellow (Yellow No. 6), which have been linked to allergic reactions, hyperactivity in children and other health concerns and their preference for natural alternatives is perceived as healthier and safer. The second factor, Taste and Aesthetics, revealed that consumers associate natural colorants with superior taste and visual appeal,

Table 5. Chi-square test results for associations

Association	Category	Aware of natural colorants	Not aware of natural colorants	Total	X^2 Value	df	*p* Value
Age vs. awareness of natural colorants	20-30 years	90	31	121	3.75	4	0.430
	31-40 years	19	7	26			
	41-50 years	14	14	28			
	Above 51 years	8	10	18			
Gender vs. preference for natural colorants	Male	57	32	89	4.24	1	0.040*
	Female	59	47	106			
Education vs. awareness of natural colorants	Illiterate	12	23	35	15.2	3	0.001**
	Primary/Higher Secondary	6	1	7			
	SSLC/PUC	22	15	37			
	Graduate or above	41	5	46			

highlighting the importance of sensory satisfaction in food choices. The third factor, Brand Trust, emphasized the role of transparency and credibility, with consumers showing a clear preference for brands that openly label the use of natural colorants. These results underscore the combined influence of health perception, sensory experience and brand integrity in shaping consumer attitudes toward naturally coloured food products. While the findings suggest that younger consumers may be more health-conscious, it is also possible that their awareness is shaped by greater access to digital information, educational campaigns and social media discourse on food safety and clean-label trends.

The Chi-square tests were conducted to examine the association between demographic variables and consumer awareness or preference for natural colorants. The analysis revealed no significant association between age and awareness of natural colorants (p = 0.430), indicating that younger consumers may be more health conscious. Their awareness may be shaped by greater access to digital information, educational campaigns and social media discourse on food safety and clean-label trends. A significant association was observed between gender and preference for natural colorants (p = 0.040), with a higher proportion of 59 female preferring natural colorants compared to 57 males, suggesting that females may be more inclined toward health-conscious food choices, possibly due to greater engagement with health and nutrition information, stronger aesthetic preferences in food presentation and traditional roles as primary household food purchasers, which enhance sensitivity to product safety and quality. Additionally, education level showed a strong association with awareness (p = 0.001), where graduates demonstrated greater awareness of natural colorants than those with lower educational attainment. These findings suggest the need for targeted awareness initiatives, especially among less-educated populations, while also acknowledging gender-specific preferences in marketing strategies.

Conclusion

The research indicates a growing consumer preference for natural colorants, driven by increasing concerns about the health risks associated with synthetic colorants and a heightened demand for transparency in food labelling. The findings suggest that while natural colorants, such as Annatto, are gaining popularity, challenges related to cost, stability and supply chain disruptions. As consumer awareness continues to rise, the role of natural colorants in food is expected to expand, contributing to a healthier, more sustainable food industry. This trend aligns with the growing movement towards sustainability and healthier eating, which is reshaping the food industry worldwide. Future research could explore innovative methods to enhance the stability of natural colorants and investigate long-term consumer preferences and behavioural patterns regarding these ingredients.

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Authors' contributions

RJS performed in article collection, analysis, interpretation and formulated the manuscript; MLS contributed by developing ideas, reviewing the manuscript; MK, IC and KN helped in summarizing and revising the manuscript.

Compliance with ethical standards

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