

## Chinese consumers' attribute preference prediction for table grapes

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### Abstract

This paper aims to understand intrinsic attribute preferences of Chinese consumers for table grapes, analyze the influencing factors, and build consumer preference prediction models. In this study, 4324 consumers from various regions of China were investigated. We analyzed consumer preferences and the influencing factors. Finally, binary logistic regression was used to construct prediction models of consumers' intrinsic attribute preferences for table grapes. The results showed that grapes popular with Chinese consumers had fixed characteristics, including moderate size, spherical or near-spherical shape, purple-red color, strawberry flavor, light aroma, soft flesh and juicy, sweet taste, seedlessness, thin skin powder, and easy to peel. The results of the prediction models showed that age, annual consumption of grapes, and other factors of consumers had significant effects on consumer preferences. The prediction models achieved 80% accuracy in predicting consumer preferences for taste, seedless and peeling degrees. Analyzing the latest attribute preferences of Chinese table grapes, consumers can provide on the one hand, breeding direction reference for breeders, and on the other, marketing suggestions for marketers in the table grape industry. This study comprehensively investigated the intrinsic attribute preferences of Chinese table grape consumers, mastered the latest results of consumer preferences, added the indicators of the intrinsic attributes from the perspective of consumer demand, and conducted relatively more complete prediction research on the preferences of Chinese consumers.

**Keywords:** binary logistic regression; consumers' preferences; intrinsic attribute; prediction models; table grapes

### Introduction

At present, China is the largest grape-producing country in the world and its grape production reached 14.314 million tons by the end of 2020 (National Bureau of Statistics of China [NBSC], 2021). The Chinese grape industry has made great strides because of progress in cultivation techniques and diversity of grape varieties (Jiang *et al.*, 2018). However, the high yield of grapes faces some challenges in economic consumption. First, table grapes are not resistant to storage. Under the impact of abundance of substitute fruits, the sales volume of grapes still has room for growth in the consumption market of table

grapes in China. Second, the concentrated listing of table grapes has led to the phenomenon of periodic oversupply, thereby leading to fluctuations in grape prices (Mu *et al.*, 2019). Therefore, it is particularly important to systematically analyze the demand of consumption market and reasonably arrange production according to changes in market demands.

China has a large population. Consumers with different sociodemographic characteristics, purchasing behavior, and perceived values are likely to have different preferences for various attributes of grapes. According to the relevant theories of behavioral economics, consumer

behavior and preferences are not always rational and are influenced by many factors. Exploring the factors influencing consumer preferences helps to promote sustainable consumption. Understanding the preferences of table grape consumers and studying the factors that affect their preferences provide breeding workers with reference breeding directions (Si-Hong *et al.*, 2020), and enable operators of the table grape industry to accurately predict consumer requirements and formulate appropriate marketing strategies (Qian *et al.*, 2018; Zhou *et al.*, 2015). In order to determine consumer preferences, some studies were conducted on their preferences of table grapes in China; however, preference predictions were not made (Mu *et al.*, 2019; Yao *et al.*, 2020; Zhou *et al.*, 2016). The table grape market in China is facing a situation where grape varieties are highly similar, coupled with the impact of alternative products, resulting in fewer choices for consumers. If consumer demands are not predicted in time, their purchasing power is reduced greatly. Therefore, in view of the competitive environment of China's table grape consumption market, it is of great practical significance to build consumer preference prediction models on the basis of understanding consumer preferences.

The attributes of fruit have an important impact on purchasing behavior. The attributes of table grapes mainly include intrinsic attributes and extrinsic attributes. Intrinsic attributes, such as size, shape, color, aroma type, aroma degree, texture, taste, seedless degree, skin powder, peeling degree, etc., are usually inherent in grapes itself and cannot be changed (Mu *et al.* 2019). The extrinsic attributes mainly refer to the attributes affected by external factors, such as price, packaging, place of origin, etc. At present, most studies believe that the intrinsic attributes of grapes mainly affect purchasing behavior. Therefore, these studies researched the intrinsic attribute preferences of Chinese table grape consumers. For example, a study conducted on the table grape consumption market in Jiangsu Province investigated consumer preferences and their consumption characteristics of table grapes (Yao *et al.*, 2020), but this survey faced a problem of uneven sample distribution. Another study conducted on the table grape market in Beijing summarized the preferences of most Chinese consumers, but the survey had a small overall sample size of 315 (Zhou *et al.*, 2015). In these two studies, the intrinsic attributes of table grapes were incomplete, lacking the analysis of consumer preferences for skin powder and peeling degree as well as the analysis of factors affecting consumer preferences for each attribute, so it was impossible to predict specific consumer preferences. Moreover, the above two surveys were conducted in a certain region; hence, the results could not represent the consumption preferences of entire Chinese consumers.

The quality of grapes cultivated under expert guidance has improved (Lohitnavy *et al.*, 2010; Piazzolla *et al.*, 2016; Poudel *et al.*, 2022); however, the traits cultivated by scholars failed to represent consumer preferences. Therefore, some researchers explored their preferences for table grapes from the perspective of consumers (Mu *et al.*, 2016; Zamzami *et al.*, 2020). However, as yet, little research is done on the prediction of consumer preferences for table grape attributes; hence, we referred to the methods used to study the influencing factors of consumer preferences for attributes or purchasing intention of other fruits.

Many studies used statistical methods to analyze consumer product attribute preferences and its influencing factors. Logistic regression model is mostly used in predicting purchasing intention of consumers because of its simple and practical advantages. Ma *et al.* (2023) used logistic regression to explore the effects of dietary knowledge and age on food preferences. The study determined that in China, the proportion of people aged more than 18 years with healthier food preferences was highest. The lower the level of dietary knowledge, the more likely they were to prefer non-healthy foods (Ma *et al.* 2023).

Romadhon *et al.* (2021) used logistic regression to analyze the influence of individual characteristics, such as age, marital status, education, and gender, on the preference of Nigerian consumers for attributes of rice, such as color, head rice, flavor, aroma, soft texture, durability, and its whiteness. Massaglia *et al.* (2023) used logistic regression to explore the influence of social demographic characteristics of Italian consumers on chocolate attributes, such as type, brand, and label information. Chu *et al.* (2020) used multivariate logistic regression to predict consumer preferences for wine attributes. Mu *et al.* (2022) also used logistic regression model for recommending consumers' wine attributes. In conclusion, logistic regression has an important significance for predicting consumer preferences regarding attributes of table grapes.

The above analysis demonstrates that, based on the framework theory in behavioral economics, people's behavioral biases or preferences have a certain impact on economic decision-making and market operations. Therefore, the present study first conducted a comprehensive survey on the consumption market of table grapes in China to obtain overall preferences of consumers; it then explored the factors affecting their preferences from the perspective of table grape consumers, and finally constructed the preference prediction models of table grapes. Our results would enhance the understanding of consumer preferences and purchasing behavior of table grapes, and provide reference and guidance for domestic and foreign grape producers and marketers.

## Materials and methods

### Design of questionnaire

Based on the analysis of previous literature, we designed a questionnaire for this survey, discussed the problems in the questionnaire with experts in the field of table grapes, and revised the questionnaire repeatedly. The questionnaire consisted of four parts. The first part investigated the participants' preferences for various intrinsic attributes of grapes, mainly including visual attributes, such as size, shape, and color, and value attributes, such as aroma type, aroma degree, texture, taste, seedless degree, skin powder, and peeling degree. In order to explore the factors that affect consumers' intrinsic attribute preferences for table grapes, subsequent parts investigated the purchasing behavior, perceived value factors, and sociodemographic characteristics of participants. Among these, the perceived value factors referred to the importance that consumers attached to the intrinsic and extrinsic attributes of table grapes, which was consumers' evaluation of the product (Cronin Jr. *et al.*, 2000). These questions were designed with five-point Likert scale with the following specifics: 1 means "very unimportant," 2 means "unimportant," 3 means "medium," 4 means "important," and 5 means "very important." The influencing factors and prediction attributes used in the prediction models constructed in this study are shown in Figure 1.

### Survey

The survey was conducted from June 2022 to July 2022. We selected and trained 28 students from China Agricultural University as investigators. The training content included survey requirements, sampling methods,

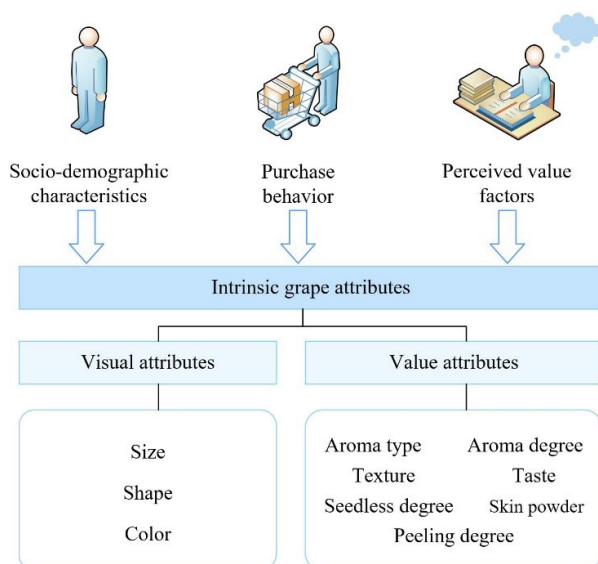


Figure 1. The conceptual framework of prediction models.

and interview skills. After training, investigators were directed to select participants by random sampling in their home province. The participants were required to have good independent thinking and understanding to ensure that they were serious in answering the survey, and that the survey results were more effective. The investigators were selected from different provinces and autonomous regions of China so that the survey results obtained by us were representative of China's geographical regions. The participants belonged to 32 provinces and autonomous regions of China, and the sample distribution of each region confirmed the population distribution of the seventh national population census of 2020. A total of 4678 questionnaires were distributed in this survey. After eliminating incomplete fillings, short answering time, and repeated questionnaires, 4324 valid questionnaires were obtained, with a high recovery rate of 92.43%.

### Data collection

Cronbach's  $\alpha$  was used to test reliability of the questionnaire. When the reliability was between 0.70 and 0.90, it indicated consistent variables within the scale (Tavakol and Dennick, 2011); when it exceeded 0.9, it indicated that the variables within the scale had high reliability. This paper used SPSS 27.0 to test reliability of the scale data in the sample, and the value was between 0.915 and 0.70, indicating that our survey data had a good consistency.

Table 1 shows the sociodemographic characteristics of all participants. A large number of studies demonstrated that the sociodemographic characteristics of consumers, such as gender, age, education, occupation, marital status, and personal disposable income, had an important impact on consumers' purchasing behavior and preferences (Del Carmen *et al.*, 2020; Okpiaifo *et al.*, 2020; Park *et al.*, 2021; Saeed *et al.*, 2020). In our survey results, women (58.81%) were more than men (41.19%). Most of the participants were aged between 18 and 25 years and had bachelor's degrees or above. Nearly one-third of the participants were company employees. More participants were unmarried, had three persons at home, had a personal disposable income <2000 renminbi (RMB, China's currency), and were urbanites. This demonstrated that the survey participants were mainly young or middle-aged, well-educated consumers with medium income.

### Analysis of influencing factors

In order to construct prediction models of consumers' attribute preferences for table grapes, this paper used  $\chi^2$  analysis of contingency table to explore the influence and correlation

Table 1. Sociodemographic characteristics of the participants.

Sociodemographic characteristics	Percentage (%)	Sociodemographic characteristics	Percentage (%)
Gender		Other	1.73
Male	41.19	Marital status	
Female	58.81	Married	47.48
Age (years)		Unmarried	52.52
18–25	41.17	Number of family members	
26–35	29.58	1	2.68
36–45	14.75	2	5.69
46–55	10.57	3	34.88
Above 55	3.93	4	30.80
Education		5	14.69
Junior high and below	5.46	6 and above	11.26
High school	9.67	Personal disposable income	
Junior college	14.78	2000 RMB or less	18.85
Undergraduate	51.57	2000–3000 RMB	13.90
Master's degree and above	18.52	3000–5000 RMB	17.95
Profession		5000–7000 RMB	17.25
Government official	10.22	7000–10,000 RMB	12.97
Enterprise employee	32.40	10,000–15,000 RMB	9.16
Freelancer	12.88	15,000–20,000 RMB	4.28
Farmer	4.44	20,000 RMB and above	5.64
Education departments	6.15	Resident type	
Student	29.72	Urban resident	63.04
Unemployed/retired	2.45	Rural resident	36.96

of consumers' sociodemographic characteristics, purchasing behavior, and perceived value factors to select independent variables of prediction models.  $\chi^2$  test was a hypothesis test based on  $\chi^2$  distribution. First, it was assumed that each influencing factor was not related to attribute preferences of fresh grapes, and then calculated deviation between observed value and theoretical value, namely  $\chi^2$  value. If the result of  $\chi^2$  test was significant and the  $\chi^2$  value was large, it tended to reject the original hypothesis, indicating that this influencing factor was related to the corresponding attribute preferences of table grapes.

### Prediction model

Logistic regression is often used for model prediction (Pucci *et al.*, 2019). The dependent variables used in this

Table 2. Assignment of independent variables.

Variables	Symbols	Definitions
Sociodemographic characteristics		
Gender	$x_1$	1 = male, 0 = female
Age	$x_2$	1 = 25 years old or less; 2 = 26–45 years old; 3 = 46 years old and more
Education	$x_3$	1 = junior high and below; 2 = high school; 3 = junior college; 4 = undergraduate; 5 = master's degree and above
Personal disposable income	$x_4$	1 = 5000 RMB or less; 2 = 5001–15,000 RMB; 3 = 15,001 RMB and more
Purchasing behavior		
Annual consumption	$x_5$	1 ≤ 10 kg; 2 = 11–20 kg; 3 ≥ 21 kg
Price preference	$x_6$	1 ≤ 20 RMB/kg; 2 = 21–40 RMB/kg; 3 ≥ 40 RMB/kg
Perceived value factors		
Size importance	$x_7$	Degree of influence (ranging from minimal (1) to maximum (5))
Shape importance	$x_8$	Degree of influence (ranging from minimal (1) to maximum (5))
Color importance	$x_9$	Degree of influence (ranging from minimal (1) to maximum (5))
...	...	...
...	...	...
Traceability of planting information	$x_{28}$	Degree of influence (ranging from minimal (1) to maximum (5))

study were binary variables, so this paper used binary logistic regression to construct consumer preference prediction models (Allison 2012). First, each option of independent variables was assigned, as shown in Table 2.

$$y = P \quad P = \frac{1}{1 + e^{-y}} \quad (1)$$

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n \quad (2)$$

$$\text{logit}(P) = \ln \frac{P}{1-P} = \beta_0 + \sum_{i=0}^m \beta_i x_i \quad (3)$$

The binary logistic regression model is shown in Equation (1), where  $y$  represents the attribute value selected by the consumer, and  $P$  represents the probability that the consumer prefers  $y$ .  $y$  In Equation (1),  $y$  is a linear combination of each independent variable,  $x_i (i = 1, 2, \dots, n)$ . In Equation (2),  $\beta_0$  represents the constant term  $\beta_i$ , representing the regression coefficient of independent variable,  $x_i$ , and  $n$  is the number of influencing factors. Another common linear form of binary logistic model can be obtained by logit transformation of  $P$ , as shown in Equation (3).

## Results and discussion

### Consumers' intrinsic attribute preferences for table grapes

The attributes of table grapes mainly include intrinsic attributes and extrinsic attributes. The intrinsic attributes referred to in this paper are inherent and unchangeable attributes of grapes (Mu *et al.* 2019), including size, shape, color, aroma type, aroma degree, texture, taste, seedless degree, skin powder, and peeling degree. Among these, size, shape, and color are the most important visual attributes for consumers (Predieri *et al.*, 2021), while the attributes related to taste, such as type and degree of aroma, texture, taste, seedless degree, skin powder, and peeling degree, determine the value experience of grape consumption (Zhou *et al.*, 2015). This paper analyzed the intrinsic attributes of table grapes that have attracted much attention. The statistical results of consumer preferences for various intrinsic attributes of table grapes are summarized in Table 3.

Our results showed that in terms of berry size, the participants preferred medium berries of about 2 cm in

diameter (68.20%), although large berries of about 2.5 cm in diameter (52.64%) also had great market potential. In terms of berry shape, the participants preferred spherical or near-spherical shape (63.44%), although more than half of the participants were also interested in oval berries, partly because consumers had limited knowledge of elongated finger and cylindrical grapes. In terms of berry color, the participants preferred purple-red (57.08%) and purple-black (53.01%), although green (45.40%) berries also occupied a large consumption market. The common aroma types of table grapes included strawberry aroma, rose aroma and non-aroma types (Mu *et al.* 2019), among which strawberry aroma type (45.31%) was the most popular one. For aroma degree, the participants preferred light aroma (47.13%). Among all texture types, soft flesh and juicy (55.23%) was the most popular type for the participants. Among taste types, the participants preferred sweet (89.98%) grapes. With the development of breeding technology, people are able to have seedlessness of most grape varieties (Akkurt *et al.*, 2019). Consistent with the global table grape consumer preferences, most Chinese consumers preferred seedless grapes (73.68%). Skin powder is a layer of powdery substance attached to the skin of grapes; it protects the berries during growth

**Table 3.** Statistical results of consumer preferences for various intrinsic attributes of table grapes.

Attributes		Statistical results						
Visual attributes								
Size*	Small	Medium	Large			Extra large		
	12.12%	68.20%	52.64%			5.69%		
Shape*	Spherical or near-spherical	Oval	Elongated finger	Cylindrical		Other		
	63.44%	53.31%	25.72%	11.91%		1.71%		
Color*	Yellowish white	Green	Yellowish green	Pink	Red	Purple-red	Purple-black	Other
	10.55%	45.40%	20.03%	17.14%	21.92%	57.08%	53.01%	0.39%
Value attributes								
Aroma type	Rose aroma	Strawberry aroma						
	45.31%	41.63%						
Aroma degree	Rich aroma	Light aroma						
	36.64%	47.13%						
Texture	Crunchy texture	Soft flesh and juicy						
	35.52%	55.23%						
Taste	Sweet	Sour with sweet						
	89.98%	7.82%						
Seedless degree	Seeded	Seedless						
	6.27%	73.68%						
Skin powder	Thick skin powder	Thin skin powder						
	28.95%	38.60%						
Peeling degree	Easy to peel	Difficult to peel						
	64.55%	14.18%						

Note: \*Attributes represented multiple-choice questions in the given questionnaire.

period, reduces diseases and pests (Fan *et al.*, 1999; Yin *et al.*, 2011), and has no adverse reactions on human consumption. However, many consumers believe that skin powder is a pesticide residue, which leads to a few people liking grapes' skin powder. Most consumers preferred thin skin powder (38.60%). For the peeling degree, most participants preferred grapes that were peeled easily (64.55%).

### Prediction models of consumers' intrinsic attribute preferences for table grapes

This paper used  $\chi^2$  analysis to explore the influence of consumers' sociodemographic characteristics, purchasing behavior, and perceived value factors for consumer preferences. Then we selected the factors related to the

attribute preferences of table grapes as independent variables and grape attributes as dependent variables, and used binary logistic regression algorithm to construct and test the prediction models of consumers' intrinsic attribute preferences for table grapes.

### Factors influencing attribute preference of table grapes

This paper used  $\chi^2$  analysis of contingency table to explore the influence and correlation of consumers' sociodemographic characteristics, purchasing behavior, and perceived value factors on the attribute preferences of table grapes to select independent variables of prediction models. We collated the  $\chi^2$  analysis results of all influencing factors and the attributes of table grapes as shown in Table 4. The  $\chi^2$  values marked with superscript

**Table 4.** Results of  $\chi^2$  analysis.

	Size diversity	Shape diversity	Color diversity	Aroma type	Aroma degree
Sociodemographic characteristics					
Gender	4.056*	0.542	10.514*	0.442	1.821
Age	22.458*	34.704*	9.501*	5.595	20.428*
Education	9.502	24.301*	19.943*	15.833*	69.272*
Personal disposable income	3.444	13.706*	8.949*	2.969	5.686
Purchasing behavior					
Annual consumption	8.365*	24.807*	48.034*	3.975	7.751*
Price preferences	8.942*	15.755*	5.736	10.032*	4.151
Perceived value factors					
Size importance	19.896*	13.040*	8.691	7.148	11.002*
Shape importance	3.532	5.424	5.615	3.309	7.237
Color importance	4.757	13.254*	23.684*	7.279	12.025*
Aroma type importance	18.697*	15.814*	40.796*	57.213*	183.498*
Aroma degree importance	4.419	6.225	38.617*	39.645*	322.264*
Texture importance	18.940*	29.631*	25.048*	2.549	18.424*
Taste importance	4.411	15.197*	12.174*	7.016	18.192*
Seedless degree importance	7.075	1.193	14.490*	18.056*	1.772
Skin powder importance	4.271	5.630	21.457*	17.683*	7.862
Peeling degree importance	3.247	4.446	5.004	9.445	9.542*
Grape variety cognition	9.220*	32.047*	46.111*	4.247	5.291
Preference for grapes	25.770*	46.913*	49.839*	3.864	11.059*
Price	23.875*	28.341*	14.505*	10.959*	2.806
Freshness	10.826*	21.955*	26.668*	13.546*	4.833
Packaging	17.628*	14.875*	13.264*	9.875*	8.248
Quality	13.776*	25.095*	22.695*	16.537*	2.449
Variety	14.857*	25.124*	16.003*	11.509*	3.070
Sales environment	12.177*	30.922*	17.924*	4.208	9.740*
Pollution-free or green certification	24.034*	21.594*	17.300*	1.137	41.010*
Brand	26.285*	20.250*	9.618*	2.078	9.561*
Place of origin	19.402*	17.724*	18.289*	4.075	3.304
Traceability of planting information	15.301*	11.223*	11.578*	4.752	6.930
$\chi^2 p < 0.05$					
(continues)					

Table 4. (Continued).

	Texture	Taste	Seedless degree	Skin powder	Peeling degree
Sociodemographic characteristics					
Gender	4.056*	0.542	10.514*	0.442	1.821
Age	22.458*	34.704*	9.501*	5.595	20.428*
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Traceability of planting information	15.301*	11.223*	11.578*	4.752	6.930

Note:  $\chi^2$  values indicate that there is a significant relationship between the influencing factors and attributes ( $p < 0.05$ ). Diversity in size, shape, and color refers to the number of attribute values selected by participants for each attribute.

asterisks\* indicated that the original hypothesis was rejected ( $p < 0.05$ ), which means that this influencing factor had a significant relationship with the corresponding attribute of table grapes.

It is observed in Table 4 that the age factor is very important in sociodemographic characteristics and has a significant impact on all 10 grape attributes. Among the purchasing behavior factors, the annual consumption was related to the other nine grape attributes, except skin powder. Among the perceived value factors, the texture importance factor was related to the other nine grape attributes, except aroma type, and the freshness factor was related to the other nine grape attributes, except the aroma degree. Factors such as aroma type importance,

preference for grapes, packaging, quality, and variety were related to eight grape attributes. The mentioned 10 factors were proved as important influencing factors for consumers' purchasing behavior (Chu *et al.*, 2020; Kleih and Sparke, 2021; Marques *et al.*, 2021; Siegrist *et al.*, 2013; Szczesniak, 2002; Taylor *et al.*, 2019; Uribe *et al.*, 2020; Verbeke, 2015; Wang *et al.*, 2021a).

#### Construction of prediction models

In this paper, binary logistic regression of SPSS 27.0 was used to construct the prediction models of consumers' intrinsic attribute preferences for table grapes in combination with the previous selection results of influencing

factors. The complete parameter estimation results of each attribute are summarized in Table A1 given in Appendix. Parameter estimation results reflected the fitting degree of the model, and effectiveness of the influencing factors. Significance value  $<0.05$  demonstrated that the influencing factor had a significant impact on the attribute preference of table grapes. The influence results of the 10 most important factors of table grape attribute preferences are summarized in Table 5.

It is observed in Table 5 that compared to elderly consumers, young consumers had higher acceptance of grapes with rich aroma, crunchy texture, sour with sweetness, seedlessness, thin skin powder, and peeling difficulty. They preferred grapes with diverse sizes and shapes, which indicated that young people pursued grape quality, gave attention to visual effects, and were more inclusive regarding different grapes varieties. This type of consumer group had a strong ability to accept new grape varieties.

**Table 5.** Partial parameter estimation results of prediction models.

	Size diversity	Shape diversity	Color diversity	Aroma type	Aroma degree
$x_2$	-0.161*	-0.159*	0.014		0.258*
$x_5$	0.080	0.158*	0.238*		-0.010
$x_{10}$	0.011	0.000	0.012	-0.181*	-0.299*
$x_{12}$	0.076	0.122*	0.088		0.125*
$x_{18}$	0.222*	0.338*	0.349*		-0.154*
$x_{20}$	0.003	0.055	0.075	-0.002	
$x_{21}$	0.020	0.017	0.037	0.032	
$x_{22}$	-0.004	0.021	0.032	-0.023	
$x_{23}$	0.003	-0.099*	-0.064	0.000	
$x_{26}$	0.026	-0.003	-0.076*		0.088*
$p < 0.05$					
	Texture	Taste	Seedless degree	Skin powder	Peeling degree
$x_2$	0.422*	-0.343*	-0.225*	-0.071	-0.158*
$x_5$	0.099	0.049	-0.160		-0.153*
$x_{10}$	0.146*			0.043	0.019
$x_{12}$	-0.198*	-0.085	0.146	0.137*	-0.259*
$x_{18}$		-0.318*	0.156	0.127	-0.016
$x_{20}$	-0.081	-0.057	-0.107	-0.003	-0.196*
$x_{21}$		0.055	-0.021	0.027	0.129*
$x_{22}$		-0.141	0.145	0.182*	0.106
$x_{23}$	-0.039		0.001	-0.041	0.148*
$x_{26}$	0.033	0.156*	-0.118	-0.057	-0.002

Note: \*Values indicate that the result is statistically significant ( $p < 0.05$ ).

Consumers who often ate grapes had a higher acceptance of difficult-to-peel grapes, and they had more fixed preferences for the shape and color of grapes. Therefore, traditional grape varieties, such as Summer Black, Sunshine Rose, Red Earth, or their preferred varieties, could be recommended for such a consumer group.

Aroma-conscious consumers obviously preferred grapes with rose aroma, rich aroma, and soft flesh and juicy varieties. Texture-conscious consumers preferred grapes with light aroma, crunchy texture, thin skin powder, and easy-to-peel varieties; their preference for the shape of grapes was more diversified, which indicated that such consumers gave more attention to the taste of grapes. Consumers with a higher liking for grapes preferred grapes with rich aroma and sweet taste, and they had diversified requirements for the size, shape, and color of grapes; therefore, some new or unpopular grape varieties were favored for this type of consumer group.

Freshness-conscious consumers preferred easy-to-peel grapes. Packaging-conscious consumers preferred difficult-to-peel grape varieties. Easy-to-peel grapes often had a soft taste, while difficult-to-peel grapes often had a crunchy taste.

Consumers who valued packaging were potentially motivated to purchase grapes as gifts. While using grapes as gifts, such consumers usually chose difficult-to-peel grape varieties with crunchy taste. Therefore, consumers who valued packaging preferred difficult-to-peel grapes. Quality-conscious consumers preferred grapes with thin skin powder. This was because skin powder could lead to a bad eating experience, and some consumers felt that skin powder was like a dust, and even high-quality consumers did not accept grapes with skin powder.

Variety-conscious consumers preferred difficult-to-peel grapes, and their preference for shape of grapes was relatively simple. Brand-conscious consumers preferred grapes with light aroma, sweet and sour taste, and their preference for grape color was relatively simple. This indicated that consumers who valued grape sources had fixed preferences, and it was not suitable to recommend new grape varieties to them.

After constructing the prediction models, we compared the prediction results of each model to the actual situation, and tested the prediction performance of all models. The prediction results for each attribute are shown in Table 6. It is observed in the table that the binary logistic regression application performed well in the preference prediction of intrinsic attributes of table grapes, and the prediction results for taste, seedless degree, and peeling degree of table grapes were excellent, with more than 80% prediction accuracy. Although the prediction results

Table 6. Results of prediction models.

Model	Accuracy (%)	Model	Accuracy (%)
Size diversity	61.7	Texture	65.8
Shape diversity	59.5	Taste	92.0
Color diversity	59.8	Seedless degree	92.1
Aroma type	56.8	Skin powder	65.7
Aroma degree	67.3	Peeling degree	82.1

for shape diversity, color diversity and aroma type of table grapes were low, they were very close to 60%.

Based on  $\chi^2 - \chi^2$   $\chi^2$ -test results, this paper used binary logistic regression to predict intrinsic attribute preferences of Chinese table grape consumers. The probability of consumer preferences for each attribute value of table grapes was obtained by using the models constructed in this paper, which not only provided references for table grape breeders and marketers in China's table grape consumption market but also had certain references significant to the prediction of consumers' attribute preferences of other fruits.

## Conclusion

Based on the results of our national survey on table grape consumers, this paper established an in-depth discussion on the attribute preferences of Chinese consumers of table grapes. Chinese table grape consumers tended to choose medium berries, which could be related to the influence of the doctrine of mean on Chinese people (Cui *et al.*, 2022; Feng *et al.*, 2011; Zhou *et al.*, 2015). Too large or too small grapes were not very popular with Chinese consumers. Spherical and oval grapes were more common in the market, so most consumers preferred these two shapes, although many consumers also preferred elongated finger-shape and cylindrical grapes. Moreover, many consumers had no knowledge about these two shapes of grapes and buy these shapes of grapes out of curiosity so they had a great potential in the market. As far as the color of table grapes is concerned, the grapes with lighter colors were not of much concern for consumers. The common green, purple-red, and purple-black grapes in the market were more popular with consumers. In terms of aroma of table grapes, light aroma and rose aroma were more popular with consumers. In terms of taste of table grapes, consumers preferred soft flesh and juicy, sweet taste, seedlessness, thin skin powder, and easy-to-peel grape varieties, which were more palatable and had great development space.

In this study, we constructed prediction models of consumers' attribute preferences for table grapes in China

after studying the influencing factors of intrinsic attribute preferences of consumers. First, we used  $\chi^2$  analysis to screen the factors that affected consumer preferences for different attributes. Our results showed that age was the most important factor, which had a significant impact on all 10 grape attributes. Other sociodemographic characteristics had different degrees of influence on these attribute preferences. This was because consumers of different age groups had different dietary habits, which greatly affected consumer preferences for intrinsic attributes, such as texture, taste, and seedless degree.

Among the purchasing behavior factors, annual consumption was more important, which was related to other nine grape attributes, except skin powder. This showed that the consumption of table grapes greatly affected consumers' taste and preference for grapes. In other words, the higher the consumption of table grapes, the more obvious the preference for each attribute of grapes.

Perceived value factors mainly referred to the degree of consumers' attention to various attributes of table grapes. Different consumers valued different factors while purchasing grapes. Therefore, perceived value factors were important to affect consumer preferences. Among them, consumers' attention to texture, freshness, brand, aroma type, preference for grapes, packaging, quality and variety were relatively important factors. According to these sociodemographic characteristics, purchasing behavior, and perceived value factors, this paper used binary logistic regression to construct prediction models. Most models predicted consumer preferences for some intrinsic attributes of table grapes with a high accuracy of 80%, which was used to predict consumer preferences for taste, seedless degree, and peeling degree of table grapes. This indicated that we easily and accurately determined consumer preferences for the aforementioned grape attributes, and recommended varieties that satisfied their preferences based on the predicted results of these attributes. However, the predictive results of logistic regression for shape diversity, color diversity, and aroma type attributes were not very ideal. On the one hand, it indicated that these attributes were difficult to be predicted accurately, and on the other hand, it indicated that these attributes were not as important as taste, seedless degree, and peeling degree of table grapes when recommending varieties to consumers.

In the future work, our approach may need the following improvements:

First, our survey was conducted online, and most of the participants were well-educated young people, which may have caused our results not to be completely universal. Owing to rapid development

of the economy, table grapes have become one of the most common fruits, and the characteristics of consumers must be more diversified.

Second, our research was conducted from June 2022 to July 2022, which was relatively simple in terms of time. In the future, we can focus on the trend of preference change over time in the research of Chinese consumer preferences, and can conduct longitudinal comparative analysis of consumer preferences in different periods.

Finally, our question design only focused on the attributes of table grapes, not being specific to certain varieties. There could be deviations between survey results and actual preferences, so designing of the questionnaire can be optimized.

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## Conflict of interest

The authors declared to have no conflict of interest.

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## Appendix

Table A1. Parameter estimation results of prediction models.

	Size diversity	Shape diversity	Color diversity	Aroma type	Aroma degree
Intercept	-1.882	-2.226	-3.356	1.031	1.705
$x_1$	-0.161		0.199		
$x_2$	-0.161	-0.159	0.014		0.258
$x_3$		0.064	0.057	-0.045	-0.221
$x_4$		0.099	0.018		
$x_5$	0.080	0.158	0.238		-0.010
$x_6$	0.075	0.046	0.008	-0.119	
$x_7$	0.052	-0.009			-0.025
$x_8$					
$x_9$		-0.014	0.082		0.125
$x_{10}$	0.011	0.000	0.012	-0.181	-0.299
$x_{11}$			0.062	-0.082	-0.568
$x_{12}$	0.076	0.122	0.088		0.125
$x_{13}$		-0.013	-0.061		0.019
$x_{14}$			0.035	-0.121	
$x_{15}$			0.023	0.127	
$x_{16}$				0.113	0.030
$x_{17}$	0.102	0.213	0.222		
$x_{18}$	0.222	0.338	0.349		-0.154
$x_{19}$	-0.010	-0.010	-0.032	-0.044	
$x_{20}$	0.003	0.055	0.075	-0.002	
$x_{21}$	0.020	0.017	0.037	0.032	
$x_{22}$	-0.004	0.021	0.032	-0.023	
$x_{23}$	0.003	-0.099	-0.064	0.000	
$x_{24}$	-0.018	0.076	0.046		0.114
$x_{25}$	0.060	-0.013	-0.020		0.182
$x_{26}$	0.026	-0.003	-0.076		0.088
$x_{27}$	0.034	0.061	0.071		
$x_{28}$	-0.003	0.000	0.000		

(continues)

Table A1. (Continued).

	Texture	Taste	Seedless degree	Skin powder	Peeling degree
Intercept	-0.091	-0.996	1.812	0.073	-1.989
$x_1$	-0.117		0.241	0.232	-0.245
$x_2$	0.422	-0.343	-0.225	-0.071	-0.158
$x_3$	-0.010		0.084		
$x_4$	0.112				
$x_5$	0.099	0.049	-0.160		-0.153
$x_6$	-0.269				0.214
$x_7$	0.182	0.004			
$x_8$			-0.272	-0.060	-0.005
$x_9$		-0.041			-0.084
$x_{10}$	0.146			0.043	0.019
$x_{11}$	-0.016			-0.141	0.044
$x_{12}$	-0.198	-0.085	0.146	0.137	-0.259
$x_{13}$		0.012	-0.025	0.188	-0.155
$x_{14}$	-0.233	-0.066	0.511	0.078	0.144
$x_{15}$	-0.023		-0.181	-0.406	0.252
$x_{16}$	0.278				-0.504
$x_{17}$		0.287	-0.215	-0.314	0.719
$x_{18}$		-0.318	0.156	0.127	-0.016
$x_{19}$			0.005	-0.070	0.118
$x_{20}$	-0.081	-0.057	-0.107	-0.003	-0.196
$x_{21}$		0.055	-0.021	0.027	0.129
$x_{22}$		-0.141	0.145	0.182	0.106
$x_{23}$	-0.039		0.001	-0.041	0.148
$x_{24}$			0.073	0.072	-0.021
$x_{25}$				0.074	
$x_{26}$	0.033	0.156	-0.118	-0.057	-0.002
$x_{27}$	0.042		-0.040	-0.032	0.020
$x_{28}$	-0.006	0.013		-0.029	0.017