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Design and Development of Yellow Watermelon Juice Packaging

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Abstract

This project focuses on developing yellow watermelon juice, emphasizing efficient processing and suitable packaging to extend its shelf life and reduce transportation and storage costs. Yellow watermelon juice is valued for its refreshing flavor but faces challenges such as short shelf life, limiting its year-round availability. The research aims to design, prototype, and evaluate consumer satisfaction with both the taste and packaging of the juice. The scope includes consumer surveys, juice processing, sensory tests, the use of PET bottles, and detailed labeling. Customer satisfaction surveys help understand consumer preferences in packaging. The development process involves creating informative labels to meet customer needs. High-temperature pasteurization methods ensure the juice retains its nutritional value and sensory properties while extending shelf life. The project also highlights the importance of eco-friendly packaging, with PET bottles preferred for their lightweight, recyclable, and convenient properties. PET bottles successfully passed drop testing using the ASTM D2463 standard, ensuring durability during handling, transportation, and storage. Conclusion, the project successfully develops yellow watermelon juice in PET bottle packaging, focusing on consumer acceptance.

1. Introduction

The development of yellow watermelon juice in Malaysia presents unique challenges. Despite the growing popularity of yellow watermelons, efficient processes for juice production and suitable packaging options remain underdeveloped [1]. The project aims to address these challenges by focusing on high-temperature pasteurization to extend shelf life while minimizing nutrient loss. The sensory attributes of yellow watermelon juice, crucial for consumer satisfaction, are also evaluated to ensure the product meets market expectations.

Packaging is crucial for juice preservation, enhancing visual appeal, freshness, and safety. This study focuses on innovative PET bottle packaging and labels, adhering to the Food Act 1983, Food Regulation 1985, and Malaysia Ministry of Health guidelines. By integrating consumer feedback on design and sensory attributes, the goal is to develop a product that aligns with customer preferences and boosts marketability. PET packaging's benefits, including being lightweight, recyclable, and providing a strong barrier against moisture and oxygen, are highlighted.

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This study also discusses the sustainability and environmental impacts of PET packaging, comparing it with other materials. The global rise in plastic usage has significantly impacted the packaging industry, now accounting for over 31% of the 460 million metric tons of plastic used annually [3]. Plastics are favored over glass, metal, and paper due to their versatility in packaging various products. Consumer demand for fresh, perishable items has driven the industry towards adaptable, lightweight, and efficient solutions, spurring growth in innovative materials like biodegradable plastics and polyethylene variants [4]. This shift marks a transformation from traditional methods, like wooden containers, to advanced, sustainable packaging technologies enhancing shelf life and nutritional value [5]. Figure 1 shown the flow of trend in packaging field.

Moreover, the project underscores the importance of apply drop test on PET bottle with contain yellow watermelon juice. This testing aims to simulate drops that can occur while a loaded packaging such as PET bottle is being handled during distribution. By addressing these aspects, the study aims to design and develop the prototype of watermelon juice packaging through drop testing, increase customer satisfaction, and promote sustainable practices. Benefits of yellow watermelon are explored, noting its high nutritional value and potential market appeal. Previous studies on watermelon juice processing and packaging are reviewed, identifying gaps in the existing research and justifying the focus of this study on yellow watermelon juice in PET bottles [6].

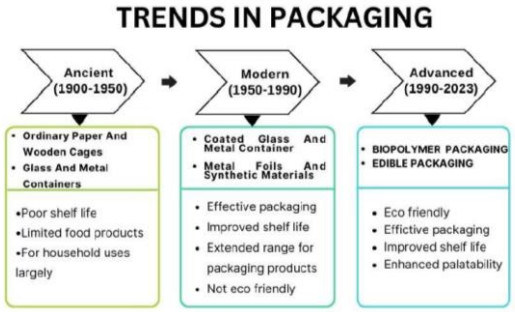

Fig. 1 Trends in Packaging

2. Materials and Methods

Watermelon juice production involves selecting ripe yellow watermelons for optimal taste. After washing to remove surface residues, the peel is removed and the fruit sliced to suitable sizes. Crushing and pressing extract the juice, which undergoes filtration by crushing and pressing machine. Adding juice and ingredients into enzyme tank for cooking process. Pasteurization process ensures safety, with the mixture heated to 80°C for 10 minutes and then cooled to 60°C for 5 minutes. The resulting juice, with a sweetness of 11 Brix. Then bottled in 250ml PET bottles, sealed tightly, and labeled. This meticulous process guarantees a high-quality product, preserving freshness and flavor while prioritizing safety and hygiene. From selection to packaging, each step is crucial in delivering a delicious and nutritious watermelon juice to consumers.

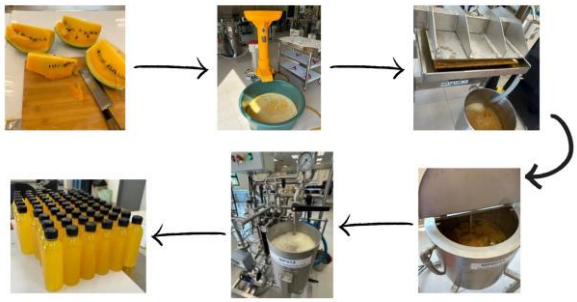

Fig. 2 Pasteurization Process

2.1 Packaging Design and Development

Packaging for yellow watermelon juice is designed to catch the eye customers with its vibrant, sustainable, and functional aesthetics. The final design of the packaging label in Fig. 3(a) was also created and assembled on the PET bottle by using SolidWorks software as shown in Fig. 3 (b-c). It clearly shows the fruit's natural yellow color while following to Food Regulation 1985 through minimalist styling and a yellow watermelon image. Key product details and branding are clearly shown in legible fonts, highlighting health benefits and eco-friendliness, making them particularly appealing to health-conscious customers. Through SolidWorks, a computer aided design software of the PET bottle design with proposed details dimension of PET bottle. 3D modeling and

labeling was done for the PET bottle design in the SolidWorks software with isometric 3D view. Fig. 3(b-c) had shown the engineering drawing in isometric 3D view and dimension of the PET bottle packaging.

(a) (b) (c)

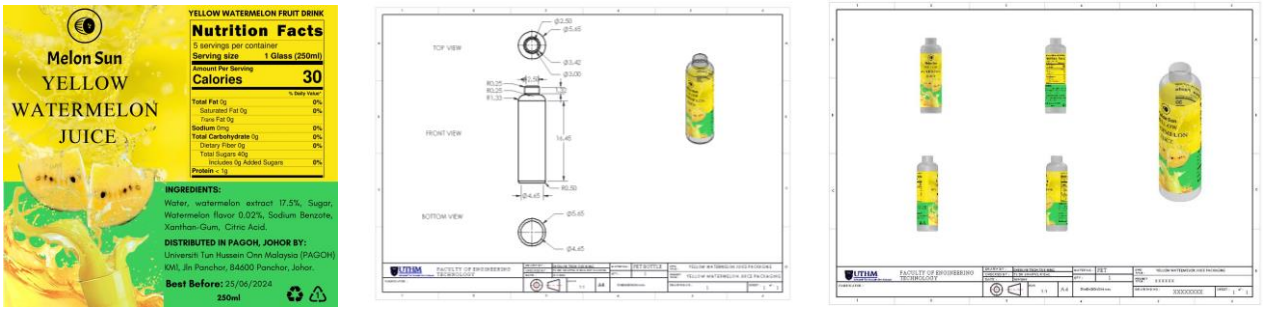

Fig. 3 (a) Label Design (b) Dimension Engineering Drawing (c) Isometric 3D View Design

3. Results and Discussion

3.1 Product Preservation and Quality

In this study, mainly observation 2 types sample of yellow watermelon juice which is Sample J (Pasteurized Yellow Watermelon Juice) and sample F (Fresh Yellow Watermelon Juice). Over four weeks of condition refrigeration at 5°C, fresh juice (Sample F) undergoes significant quality deterioration. By the first week, it shows fermentation symptoms, off-odors, and minor taste and texture changes. In the second week, visible spoilage, including dull color and sour taste, becomes evident. By the third week, extensive microbial growth and strong off-odors indicate significant degradation. By the fourth week, the juice is unsafe for consumption. In contrast, pasteurized juice (Sample J) maintains high quality throughout the same period. It preserves taste, color, and aroma, with only minimal changes over time, and remains microbiologically safe and palatable.

Table 1 Condition Analysis (Refrigeration)

Weekly	Storage Conditions	Sample	Condition Analysis (Refrigeration)	
			Sample F	Sample J
Week 1	5°C (refrigeration)		Fresh juice starts showing fermentation symptoms, off-odors, and slight taste and texture changes.	Pasteurized juice stays safe, maintaining taste, color, and aroma with low microbial counts over time.
Week 2	5°C (refrigeration)		Visible spoilage includes off-odors, dull color, and sour taste, indicating significant quality decline.	The juice still maintains its quality. The juice is still rich in good taste and smell.
Week 3	5°C (refrigeration)		It shows extensive microbial growth, strong off-odors, and significant degradation in color and taste.	The juice continues to be safe and palatable. There may be very slight changes in taste and color.
Week 4	5°C (refrigeration)		The juice is no longer safe for consumption. It shows extensive microbial growth, strong off-odors, and significant degradation in color and taste.	The juice remains microbiologically safe and sensory qualities are well-preserved. Any changes in flavor, color, or nutrient levels are gradual and minimal over the subsequent days.

As results show that over four weeks at room temperature (20-25°C), fresh yellow watermelon juice (Sample F) and pasteurized yellow watermelon juice (Sample J) show distinct changes. Sample F exhibits mild color variations, sedimentation, and pulp separation due to natural enzymatic and oxidative processes, leading to a mellowed flavor over time. In contrast, Sample J maintains its appearance and quality due to pasteurization,

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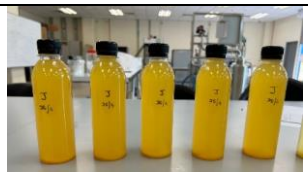
showing minimal texture changes and extended shelf life. PET bottles effectively preserve the natural flavor and quality of the juice by offering excellent gas and moisture barrier properties. Summaries, yellow watermelon juice in PET bottle packaging have more longer shelf life and assist in preserving the natural flavors and taste of the juice better than some other forms of plastic due to their good barrier properties against gas and moisture whatever is in condition refrigeration and room temperature.

Table 2 Condition Analysis (Room Temperature)

Sample	Duration	Storage Condition	Sample	Condition Analysis
Sample F (Fresh Yellow Watermelon Juice)	1 Week	20 to 25 °C (Room Temperature)		**Appearance:** Appear fresh and brilliant in colour. **Texture:** Smooth. **Smell:** Fresh and fruity aroma. **Taste:** Tastes fresh and sweet.
Sample J (Pasteurized Yellow Watermelon Juice)	1 Week	20 to 25 °C (Room Temperature)		**Appearance:** Appear its original color and clarity. **Texture:** Uniform, with no signs of separation. **Smell:** Consistent with initial post-pasteurization smell, no off odors. **Taste:** Tastes fresh and sweet.
Sample F (Fresh Yellow Watermelon Juice)	4 Week	20 to 25 °C (Room Temperature)		**Appearance:** Significant colour deterioration, visible mould or particles. **Texture:** Significant sedimentation and separation. **Smell:** Strong off odors, sour or fermented smell indicative of spoilage. **Taste:** Unpleasant and undrinkable.
Sample J (Pasteurized Yellow Watermelon Juice)	4 Week	20 to 25 °C (Room Temperature)		**Appearance:** Slight color change. **Texture:** A little bit separation. **Smell:** Some off odors may begin to develop. **Taste:** Decline in flavor quality but generally still drinkable.

3.2 Drop Testing for PET Bottles

Drop testing is a mechanical verification process used to assess the quality control, particularly PET bottles, against accidental drops during handling, transportation, or storage. These tests aim to prevent packaging damage and financial losses by ensuring packaging can withstand impacts without compromising content integrity. Findings from drop tests inform packaging design improvements, including material selection and structural reinforcements, to enhance durability and impact resistance. This study applies standard ASTM D2463 which is a widely recognized standard test method for the impact resistance of blow-molded thermoplastic containers such as PET bottles through quick free-fall drop testing. This method applies Procedure A which is Static Drop Height Method involves dropping loaded packaging from a specified height onto a rigid surface and assessing structural integrity post-impact. Ultimately, adherence to such standards enhances packaging quality and durability across various applications, including packaging and shipping. During drop testing for PET bottle with contain 250ml yellow watermelon juice, the packaging of PET bottle was successful protect the yellow watermelon juice even drop from 1.8 meter.

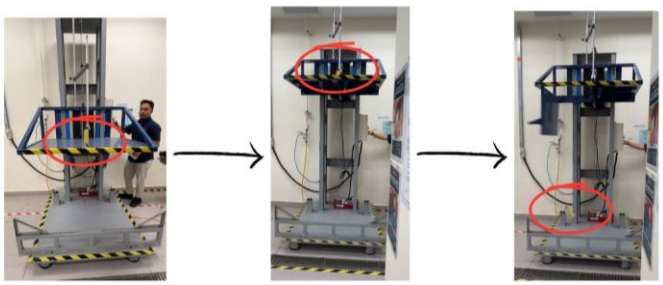


Fig. 4 Drop Test

3.2.1 Interpreting Test Results

As results, visual inspection of the PET bottle before and after the drop test showed no deformations, cracks, or leaks and the only change observed post-test was the formation of some bubbles. Interpreting the results from drop tests involves evaluating several factors to determine the PET bottle passes. In this drop test experiment with PET bottles containing yellow watermelon juice, the bottles were deemed successful based on the criteria such as leakage, visual damage and performance Impact. Figure 6 shown the bottle condition after drop testing.

Fig. 5 PET Bottle Condition After Drop Test

3.3 Feedback and Acceptance

The respondent's feedback collected from UTHM students in Pagoh, Johor, regarding the yellow watermelon juice packaging indicates a positive reception overall. The sensory attributes, including color, odor, sweetness, smoothness, and freshness, are important factors influencing consumer acceptance. Out of 20 respondents, 11 rated the color of the juice at 8, signaling a high level of acceptance. Additionally, a majority of respondents, between 8 and 9 individuals, rated the odor, sweetness, smoothness, freshness, and overall acceptability at 8, signifying strong preference for these sensory properties. These findings suggest that the yellow watermelon juice, packaged in PET bottles, aligns well with consumer preferences in terms of sensory experience. Such insights are invaluable for gauging market trends, understanding customer preferences, and identifying areas for potential improvement in competitive positioning.

(a) (b)

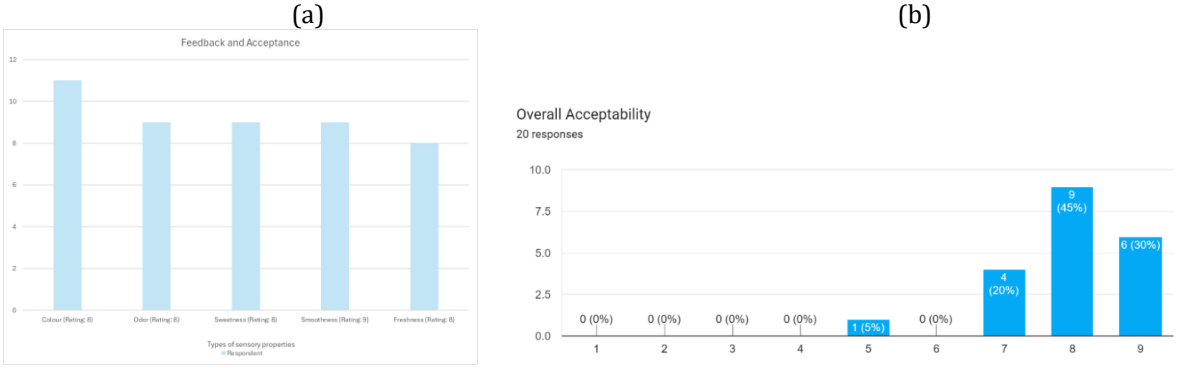


Fig. 6 (a) Sensory Properties Feedback (b) Overall Acceptability

According to a survey, 76.2% of respondents, total 15 individuals, believe that PET bottles do not impact the taste of yellow watermelon juice. They trust in PET's harmless manufacturing process, preserving odors and meeting stringent standards for minimal interaction with contents. Convenience and widespread acceptance further bolster confidence in maintaining juice integrity. Moreover, having 65% of responders favor purchasing yellow watermelon juice in PET bottles due to their lightweight and recyclable nature. The vibrant color in clear PET bottles enhances visual and consumer appeal, promising convenience and sustainability.

(a) (b)

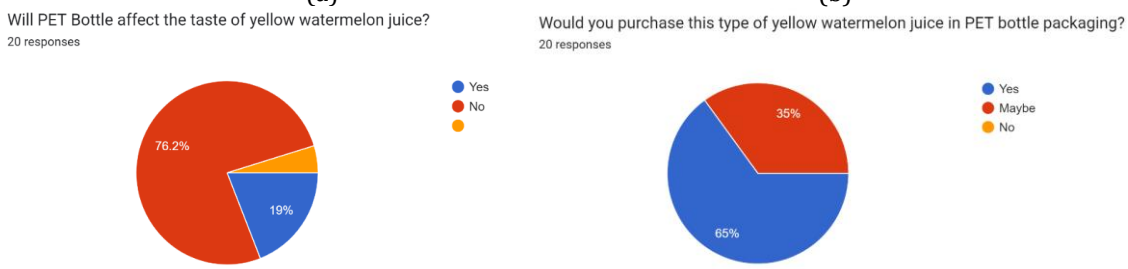


Fig. 7 (a) Will PET Bottle Affect the Taste (b) Purchase Yellow Watermelon Juice in PET Bottle

3.4 Manufacturing and Cost Analysis

The production of yellow watermelon juice packaging involves several critical stages, each contributing to the overall cost. This process encompasses design, material selection, manufacturing, and quality control. Comprehensive cost analysis is essential to assess the pricing strategy effectively. Table 3 below outlines cost elements across these stages, guiding decision-making from raw material procurement to the final packaging.

Table 3 Cost Elements at Each Stage

Stage	Item	Description	Cost
Raw Material Purchasing	Yellow Watermelons	Cost of sourcing yellow watermelons. Price of yellow watermelon is RM3.8/kg. • 42kg of yellow watermelon had used.	RM159.60
	Other Ingredients	Costs for additional ingredients. • Price of sugar is RM2.85/kg - (Was Used 2.30kg) • Price of sodium benzoate is RM13/500g - (Was Used 7.14g) • Price of citric acid is RM3.4/100g - (Was Used 28.57g) • Price of Xanthan Gum is RM6.10/100g - (Was Used 8.57 g)	RM8.24
Juice Processes	Utility Costs	i. Electricity (Minimum payment RM3.00) ii. Water (Minimum payment RM7.00)	RM10
	Labor Costs	Payroll for who in manufacturing products. RM 8 for an hour. • 4 hours in produce yellow watermelon juice with three labors.	RM96
Packaging and Bottling	Packaging Materials	Capital costs for bottling. • Price of bottle and cap is RM0.55/bottle. 93 PET bottle was used	RM51.15
Marketing and Branding	Branding and Design	Costs for labelling design. • Price of labelling is RM2/sheet. 10 pieces labelling was labeled.	RM20

4. Conclusion

The study successfully developed yellow watermelon juice packaging and labeling emphasizes clear, informative labels to meet customer satisfaction. The project highlights the importance of transparent labeling for consumer trust and informed decisions. High-temperature pasteurization preserves nutritional value and extends shelf life, addressing production challenges. Environmentally friendly PET packaging reduces costs and appeals to eco-aware consumers. As results, PET bottle can protect yellow watermelon juice during transportation after passed the Drop Testing ASTM D2463. Overall, the new packaging design is expected to significantly impact the market, consumers, and the environment, focusing on brand differentiation, consumer acceptance, and sustainability for product success.

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