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CONSUMER AWARENESS, PREFERENCE, AND WILLINGNESS-TO-PURCHASE BLACK WHEAT *(TRITICUM AESTIVUM L.)* IN URBAN INDIA: EVIDENCE FROM COIMBATORE CITY

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ABSTRACT

The biofortified anthocyanin-rich wheat variety, black wheat (*Triticum aestivum L.),* was developed by the National Agri-Food Biotechnology Institute (NABI), India, and has the potential to combat micronutrient deficiencies and diet-related non-communicable diseases in South Asia. The nutritional potential of this crop is not fully understood, and the dynamics of the market on the consumer side are not well understood for commercialization in the urban Indian market. This study aimed to explore the awareness, sensory preferences, and socio-economic and perception factors affecting the willingness to purchase (WTP) black wheat in Coimbatore, Tamil Nadu, India. Data were collected from 159 purposively sampled urban respondents with prior black wheat experience and analyzed using percentage analysis, mean score analysis, and binary logistic regression. Awareness of black wheat was high (88.7%), and 86.8% of the respondents had eaten black wheat, but only 48.4% would buy it regularly. The most common sources of awareness were television/newspapers, friends/relatives, and social media, and the most trusted sources of information were family and friends (56.6%) and doctors/nutritionists (38.4%). The sensory evaluation showed high acceptance of the grain taste (mean = 4.57/5) and high rejection of the dark color of the grains (mean = 2.59/5). Six factors were significant predictors of WTP: perceived nutritional benefits (OR = 6.16), brand reputation (OR = 4.80), healthy lifestyle orientation (OR = 3.86), price reasonableness (OR = 3.76), comparative health perception (OR = 3.38), and being well-informed about health benefits (OR = 2.19). The model accounted for approximately 84.4% of the variance in WTP (Nagelkerke $R^2 = 0.844$). The results offer practical suggestions for agribusinesses, food processors, and policymakers regarding health communication, branding, sensory education, and value-based pricing strategies to stimulate demand for black wheat.

KEYWORDS: anthocyanin; biofortified wheat; consumer preference; functional food; logistic regression; willingness-to-purchase

INTRODUCTION

With the rise in disposable income, health consciousness, and demand for functional foods with nutritional values other than energy, the eating habits of urban Indians are undergoing structural changes. This transition has implications for agribusiness value chains, with food processors, retailers, and supply chain intermediaries seeking commercially viable biofortified and health functional products that will satisfy changing consumer preferences in one of the world's largest and fastest-growing emerging markets (1).

Black wheat (*Triticum aestivum L.*) is a pigmented wheat that is a potential alternative to conventional wheat in terms of commercial production and nutritional value. Black wheat developed at the National Agri-Food Biotechnology Institute (NABI), Mohali, is dark purplish-black in color and contains higher levels of anthocyanins (40–278 mg kg^{-1}) than regular wheat (5–15 mg kg^{-1}), which are reported to have strong antioxidant properties and protective effects against cardiovascular diseases, diabetes mellitus, and some cancers (2). Black wheat is also a good source of anthocyanins and contains more iron, zinc, dietary fiber, and protein than conventional wheat. Therefore, it is a relevant crop for the double burden of micronutrient deficiency and diet-related non-communicable diseases in populations of South Asia (3).

Black wheat was approved as a food product by the Food Safety and Standards Authority of India (FSSAI) in June 2018 and is still in the early stages of commercialization. The early stage of market development brings challenges and opportunities to agribusiness actors, such as limited cultivation area and seed availability on the supply side, and consumer unfamiliarity, color-based product resistance, and information asymmetries regarding nutritional attributes on the demand side. These are demand-side dynamics that are crucial for developing a viable and commercially sustainable biofortified grain market.

Previous studies have shown that health consciousness and nutritional knowledge positively affect consumer willingness to purchase (WTP) biofortified staples; however, this effect is moderated by product availability and consumer familiarity (4). Bharti et al. (5) reported that the nutritional value of black wheat flour products was known to the beneficiaries of Anganwadi, but the dark color and difficulty in preparation decreased the acceptability of the products. Geetha et al. (6) reported that urban consumers in Delhi were knowledgeable about biofortified products but had varying WTP, indicating the need for a market-context-specific analysis. In this study, however, the specific determinants of WTP for black wheat were modelled in the context of an urban market in South India, with a comprehensive set of perception-based predictors included.

Coimbatore city in Tamil Nadu is an important market for this research. Coimbatore is a rapidly expanding urban city with a health-conscious, educated, and affluent population. Black wheat has been reported in at least 18 trade entities, making it ideal for examining market conditions and drivers for agribusiness that may be relevant to broader market strategies for commercialization. A recent study conducted in South India also showed an increasing interest in and acceptance of new functional and alternative food products among similar urban consumer groups (7). (2) What are the reasons for consumer awareness of black wheat? (3) What is the level of consumer awareness of the black wheat? (2) What are the sensory preferences and perceived purchase barriers for black wheat? What are the socio-economic and perception-based factors that influence WTP for black wheat in the binary logistic regression model? The findings are discussed in the context of the growth of the Indian economy and explicitly linked to the implications for agribusiness strategy, value chain development, and food marketing policy.

MATERIALS AND METHODS

Study area and rationale

This study was conducted in Coimbatore, Tamil Nadu, India, from November 2025 to April 2026. Coimbatore was purposively selected for this study for three reasons: First, its urban demographic profile, with a high proportion of educated, middle to upper income consumers who have been proven to be health conscious, is a key segment for functional food adoption in South India. Second, specialty and health food stores are available in the city. Third, a preliminary reconnaissance survey was conducted, and it was established that black wheat products are available in the market through at least 18 trade entities (six stores, five dealers, four suppliers, two distributors, and one exporter), and a minimum threshold for a meaningful consumer study was set. Black wheat is not grown in the area, and the study scope was not determined by the crop production cycle but by the rounds of the consumer survey.

Sampling design and sample size

The respondents were identified and sampled through a non-probability purposive-cum-snowball sampling technique in which those who fulfilled the three eligibility criteria (a) residing in Coimbatore city, (b) main decision-maker for food purchases in the household, and (c) prior knowledge/experience of consuming black wheat were selected and sampled. The design was appropriate for the relatively small but growing number of black wheat consumers and the requirement for informed respondents to evaluate detailed perception items. Cohen's power analysis for logistic regression was used to determine the a priori sample size adequacy at $\alpha = 0.05$ and statistical power = 0.80, and it was determined that the achieved sample size (n = 159) was adequate for the predictor set used. A total of 159 respondents were selected from various retail and health food points in the city.

Data collection instrument

A pre-tested and structured questionnaire was used for primary data collection, which comprised five sections: (i) socio-economic profile (gender, age, education qualification, occupation, family type, and monthly household income); (ii) black wheat awareness and information sources; (iii) black wheat consumption pattern and purchasing behavior (preferred product format, purchase channel); (iv) sensory preference (taste, texture/mouthfeel, aroma/smell, appearance/colour) rated on a 5-point Likert scale (1 = strongly dislike, 5 = strongly like); and (v) willingness to pay (WTP) rated on a 5-point scale (1 = very unwilling, 5 = very willing). Five-point Likert scales were also used to capture consumer perceptions of 12 attitudinal dimensions and purchase barriers on nine dimensions, as reported in the supplementary material.

Model specification

Socio-economic profile, awareness and consumption pattern of the respondents were described by percentage analysis. Descriptive statistics (mean and standard deviation) were used to determine sensory preference scores and consumer perception ratings. Binary logistic regression was used to determine the significant factors affecting the WTP for black wheat. The dependent variable was coded as 0 (neutral, unwilling, or very unwilling) or 1 (willing or very willing). The 11 predictor variables were entered in a single block: Healthier_Than_Regular, Nutritional_Benefits, Healthy_Lifestyle_Intent, Price_is_Reasonable, Easily_Available, Convenient_Packaging, Well_Informed_About_Benefits, Labels_Affect_Buying, Doctor_Recommendation, Brand_Reputation, and Trust.

All predictors were independent of each other, as indicated by the Variance Inflation Factor (VIF), which was computed for all predictors, and all VIF values were close to 1.0. The Omnibus chi-square test, Hosmer–Lemeshow goodness-of-fit test, Nagelkerke R^2, and percentage of correct classification were used to assess the model fit. IBM SPSS Statistics Version 26.0 (IBM Corp., Armonk, NY, USA) was used for all analyses. The logit model is as follows:

The logit function for WTP is: $\text{logit}(WTP) = \beta_0 + \beta_1(\text{Nutritional\_Benefits}) + \beta_2(\text{Brand\_Reputation}) + \beta_3(\text{Healthy\_Lifestyle\_Intent}) + \beta_4(\text{Price\_is\_Reasonable}) + \beta_5(\text{Healthier\_Than\_Regular}) + \beta_6(\text{Well\_Informed}) +$

β_7(Easily_Available) + β_8(Convenient_Packaging) + β_9(Labels_Affect_Buying) + β_{10}(Trust) + β_{11}(Doctor_Recommendation) + ε (Eqn. 1)

RESULTS

Socio-economic profile of respondents

Table 1 presents the socioeconomic profiles of the 159 respondents. Of the sample, 51.6% were female and 48.4% were male. The majority fell in the 31–40 years age group (40.9%), followed by the 20–30 years age group (32.7%). Undergraduates (30.8%) and postgraduates (31.4%) had the highest levels of education. The largest group of people was self-employed or business persons (36.5%), followed by government (20.8%) and private sector employees (20.1%). Nuclear families were the most common (91.2% of the sample). The top income group was between ₹40,001 and ₹60,000 per month (33.3%), followed by above ₹80,000 (20.8%), which is a higher middle-class sample that is well-suited for the premium functional food market.

Awareness and information sources

The awareness of black wheat was high, with 88.7% of respondents being aware of the product (Table 2). The awareness level of the purposively sampled urban population was similar to that observed in biofortified food studies in other urban markets in India (6). Television/newspapers (22.6%), friends/relatives (22.0%), and social media (21.4%) were the three most commonly cited main sources of awareness. Family and friends (56.6%) and doctors/nutritionists (38.4%) were the most trusted sources of information on food products. Interestingly, social media influencers were the least trusted (1.3%) but were a significant source of awareness, indicating that there is a gap between the reach and credibility of information sources, which has implications for agribusiness communication strategies. High market visibility: 78.6% of respondents reported that black wheat products were visible in the retail market.

Consumption pattern

A total of 159 respondents completed the questionnaire, of which 86.8% (n = 138) had consumed black wheat or black wheat products. For the consumer population, 31.2% had consumed for 1-6 months, 26.8% for 6 months to 1 year, 26.8% for less than 1 month, and 15.2% for more than 1 year, which means that the majority of consumers' experience of consuming the product was recent, as would be expected in the early stages of commercialization. Monthly (39.9%) was the most frequent frequency of consumption, followed by occasional (30.4%). The most preferred product form was black wheat flour (31.9%), followed by bread (27.5%) and chapati (13.8%), indicating that consumers preferred the familiar and staple compatible product forms, which has direct implications for product development strategy among food processors. The integrity of the supply chain, perception of freshness, and trust in provenance were purchase channel drivers, as indicated by the preference for direct farmer purchasing (42.1%) over online (28.3%) and health food store channels (11.3%) (Fig. 1).

Sensory preference

The mean sensory preference scores for black wheat for the 138 consumers in the sample are shown in Table 3. Taste received the highest mean score (4.57 ± 0.71), followed by aroma/smell (4.20 ± 0.72), and overall acceptability (4.00 ± 0.95). The texture/mouthfeel was moderate (3.80 ± 1.13). The appearance/color score had the lowest mean score (2.59 ± 1.35) and the highest SD of all scores, indicating the highest inter-individual variability. This is comparable to the consumer resistance to black wheat reported by Bharti et al. (5) and Razzaq et al. (8). More importantly, the high taste score of actual consumers indicates that the hedonic satisfaction is high once the color barrier is overcome, indicating that experiential marketing (in-store tasting, recipe demonstration, and trial size packaging) works well to convert potential consumers.

Willingness-to-purchase

Regarding the regular purchase of black wheat, 35.8% of the respondents were willing to buy black wheat regularly, and 12.6% were strongly willing, which makes a total of 48.4% willing to buy black wheat regularly (Table 4; Fig. 2). Of the respondents, 29.6% were neutral, and 22.0% were unwilling or very unwilling. The positive overall WTP response, coupled with the high level of product awareness, implies that the main challenge for market development is not awareness creation but building purchase-driving beliefs (health benefit, brand trust, price value) that are directly actionable for agribusiness marketing strategies.

Binary logistic regression: determinants of willingness-to-purchase

The overall binary logistic regression model was statistically significant (omnibus chi-square = 94.527, df = 11, $p < 0.001$). Goodness of fit of The Hosmer–Lemeshow test indicated good model calibration (chi-square = 1.373, df = 8, $p = 0.995$). The Nagelkerke R^2 of 0.844 suggests that the model explains approximately 84.4% of the variance in WTP, and the correct classification of cases was 91.8%. The complete regression results are presented in Table 5.

WTP was significantly predicted by six of the 11 variables. Perceived nutritional benefits had the highest odds ratio (OR = 6.16, $p < 0.001$), with those who strongly believed that black wheat was nutritionally superior being more than six times more likely to report WTP than those who did not. The results highlight the importance of health-value beliefs in the acceptance of functional foods (9, 10) and suggest that agribusiness communication strategies should focus on specific, credible health claims, especially those associated with anthocyanin content, cardiovascular disease, and diabetes protection.

Brand reputation (OR = 4.80, $p < 0.001$) was the second most significant predictor. In emerging markets, where food quality claims are not necessarily enforced, brand credibility acts as a heuristic quality signal for consumers, as shown by Garcia-Salirrosas et al. (11). This finding suggests that the investments agribusiness firms make in brand-building activities (e.g., quality certification, third-party endorsements, and open communication in the supply chain) can yield substantial profits in the black wheat market. Healthy lifestyle orientation (OR = 3.86, $p = 0.001$) and perceived price reasonableness (OR = 3.76, $p = 0.001$) were the third and fourth most significant factors, respectively. The price reasonableness finding is important because it indicates that the price is not the only factor influencing WTP, but also the perceived value-for-money proposition as a result of the nutritional premium offered, as suggested by De Steur et al. (4). Thus, agribusiness pricing strategies that enable the health premium to be communicated to consumers (such as unit cost comparisons and cost per nutritional benefit framing) may be more effective than price reductions.

The perception of the health benefits of black wheat compared to regular wheat (OR = 3.38, $p = 0.002$) and being well-informed about health benefits (OR = 2.19, $p = 0.040$) were also significant, and together, they confirmed the importance of health literacy and comparative nutritional awareness in influencing WTP. Availability, convenient packaging, influence of the label, product trust, and doctor recommendation were not statistically significant in this sample. The non-significance of availability is interesting and may be due to the fact that black wheat products are already available in the market in Coimbatore (78.6% of respondents had seen it in the market); therefore, availability is not as restrictive as belief-based restrictions on WTP.

DISCUSSION

The findings of this study have far-reaching implications for the commercialization of black wheat in the new agribusiness context in India. The high awareness rate (88.7%) and high prior consumption experience (86.8%) of the urban Coimbatore sample indicate that the market is not in the awareness stage of product adoption. The actual product discovery is not the problem; the problem is the consolidation of belief and preference, and this is where the real challenge of market development lies, with important strategic implications for agribusiness companies investing in this product category. The dominance of interpersonal trust networks (family and friends: 56.6%; health professionals: 38.4%) as the most trusted information sources is comparable to that of the pulses and other agricultural commodity markets in India, where interpersonal trust networks are over represented in influencing producer and consumer behavior (12). Thus, agribusiness marketers may be more cost-effective in adopting WOP strategies, nutritionist partnerships, and community-based health communication programs to transform WTP in this market segment than traditional advertising. The sensory preference pattern, characterized by high satisfaction with taste (4.57/5) and high aversion to color (2.59/5), suggests a product-market fit paradox with direct supply chain implications. Food processors must overcome pre-trial resistance by innovating packaging (opaque packaging for raw flour, highlighting end product rather than raw grain), diversifying product formats (chapati, bread, and biscuits, where the dark color is less noticeable or is normalized through product category associations), and offering in-store tasting experiences that allow consumers to experience the positive sensory attributes first hand. This is in line with the idea of cognitive reframing of the appearance of biofortified food, such as the dark color as a quality signal of anthocyanin content, which can be important for pre-trial acceptance, as suggested by Razzaq et al. (8). It is important that perceived price reasonableness is a significant factor in WTP (OR = 3.76) and simple product availability is not (OR = 1.51, $p = 0.247$) when designing the value chain. This implies that the constraint on market development is not the supply side distribution but the communication of value, namely, the ability to communicate the price-value proposition that the nutritional premium of black wheat offers to consumers. At this stage of market development (13), it is therefore necessary for agribusiness companies and food processors to invest in value communication tools, such as nutritional comparison labelling, health certification marks, and consumer education material at point of sale. This is similar to the Indian pulses value chain, where not only physical market access constraints but also information asymmetries were identified as factors that limit smallholder producers' market access (12). Policy wise, the high impact of health literacy (well-informed about health benefits: OR = 2.19) on WTP indicates that investments in consumers' nutrition education (e.g., through school curricula, public health campaigns, and agricultural extension programs for urban retail markets) can lead to measurable demand-side returns on biofortified crops. Policy interventions can result in a virtuous circle: higher consumer demand can lead to higher willingness to pay premiums, which can lead to better farmgate price signals for black wheat farmers, which can lead to more supply and a more commercially viable black wheat value chain.

CONCLUSION

In this study, eleven perception-based determinants were used in a binary logistic regression model to investigate the determinants of WTP for black wheat, and consumer awareness and sensory preference in urban Coimbatore, India. The results indicate that black wheat has succeeded in raising awareness and high uptake of trials among urban consumers in South India, as half of the sample exhibited positive WTP for regular future purchases. Perceived nutritional benefits, brand reputation, healthy lifestyle orientation, price reasonableness, comparative health perception, and health information access were the six most important determinants of WTP, explaining approximately 84% of the variance in purchase intention. The study reveals that, as an agribusiness, the primary limitation to market development for black wheat is not product awareness or physical distribution, but the convergence of health value beliefs and brand trust. For this stage of market development, food processors, agri-marketers, and value chain investors should focus on health communication, sensory education, brand building, and value-communicating pricing strategies, instead of distribution expansion. Extension agencies and policymakers should take advantage of the significant contribution of health literacy to WTP and develop targeted nutrition education programs for consumers that provide incentives to smallholder black wheat growers

in the market. This study has several limitations. The non-probability purposive-cum-snowball sampling method led to a high level of selection bias: the high awareness (88.7%) and prior consumption (86.8%) observed in the sample may be exaggerated and may not reflect the overall urban population in Coimbatore and other cities in India. Thus, the results are more representative of health-conscious, experienced black wheat users than the average urban consumer. The sample also consisted of middle to upper income, educated, nuclear family members from a single city, limiting external validity. The WTP was measured using a perception-based single-item scale, which may have overstated purchase intention due to social desirability bias, rather than through actual purchase behavior or experimental methods (e.g., contingent valuation or discrete choice experiments). Finally, consumer perceptions and WTP may change as the market matures and products become more widely available.

Future research should employ probability sampling across multiple cities, include both users and non-users of black wheat, and adopt revealed preference methods to provide more robust and generalizable insights.

Authors' Contributions

PS: Conceptualization, study design, development and administration of survey instrument, primary data collection, data cleaning, statistical analysis (including binary logistic regression), results interpretation, original manuscript drafting, and all revisions. MC: Overall research design, development of the analytical framework, critical review of the manuscript for intellectual content, and supervision. DM: Methodological design, input on data analysis and interpretation, and manuscript review. MP: Provided advice on economic analysis and willingness-to-purchase modelling, and manuscript review. GV: Guidance on data management, statistical software application, and manuscript review. The final manuscript was read and approved by all the authors.

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Ethical Compliance

The study was conducted using human subjects and a structured questionnaire. All respondents provided informed consent, and participation was voluntary. The respondents were assured of the confidentiality and anonymity of their responses. This study was conducted in the academic research governance system of Tamil Nadu Agricultural University, Coimbatore, India. All procedures were performed in compliance with the ethical standards for research involving human subjects, as stated in the relevant institutional and national guidelines.

Competing Interests

The author(s) declare(s) that they have no competing interests.

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Tables and Figures

Table 1. Socio-economic profile of respondents (n = 159)

Characteristic	**Category**	**n**	**%**
Gender			
	Male	77	48.4
	Female	82	51.6
Age group			
	Below 20 years	25	15.7
	20–30 years	52	32.7
	31–40 years	65	40.9
	41–50 years	10	6.3
	Above 50 years	7	4.4
Educational qualification			
	School level	29	18.2
	Undergraduate	49	30.8
	Postgraduate	50	31.4
	Professional degree	31	19.5
Occupation			
	Self-employed / Business	58	36.5
	Employed (Government)	33	20.8
	Employed (Private)	32	20.1
	Student	18	11.3
	Retired	11	6.9
	Unemployed	5	3.1
	Homemaker	2	1.3
Type of family			

Characteristic	Category	n	%
	Nuclear family	145	91.2
	Joint family	14	8.8
Monthly family income (₹)			
	Below ₹20,000	7	4.4
	₹20,001–₹40,000	34	21.4
	₹40,001–₹60,000	53	33.3
	₹60,001–₹80,000	32	20.1
	Above ₹80,000	33	20.8

Table 2. Awareness, market exposure, and information sources (n = 159)

Indicator	Category	n	%
Awareness of black wheat			
	Yes	141	88.7
	No	18	11.3
Primary source of awareness			
	Television / Newspapers	36	22.6
	Friends / Relatives	35	22.0
	Social media	34	21.4
	Doctors / Nutritionists	24	15.1
	Fitness trainers	22	13.8
	Retail stores / Supermarkets	8	5.0
Most trusted source			
	Family and friends	90	56.6
	Doctors / Nutritionists	61	38.4
	Scientific articles / Research	6	3.8
	Social media influencers	2	1.3
Seen products in market			
	Yes	125	78.6
	No	34	21.4

Table 3. Mean sensory preference scores for black wheat among consumers (n = 138)

Sensory attribute	n	Mean	SD	Rank
Taste	138	4.57	0.71	I

Sensory attribute	n	Mean	SD	Rank
Aroma / Smell	138	4.20	0.72	II
Overall acceptability	138	4.00	0.95	III
Texture / Mouthfeel	138	3.80	1.13	IV
Appearance / Colour	138	2.59	1.35	V

Scale: 1 = Dislike very much, 2 = Dislike, 3 = Neither like nor dislike, 4 = Like, 5 = Like very much. SD = standard deviation.

Table 4. Distribution of respondents by willingness to purchase black wheat regularly (n = 159)

Response category	n	%
Very willing	20	12.6
Willing	57	35.8
Neutral	47	29.6
Unwilling	28	17.6
Very unwilling	7	4.4
Total affirmative (Willing + Very willing)	77	48.4

Table 5. Binary logistic regression results — variables in the equation (n = 159)

Predictor variable	B	S.E.	Wald	p	Exp(B) (OR)
Perceived nutritional benefits	1.818	0.452	16.19	<0.001	6.16***
Brand reputation	1.569	0.423	13.76	<0.001	4.80***
Healthy lifestyle orientation	1.351	0.397	11.58	0.001	3.86***
Perceived price reasonableness	1.325	0.408	10.55	0.001	3.76***
Perception: healthier than regular wheat	1.217	0.392	9.63	0.002	3.38***
Well-informed about health benefits	0.784	0.381	4.23	0.040	2.19**
Easily available	0.412	0.356	1.34	0.247	1.51
Convenient packaging	0.298	0.344	0.75	0.387	1.35
Labels affect buying decision	0.241	0.318	0.57	0.449	1.27
Trust in product	0.189	0.307	0.38	0.539	1.21
Doctor recommendation	0.143	0.301	0.23	0.633	1.15

*B = regression coefficient; S.E. = standard error; Wald = Wald chi-square statistic; p = significance level; Exp(B) = odds ratio (OR). **p < 0.05; ***p < 0.01. Model fit: Omnibus $\chi^2 = 94.527$, df = 11, p < 0.001; Hosmer–Lemeshow $\chi^2 = 1.373$, df = 8, p = 0.995; Nagelkerke $R^2 = 0.844$; Correct classification = 91.8%.*

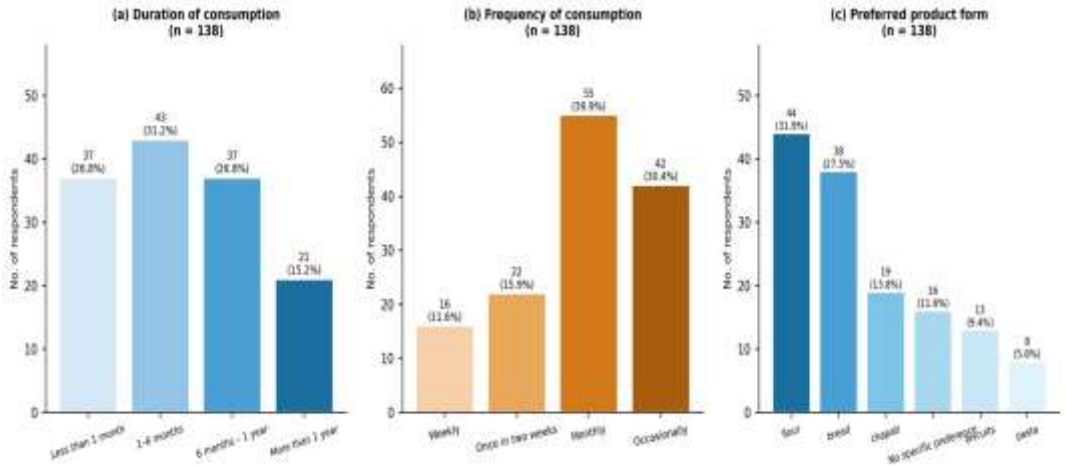

Fig. 1. Consumption pattern of black wheat among consumers (n = 138): (a) duration of consumption, (b) frequency of consumption, and (c) preferred product form.

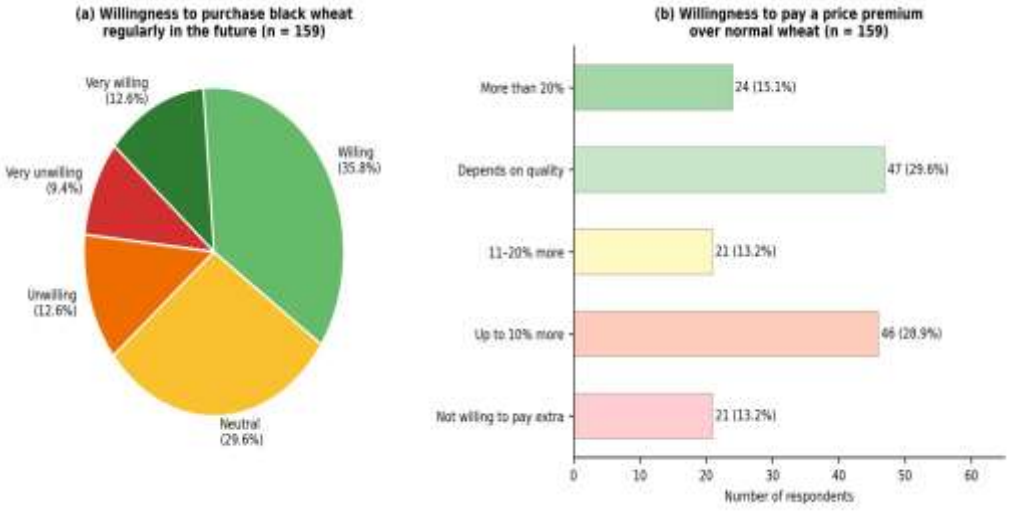

Fig. 2. Distribution of respondents by willingness to purchase black wheat regularly (n = 159): (a) willingness to purchase black wheat regularly in the future, and (b) willingness to pay a price premium over normal wheat.