

# A Preliminary Study on Consumer Sensory Evaluation and Acceptance of Pomelo Peel Jelly

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## Abstract

Pomelo peel is a by-product from pomelo consumption, but it is also rich in a variety of nutrients and functional substances. In order to solve the environmental problems caused by the large amount of discarded pomelo peels every year, in this study, we recycled pomelo peels to make pomelo yellow peel jelly (PYPJ) and pomelo white peel jelly (PWPJ) according to their different characteristics in pomelo peels. And the consumer sensory evaluation (n = 50) was carried out to explore the consumers' evaluation and acceptance for these two innovative products. The results showed that both jellies received high mean scores for all sensory attributes except PYPJ' taste, and the consumer acceptances of PYPJ and PWPJ were 62% and 92%, respectively. These results displayed that there is a need to further improve PYPJ, and PWPJ is a product recognized by consumers.

## Keywords

Pomelo Peel, Jelly, Sensory Evaluation

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## 1. Introduction

Pomelo (*Citrus maxima*) belongs to the family Rutaceae and is the largest citrus fruit. Pomelo is widely distributed and cultivated in China and Southeastern Asia. China is the largest country in the world for planting pomelo crops, the average planting area of pomelo crops in China is about 1.4 million acres. From 2017 to 2021, the pomelo production of China was 4.67 million tons, 5.05 million tons, 5.08 million tons, 5.12 million tons and 5.16 million tons, respectively. The annual growth rate of pomelo production in China was about 0.78%, accounting for more than 50% of the global yield. The pomelo consumption of China in 2021 and the first half of 2022 was 4.96 and 1.86 million tons, respec-

tively [1] [2]. The pomelo pulp is sweet and juicy, is the main consumed part, but the discarded pomelo peel is thick, accounting for approximately 35% - 60% (w/w) of the fruit [3]. Therefore, the pomelo consumption leads to a large amount of pomelo peel waste every year. However, a lot of research shows that pomelo peel is rich in various nutrients and functional compounds such as dietary fiber, pectin, essential oils and various polyphenols [4] [5] [6] [7] [8]. Among them, dietary fiber accounts for more than 40% (w/w) of pomelo peel based on dry weight, and it is known that dietary fiber may help to decrease appetite, food intake, obesity risk, blood glucose, and cholesterol [9].

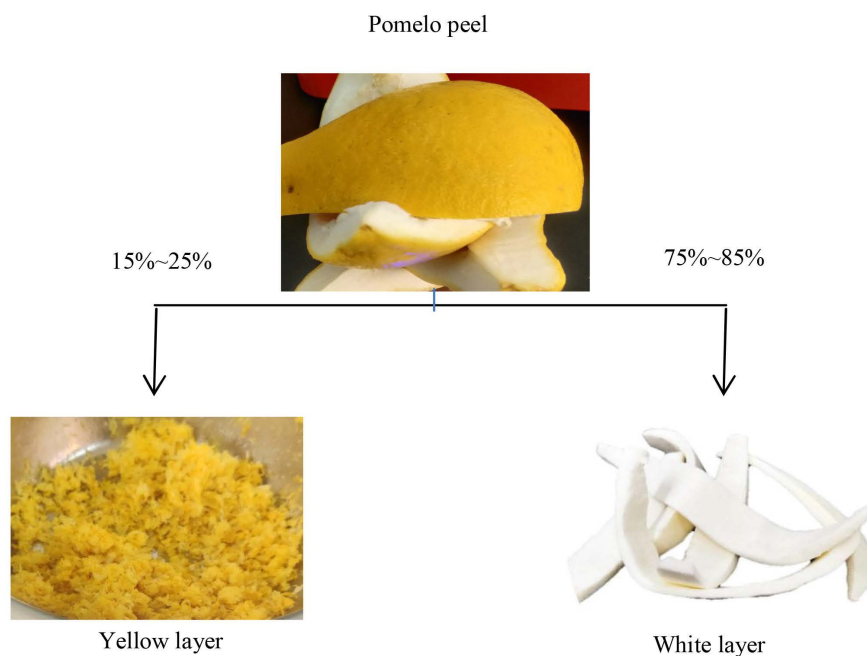
Originally, jelly was popular by consumers because of its low calorie and satiety, and was used as an anti-obesity food [10]. It was reported that jelly market in China has expanded to RMB 32 billion as of December 2022. Jelly has become a snack food with great development advantages [11]. The main ingredients of jelly are water and edible gel (thickener), such as agar, konjac powder, carrageenan, edible gelatin, etc. But in recent years, most of the commercially available jelly is added with sugar, synthetic flavors and artificial colors, which reduces its nutritional value [12], and is even considered as an unhealthy food [13]. Therefore, the purpose of this study was to use Kantan (a thickener extracted from red algae with high fiber content) as a gelling agent and recycle pomelo peel to develop healthy pomelo jellies without adding any chemical flavor and pigment. In this study, the yellow layer and white layer of pomelo peel were separated to prepare two different pomelo peel jellies, respectively, due to their different texture and nutritional characteristics. And then, the consumer sensory evaluation was carried out to explore the consumers' evaluation and acceptance of these two innovative products.

## 2. Materials and Methods

### 2.1. Preparation of Pomelo Peel Jelly

#### 2.1.1. Pretreatment of Pomelo Peel

Pomelo peel was pretreated following the method of our previous research [14]. Firstly, the yellow layer and the white layer of pomelo peel were separated, shown as **Figure 1**. We found that the yellow layer and white layer accounted for about 15% - 25% and 75% - 85% of pomelo peel, respectively. As known, pomelo peel has a strong bitter taste, so it is necessary to remove bitterness before processing. Because the essential oil that contributes to the special pomelo aroma is mainly found in the yellow layer [15] [16], we used a low-temperature (50°C) vacuum method to remove bitterness for the yellow layer in order to retain its aroma as much as possible. On the other hand, the white layer has neither special pomelo aroma nor taste except bitterness, therefore, it was debittered by a usual way. The white layer of pomelo peel was cut into small dices of about 1 cubic centimeter, then was boiled in hot water for 10 minutes and cook repeatedly with fresh water until no bitterness. The pretreated white layer is rich in dietary fiber [17].



**Figure 1.** The yellow and white layers of pomelo peel.

### 2.1.2. Preparation of Pomelo Yellow Peel Jelly

86% Water, 5% sugar, 6% lemon juice, 0.75% salt and 0.4% Kantan solution were mixed well and poured into a jelly container, and 1.5% prepared yellow peel powder was added into the container and stirred evenly into a yellow powder suspension. Finally, the products were put in the refrigerator to cool for gelling. The finished product was pomelo yellow peel jelly (PYPJ) shown as **Figure 2(a)**.

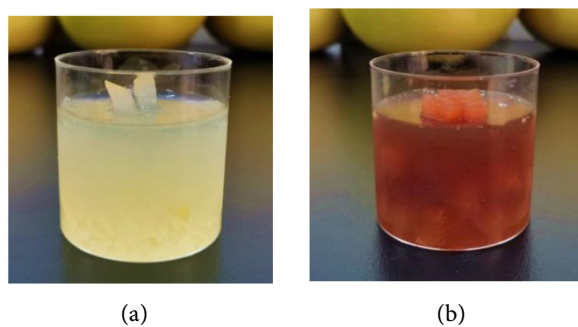
### 2.1.3. Preparation of Pomelo White Peel Jelly

The prepared white peel dices were marinated in plum juice for 1 hour since it has no taste, baked in oven at 55°C for 4.5 hours and then taken out for using later. 79.6% water, 3.5% brown sugar, 1.5% white sugar, and 0.4% Kantan solution were mixed well, and poured into a jelly container, and then 15% marinated white peel dices were added and stirred well, and placed in the refrigerator to cool for gelling. The finished product was pomelo white peel jelly (PWPJ) shown as **Figure 2(b)**.

## 2.2. Consumer Sensory Evaluation and Acceptance of Pomelo Peel Jelly

### 2.2.1. Recruitment of Consumer Participant

A convenience sample of consumers ( $n = 50$ ) was recruited from the faculty, staff, and students of Yulin Normal University, since this experiment was a preliminary study on consumer acceptance for the new products of pomelo peel jellies. Qualified study participants were between the ages 20 to 65 years. Participants were provided with the pomelo peel jellies as tasting samples. Participant characteristics are presented in **Table 1**.



**Figure 2.** Images of pomelo yellow peel jelly (a) and pomelo white peel jelly (b).

**Table 1.** Consumer participant characteristics.

Characteristics	Total population (n = 50)
Female/male (n)	25/25
Age categories in years (n)	
20 - 30	27
31 - 40	11
41 - 50	9
51 - 60	2
>60	1
Occupations	
Faculty	26
Staff	3
Student	20
Others	1
Regions	
Guangxi	28
Henan	5
Hubei	3
Taiwan	3
Hunan	2
Shandong	2
Liaoning	2
Guangdong	1
Shanghai	1
Sichuan	1
Ningxia	1
Yunnan	1

### 2.2.2. Consumer Sensory Evaluation and Acceptance

Consumer sensory perception and acceptance evaluation were performed refer to the methods as described [18]. The questionnaire was filled in with an electronic form through scanning the questionnaire code by a mobile phone. The content of the questionnaire referred to the consumer sensory evaluation design of Xiao *et al.* [18], and was divided into two parts: 1) Basic information including age, gender and occupation, etc. and 2) Sensory evaluation for jellies. The latter included the product appearance, flavor, taste, hardness, innovation and acceptance. The sensory evaluation items used a Likert scale (five-point scale) as the ranking as very poor (=1 point), poor (=2 point), normal (=3), good (=4 point) and very good (=5 point). The Acceptability option consisted of two options: Acceptable and unacceptable. The data were analyzed by using IBM SPSS Statistics 27.

## 3. Results and Discussion

In this study, two products were developed: pomelo yellow peel jelly (PYPJ) and pomelo white peel jelly (PWPJ). The results of their consumer sensory evaluation are described as follows.

### 3.1. Consumer Participant Characteristics

The consumer participant characteristics are presented in **Table 1**. Among the 50 consumer participants, 25 were men and 25 were women, the data showed that the ratio of men to women was 1 to 1. Age distribution, the number of 20 - 30 years old is 27, accounting for 54% of the total; the numbers of people aged 31 - 40, 41 - 50, 51 - 60 and over 61 years old were 11 (22%), 9 (18%), 2 (4%) and 1 (2%), respectively. This result showed that the younger were the majority. Occupations were mostly the faculties (52%) and students (40%). And, most of the participants came from Guangxi.

### 3.2. Consumer Sensory Perception and Acceptance for PYPJ

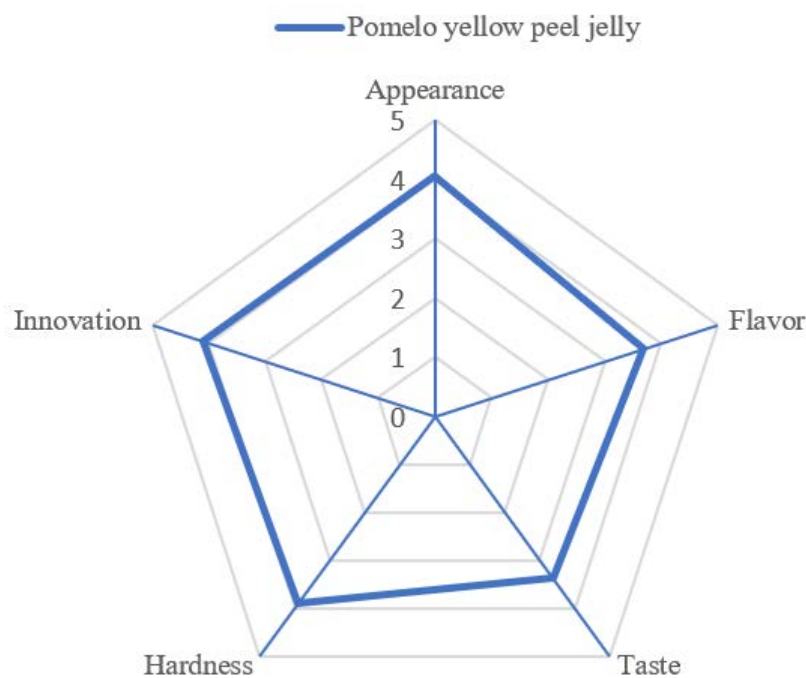
The results of consumer sensory evaluation for the appearance, flavor, taste, hardness and innovation of PYPJ were shown as **Table 2**. With respect to appearance of PYPJ, there were 17 (34%) consumer participants rating “very good”

**Table 2.** Consumer sensory evaluation of pomelo yellow peel jelly (PYPJ) (n = 50).

Sensory attribute	Very good n/%	Good n/%	Normal n/%	Poor n/%	Very poor n/%	Means ± SE
Appearance	17/34%	22/44%	8/16%	3/6%	0/0%	4.06 ± 0.87
Flavor	10/20%	19/38%	17/34%	4/8%	0/0%	3.70 ± 0.89
Taste	8/16%	14/28%	17/34%	11/22%	0/0%	3.38 ± 1.01
Hardness	16/32%	17/34%	13/26%	4/8%	0/0%	3.90 ± 0.95
Innovation	22/44%	14/28%	11/22%	3/6%	0/0%	4.10 ± 0.95

and 22 (44%) consumers rating “good”, these results meant that nearly 80% of consumers were satisfied with PYPJ’s appearance. Regarding flavor, there were 10 (20%) consumers rating “very good” and 19 (38%) consumers rating “good”, these results indicated that nearly 60% of consumers were satisfied with PYPJ’s flavor. In the term of taste, there were 8 (16%) consumers rating “very good” and 14 (28%) consumers rating “good”, these results showed that nearly 50% of consumers were satisfied with PYPJ’s taste. About hardness, there were 16 (32%) consumers rating “very good” and 17 (34%) consumers rating “good”, these results denoted that nearly 70% of consumers were satisfied with PYPJ’s hardness. Concerning the innovation, there were 22 (44%) consumers rating “very good” and 14 (28%) consumers rating “good”, these results illustrated that more than 70% of consumers though PYPJ was an innovative product.

The means of consumer sensory evaluation scores about the appearance, flavor, taste, hardness and innovation of PYPJ were also shown in **Table 2** and **Figure 3**. It is seen from **Figure 3** that the score means of both appearance and innovation were above 4, their ratings were between “good” and “very good”. On the other hand, the score means of flavor, taste and hardness of PYPJ were 3.70, 3.38 and 3.90, respectively. Their ratings were between “good” and “normal”. On the whole, these results indicated that the consumers had a high evaluation about the appearance and innovation of PYPJ, while the evaluation about the flavor and taste of PYPJ were relatively low. In addition, we also found that only 64% of consumers were receptive to PYPJ, which may be because PYPJ is salty unlike the ordinary sweet jelly. Some consumers couldn’t accept it for a while, since they had not eaten salty jelly.

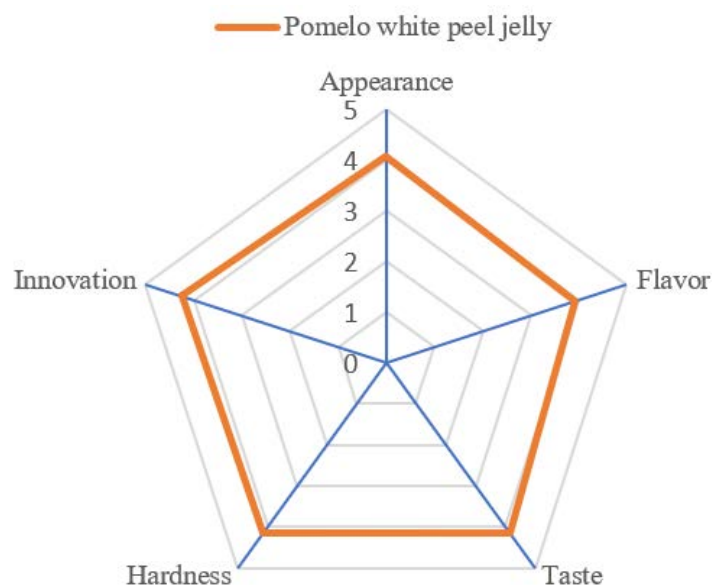


**Figure 3.** Sensory evaluation of pomelo yellow peel jelly (PYPJ) (n = 50).

### 3.3. Consumer Sensory Perception and Acceptance for PWPJ

The results of consumer sensory evaluation for the appearance, flavor, taste, hardness and innovation of PWPJ were shown as **Table 3**. With respect to appearance of PWPJ, there were 14 (28%) consumer participants rating “very good” and 23 (46%) consumers rating “good”, these results meant that more than 70% of consumers were satisfied with PWPJ’s appearance. Regarding flavor, there were 11 (22%) consumers rating “very good” and 25 (50%) consumers rating “good”, these results indicated that more than 70% of consumers were satisfied with PWPJ’s flavor. In the term of taste, there were 17 (34%) consumers rating “very good” and 23 (46%) consumers rating “good”, these results showed that 80% of consumers were satisfied with PWPJ’s taste. About hardness, there were 19 (38%) consumers rating “very good” and 21 (42%) consumers rating “good”, these results denoted that 80% of consumers were satisfied with PWPJ’s hardness. Concerning the innovation, there were 27 (54%) consumers rating “very good” and 11 (22%) consumers rating “good”, these results illustrated that nearly 80% of consumers thought PWPJ was an innovative product.

The means of consumer sensory evaluation scores about the appearance, flavor, taste, hardness and innovation of PWPJ were also shown in **Table 3** and **Figure 4**. It is seen from **Figure 4** that the score means of the appearance, taste, hardness and innovation were above 4, their ratings were between “good” and “very good”. While, the score mean about PWPJ’s flavor was 3.92, its rating was between “good” and “normal”. As the above, these results indicated that the consumers had high evaluations for the appearance, taste, hardness and innovation of PWPJ, while the evaluation about the flavor was relatively low, which may be because the jelly product was cold, the flavor was not strong. According to sensory evaluation surveys, consumers’ acceptance for PWPJ was as high as 92%.



**Figure 4.** Sensory evaluation of pomelo white peel jelly (PYPJ) (n = 5).

**Table 3.** Consumer sensory evaluation of pomelo white peel jelly (PWPJ) (n = 50).

Sensory attribute	Very good n/%	Good n/%	Normal n/%	Poor n/%	Very poor n/%	Means ± SE
Appearance	14/28%	23/46%	11/22%	2/4%	0/0%	4.06 ± 0.82
Flavor	11/22%	25/50%	13/26%	1/2%	0/0%	3.92 ± 0.75
Taste	17/34%	23/46%	10/20%	0/0%	0/0%	4.14 ± 0.73
Hardness	19/38%	21/42%	9/18%	1/2%	0/0%	4.16 ± 0.79
Innovation	27/54%	11/22%	10/20%	2/4%	0/0%	4.26 ± 0.92

## 4. Conclusions

In this study, we took advantage of the different properties of the yellow and white layers in pomelo peel and made them separately to make pomelo yellow peel jelly (PYPJ) and pomelo white peel jelly (PWPJ), respectively. Through the results of consumer sensory evaluation, we found that consumers were satisfied with the appearance of both PYPJ and PWPJ, and affirmed that they were innovative. PYPJ's sensory scores for flavor and hardness are 3.70 and 3.90, respectively, both of which were close to the "good" rating. The sensory score of taste for PYPJ was 3.38, which was not as high as expected, but it was acceptable to 64% of consumers. As we described earlier, this may be because PYPJ was a salty jelly, and some consumers were temporarily unable to accept it based on the existing cognition that jelly should be sweet. However, this also provided a direction for improving PYPJ further.

In addition, the sensory evaluation scores of PWPJ's taste and hardness were 4.14 and 4.16, respectively, which showed that both had been recognized by the consumers. The sensory evaluation score of PWPJ's flavor was 3.92, but it was also close to the "good" rating. Overall, consumers' sensory evaluation for PWPJ was high, and the survey results also showed that the consumer acceptance for PWPJ was 92%. This showed that PWPJ was a recognized product by consumers.

The purpose of this research was to reduce the burden on the environment and recycle discarded pomelo peels to make innovative processed products. From the consumer sensory evaluation results of PYPJ and PWPJ developed by us, it was found that these two jellies do be potential for marketing. These results can provide a new research and development direction for the pomelo processing industry, to solve the problem of a large amount of pomelo peels as a by-product every year, and may also provide consumers with delicious and healthy snack foods to promote their health.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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