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Evaluation of Antioxidant and Organoleptic Properties of Lycopene-Rich Fruits Jelly

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Abstract

As consumer interest in functional foods rises, lycopene-rich fruit jelly stands out as a flavourful option that aligns with health-conscious lifestyles. This study examined the antioxidant and organoleptic properties of lycopene fruits jelly, which approximately, 25%, 55%, 75% and 100%of papaya and tomato were used to make jelly. A sensory evaluation comprised of 50 participants were done for 8 formulations, 4 formulations for each fruit and each formulation were evaluated for physicochemical proprieties, sensory attributes and antioxidant availability. The moisture content analysis revealed that 100% papaya (P100) jelly had the highest moisture content at 99.94%, while 25% tomato (T25) exhibited the highest moisture content among tomato jellies at 86.880%. The pH levels of the jellies were decreased with increasing the papaya and tomato extract's concentration, which ranged between 5.73 and 4.87. Total soluble solid content of papaya and tomato jellies increased progressively from 22.69 to 28.55 and from 20.46 to 24.50, respectively. Papaya jelly demonstrated a decreasing trend in stickiness from -12.92N to -2.285N and hardness from 33.487 to 9.415 while tomato jelly exhibited fluctuating stickiness, with the lowest at 55%, and an overall increase in hardness from 29.332N to 54.04N. Colour analysis revealed concentration-dependent trends, with papaya displaying significantly decreased ($p<0.05$) in lightness and significantly increased ($p<0.05$) in redness (a*) and yellowness (b*). Antioxidant activity of 100% of papaya and tomato extract in the jellies showing the highest phenolic content, highlighting their potential health benefits. Sensory evaluation favoured 25% of tomato and 55% of papaya extracts in the jellies. In overall, concentration level of the extracted lycopene-rich fruits are crucial in optimizing both physicochemical properties and sensory qualities of the jellies.

1. Introduction

Lycopene stands is a naturally occurring pigment and antioxidant within the carotenoid family, prominently present in red fruits and vegetables such as tomatoes, watermelons, pink grapefruit, guava, and papaya. Its renown extends to potential health benefits, including a reduced risk of specific cancers, heart disease, and age-related eye disorders. Additionally, lycopene is recognized for its anti-inflammatory properties and its potential to protect the skin from damage caused by ultraviolet (UV) radiation [1]. Given that the human body does not produce lycopene, obtaining it through dietary sources or supplements is imperative, especially considering its fat-soluble nature, indicating better absorption when consumed with dietary fat [2].

Papaya and tomatoes emerge as notable fruits rich in lycopene, with the content varying based on factors such as ripeness and fruit variety. Ripe papayas and tomatoes tend to exhibit higher levels of lycopene compared to their unripe counterparts. According to the United States Department of Agriculture (USDA), one cup of cubed, ripe papaya contains approximately 2.6 milligrams of lycopene, though slight variations exist due to factors like the specific variety of papaya and growing conditions. Despite tomatoes being the most recognized source of lycopene, papaya, guava, watermelon, and pink grapefruit also serve as substantial sources of this vital antioxidant compound.

According to Lee *et al*., (2010) [3], jelly production is a method to incorporate lycopene into a palatable dessert. Jellies, known for their pleasing texture and ease of digestibility, often incorporate various additives such as gelling agents, sweeteners, acidulants, colouring agents, and flavourings. Historical uses of diverse fruit varieties in jelly preparation, whether in the form of juice, puree, or concentrate, is contributed to the flavour and colour enhancement as well as to the infusion of phytonutrients beneficial to human health [4]. The integration of plant-derived extracts into jelly formation has become a strategic approach to meet consumer preferences for nutritional value and naturalness while maintaining sensory attributes. This study, in particular, aims to investigate the antioxidant and sensory acceptability of fruit jelly from tomato and papaya.

2. Materials and Methods

2.1 Material

Tomatoes and papayas were collected from the local market around Pagoh, Johor, and papayas sourced from a local farmer in Muar, Johor. The jelly production involved the incorporation of sucrose, gelatine, citric acid, and potassium metabisulphite, all sourced from the brand "Orc Chem" origin of Malaysia.

2.2 Preparation of Tomatoes and Papaya Extract

The fruit was sliced thinly and subjected to gentle heating for a duration of approximately 20-30 minutes until they attained a softened consistency, with amount of water based on the formula Table 2.1. Subsequently, the boiled extract was filtered using a coarse muslin cloth, and the resulting strained extract was utilized in the production of jelly made from tomatoes and papaya fruit [5].

2.3 Preparation of Lycopene-Rich Fruit Jelly

The formulation of jelly was based on established commercial jellies in the industry, albeit with certain modifications. Jelly production was conducted utilizing varying concentrations of extracts present in both tomatoes and papaya. The ingredients comprising of tomatoes and papaya juice, along with water, sugar, gelatin, citric acid, and potassium metabisulphite (KMC), will be prepared. The formulation was decided based on Chen *et al*., (2021)[6].

Table 1 *Ingredient used for preparation of tomatoes jelly*

Ingredients	weight (g)			
	T25	T55	T75	T100
Tomatoes	250	550	750	1000
Water	750	450	250	0
Sugar	550	550	550	550
Gelatin	40	40	40	40
Citric acid	0.5	0.5	0.5	0.5
KMC (Potassium metabilsulphite)	0.03	0.03	0.03	0.03

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Table 2 *Ingredient used for preparation of papaya jelly*

Ingredients	Weight (g)			
	P25	P55	P75	P100
Papaya	250	550	750	1000
Water	750	450	250	0
Sugar	550	550	550	550
Gelatin	40	40	40	40
Citric acid	0.5	0.5	0.5	0.5
KMC (Potassium metabisulphite)	0.03	0.03	0.03	0.03

2.4 Determination of Physicochemical Properties Lycopene-Rich Fruit Jelly

The pH was measured using a pH meter, and total acidity was determined following [7] method. The moisture content was analysed using the rapid moisture analyzer (A&D Company, Limited, ML-50, A&D WEIGHING, Japan) following [8] method, with aluminium pans supporting and measuring the 1 gram of jelly specimens. The texture was analysed by the texture analyzer Stable Micro System TA. XT Plus, Surrey, UK) method described by [9], involved using a conical probe to compress the jelly cubes by 40% of their initial height on double compression. The compression rate was set at 0.5 mm/s, with a 5-second interval between each compression. The entire test procedure was conducted at room temperature to measure hardness and stickiness based on the acquired curve. The total solid content analysis was analysed by using a refractometer (ATAGO, RX-5000α, Japan).

For colour analysis, the colorimeter (MiniScan EZ Hunter Lab 4500) was used to determine the hue of the jelly. The jelly, dispensed into individual sample cups, was undergo calibration, and its hue assessed using a colorimeter. The colour denoted by L*, a*, and b* values, with L* representing lightness, a* indicating red or green values, and b* indicating yellow or blue values [10].

2.5 Antioxidant Activity of Lycopene-Rich Fruit Jelly

The antioxidant assessment of the jelly involved three assays: 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid (ABTS), 2,2- Diphenyl-1-picrylhydrazly (DPPH), and Total Phenolic Content (TPC) . The ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) assay, a well-established method for assessing radical-scavenging abilities. The ABTS assay solution was prepared by combining 7 millimolar ABTS with 2.45 millimolar potassium persulfate, allowing it to incubate in the dark for 12 to 16 hours. Subsequently, 0.15 millilitres of jelly extract was mixed with 0.00385 millilitres of the ABTS·+ solution, and the absorbance was measured at 734 nm. The recorded values were used to calculate the percentage inhibition of ABTS radicals, providing insights into the antioxidant capacity of the jelly samples. This widely recognized assay contributes valuable information about the samples' ability to neutralize free radicals and complements the overall assessment of their antioxidant properties [11][12]. The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity of the jelly samples was determined using a well-established methodology. A stable organic compound, DPPH, served as the indicator to measure the reduction of deep purple DPPH radicals by antioxidants present in the samples. The procedure involved the preparation of varying concentrations of jelly samples, namely P25, P55, P75, and P100 for papaya jelly, and T25, T55, T75, and T100 for tomato jelly. These samples were subjected to the DPPH assay, and the results were compared between papaya and tomato jellies. The percentage of inhibition toward DPPH was calculated, indicating the extent of radical scavenging activity in each sample. The DPPH assay provides valuable insights into the antioxidant potential of the jellies by assessing their ability to neutralize free radicals. The increased DPPH scavenging activity corresponds to higher antioxidant activity, and the results contribute to the overall evaluation of the antioxidant properties of the lycopene-rich fruit jellies [13][14].

Percentage of radical scavenging activity =

$$\frac{ADDPPH.AS}{ADPHH} \times 100 \quad (1)$$

The total phenolic content (TPC) of the antioxidant jelly was determined following a modified version of the Folin-Ciocalteu method, as outlined by [15]. The procedure commenced with the preparation of reagents, involving the addition of 3.16 mL of distilled water to each test tube, followed by the incorporation of 200 µL of Folin-Ciocalteu reagent. Subsequently, 7.5% (w/v) sodium carbonate (0.6 mL) was introduced to the same test tube. The resulting mixture underwent a thorough blending and was left to incubate in darkness at room

temperature for a duration of 90 minutes. Following incubation, the absorbance of the solution was measured at 765 nm using a spectrophotometer. The absorbance values obtained were utilized in the calculation of the TPC, expressed in milligrams of gallic acid equivalent (GAE) per gram of the sample. A calibration curve, constructed with gallic acid as the standard, provided the regression equation ($y = 91.883x - 0.157$, $R^2 = 0.994$), facilitating the quantification of phenolic content in the jelly samples

2.6 Sensory Evaluation

The sensory evaluation conducted utilising a 9-point hedonic scale, with a sample size of 50 untrained panellist. The assessment metric ranges from 1 to 9, wherein 1- Dislike Extremely,2- Dislike Very Much,3- Dislike Moderately, 4- Dislike Slightly,5- Neither Like nor Dislike,6- Like Slightly,7- Like Moderately,8- Like Very Much and 9- Like Extremely. The panellist will be presented with a singular tray comprising of a solitary glass of water, two antioxidant jelly samples that have been assigned coded numbers, and a scorecard form. The individuals comprising the panel proceeded to the designated sensory evaluation space, commonly referred to as the booth area. Subsequently, the red lamp was activated. Upon completion of the test, the panellists are replaced by activating the green lamp, and the tray is subsequently presented.

2.7 Statistical Analysis

Each attribute was assessed in triplicate. Statistical analysis was performed using Minitab 2021 software, and the acceptance trial utilized a randomized full block design, with blocks representing participants and treatments representing formulas. The data were subjected to ANOVA, and Tukey's comparison of the means test was applied with a significance level of ($p \leq 0.05$), following the methodology outlined by [16].

3. Results and Discussion

3.1 Physicochemical Properties of Lycopene-Rich Fruits Jelly

The study demonstrated significant variations in moisture content among lycopene-rich papaya (P25, P55, P75, P100) and tomato (T25, T55, T75, T100) jelly formulations, with P100 and T25 exhibiting the highest moisture levels, emphasizing potential shelf-life limitations [16]. The elevated moisture content in papaya, attributed to papain, hindered jelly consistency, aligning with the findings of [17] and [18] in their studies on mango-pineapple and lychee jelly, respectively [19]. pH values followed a descending order in both papaya and tomato jellies, with the tomato formulation having a lower pH. The total soluble solid (brix) analysis indicated an increase in sugar content in papaya fruit from P25 to P100, while tomato jelly, particularly T100, exhibited the highest brix values [20][21]. Texture analysis revealed varying hardness across formulations, with T55 and T100 tomato formulations being the firmest [5]. Stickiness decreased with higher fruit concentrations in both papaya and tomato formulations. These findings underscore the importance of understanding physicochemical attributes and texture in formulating lycopene-rich fruit jellies [18]. (P25 : 25% concentration of papaya, P55 : 55% concentration of papaya, P75 : 75% concentration of papaya, P100 : 100% concentration of papaya, T25 : 25% concentration of tomato, T55 : 55% concentration of tomato, T75 : 75% concentration of tomato, T100 : 100% concentration of tomato).

Table 3 *Moisture content, pH, total soluble solid (TSS), and texture of the fruits jelly*

Sample	Moisture Content	pH	Brix	Texture	
				Stickiness (g)	Hardness (g)
(P25)	84.21±1.03^{c}	5.73±0.01^{a}	22.70±0.02^{d}	-12.92±16.76^{a}	33.49±1.36^{a}
(P55)	92.89±2.06^{b}	5.57±0.01^{b}	25.70±0.21^{c}	-5.07±2.87^{a}	16.92±0.97^{b}
(P75)	98.65±0.97^{a}	5.54±0.01^{c}	27.62±0.11^{b}	-6.01±4.75^{a}	12.32±1.42^{c}
(P100)	99.94±0.067^{a}	5.48±0.01^{d}	28.55±0.01^{a}	-2.29±0.22^{a}	9.42±0.19^{d}
(T25)	86.88±0.30^{a}	5.26±0.01^{a}	20.46±0.28^{c}	-3.82±0.93^{a}	29.33±0.30^{c}
(T55)	85.16±0.60^{ab}	5.06±0.029^{b}	22.94±0.16^{b}	-10.66±7.63^{a}	39.10±2.10^{b}
(T75)	84.39±2.81^{ab}	4.98±0.001^{c}	23.45±0.19^{b}	-5.04±0.48^{a}	51.45±5.23^{a}
(T100)	81.79±1.20^{b}	4.89±0.012^{d}	24.50±0.52^{a}	-6.310±0.84^{a}	54.40±1.83^{a}

Means values followed by the different letter within a column are significant different ($p<0.05$)

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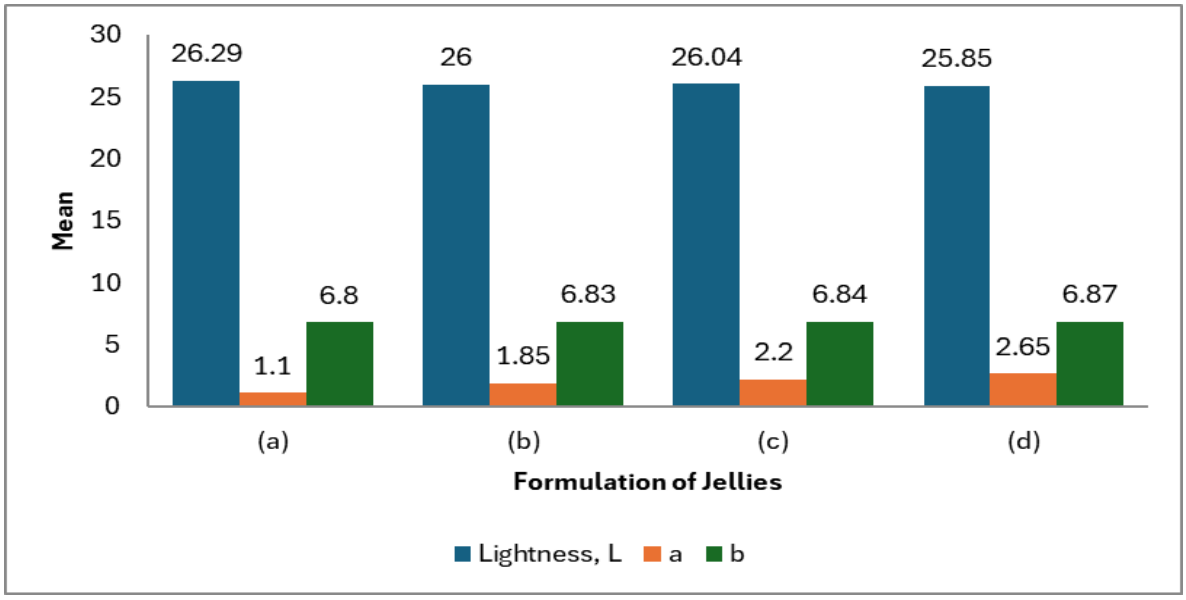
The Hunter Color Lab analysis of lycopene-rich papaya and tomato jelly samples (P25, P55, P75, P100, T25, T55, T75, T100) revealed significant differences ($p < 0.05$) in the L*, a*, and b* parameters, indicating variations in lightness, redness, and yellowness among formulations. In papaya jelly, P25 exhibited the highest lightness (L*) at 26.29, while tomato jelly's T100 displayed the brightest colour at 28.40. The positive a* values representing redness were significantly higher in P100 (2.65) for papaya and T100 (1.39) for tomato. Yellowish colour (b*) was prominent in P100 papaya (6.87) and T25 tomato (6.59). Contrary to these findings, a study by [5] reported higher values of lightness, yellowness, and redness for tomato jelly. The results suggest that papaya significantly contributes to the redness and yellowness of the jelly, attributed to the carotenoids present in both tomato and papaya juices [22].



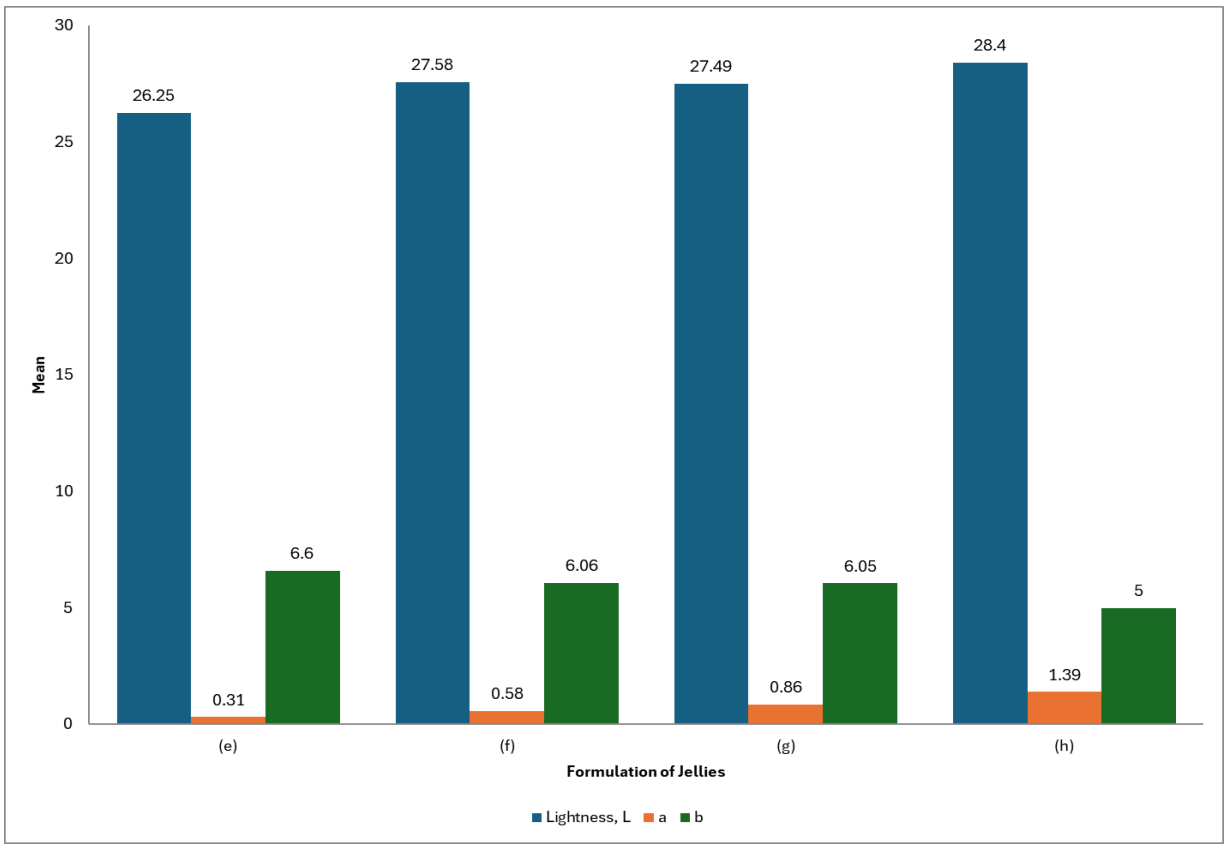


Fig. 1 *Colour Analysis of the fruits jelly (a) 25% of papaya (b) 55% of papaya (c) 75% of papaya (d) 100% of papaya (e) 25% of tomato (f) 55% of tomato (g) 75% of tomato (h) 100% of tomato*

3.2 Antioxidant Activity

Table 4 *2,2- Diphenyl-1-picrylhydrazly (DPPH), Total Phenolic Content (TPC)of 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid (ABTS) of lycopene-rich fruits jelly*

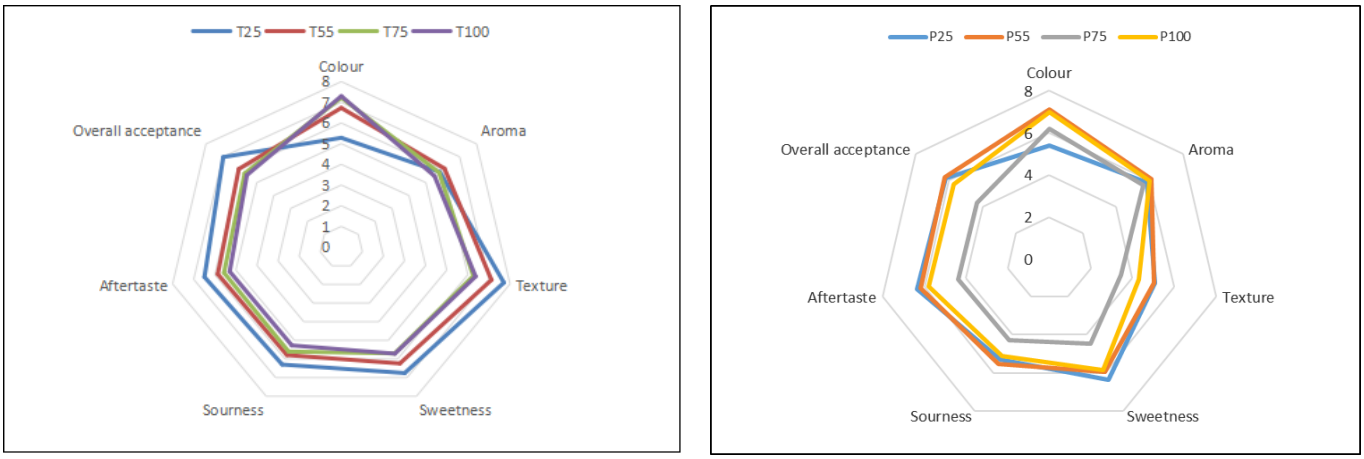
Sample	DPPH(%)	TPC(mg GAE/g)	ABTS(%)
Pure papaya (PP)	65.51±2.19^{a}	0.03±0.002^{c}	75.23±0.382^{a}
(P25)	32.86±2.48^{e}	0.02±0.0002^{d}	9.88±0.12^{b}
(P55)	40.90±0.21^{d}	0.03±0.001^{bc}	22.07±0.24^{b}
(P75)	45.53±0.82^{c}	0.03±0.001^{b}	22.2±18.80^{b}
(P100)	50.20±0.72^{b}	0.04±0.0005^{a}	66.92±0.11^{a}
Pure tomato (PT)	92.62±1.48^{a}	0.02±0.0006^{a}	88.39±0.90^{a}
(T25)	46.55±3.60^{d}	2.31±3.98^{a}	60.26±0.98^{d}
(T55)	52.13±2.63^{d}	0.01±0.00005^{a}	68.23±0.42^{c}
(T75)	62.14±1.62^{c}	0.01±0.001^{a}	79.08±0.49^{b}
(T100)	74.92±0.78^{b}	0.02±0.004^{a}	88.12±0.85^{a}

Means values followed by the different letter within a column are significant different ($p<0.05$)

The radical scavenging activity (RSA) of papaya and tomato jellies was assessed through DPPH and ABTS assays, along with total phenolic content (TPC) determination. The DPPH results revealed significant differences ($p < 0.05$) between papaya and tomato jellies, with P100 (50.20%) and T100 (74.92%) exhibiting substantial inhibition, approaching pure papaya (65.51%) and tomato (92.627%), respectively [23]. This could be due to the high amount of antioxidant activity present in tomato compared to papaya fruits. This reason was agreement by study from [24] that found tomato (104.7) had high amount of lycopene compared to papaya (45.34%). The ABTS assay demonstrated that P100 (66.92%) and T100 (88.12%) had high antioxidant activity, closely resembling pure papaya (75.23%) and tomato (88.39%) [24]. Nevertheless, the outcomes obtained markedly surpass the findings reported in an earlier investigation by [25], where ABTS values ranged from 314.90 µmol/100 g for grapefruit jelly to 807.70 µmol/100 g for blood orange jelly, and beetroot jelly exhibited an ABTS content of 6.39-13.94% [26]. TPC analysis showed significant differences ($p < 0.05$) between papaya formulations, with P100 having the highest phenolic content (0.038418 mg GAE/g), surpassing pure papaya [22]. In contrast, tomato jelly, especially T100 (0.015866 mg GAE/g), approached the phenolic content of pure papaya. The antioxidant capacities of jellies increased along with the polyphenolic compounds (TPC), proving a positive relationship between them [27]. This could be due to the high amount of activity phenolic content in papaya compared tomato. This reason was agreement by study from [28] that found papaya (240.7 mg GAE/g) had high amount of phenolic compared to tomato (91.47 mg GAE/g). Prior studies have demonstrated that jellies incorporating plant-derived extracts or fruit powders rich in polyphenolic compounds exhibit heightened antioxidant efficacy [3][29][30][31].

3.3 Sensory Evaluation

The sensory evaluation data for the tomato and papaya jelly formulations were analysed based on various attributes, including colour, aroma, texture, sweetness, sourness, aftertaste, and overall acceptance.



(a) **(b)**

Fig. 2 *Spider web graph for each attribute of sensory evaluation (a) Papaya jelly; (b) Tomato jelly*

Analysis revealed distinct preferences among consumers. In tomato jelly formulations, T25 (25% tomato) garnered the highest overall acceptance, indicating a preference for a milder tomato flavour that balances well with sweetness. Colour intensity increased with higher tomato content, while aroma scores and texture showed varying trends. Sweetness and overall acceptance declined with increased tomato content. For papaya jelly, P55 (55% papaya) emerged as the preferred formulation, displaying the highest scores in colour and overall acceptance. Similar to tomato jelly, overall acceptance decreased with higher papaya content. P25 (25% papaya) was favoured for a less intense papaya flavour. Thus, lower concentration of fruits should be considerate to produce higher acceptance jelly. Texture played a crucial role in overall acceptance, with higher fruit concentrations generally resulting in lower texture ratings. Aroma consistency across formulations suggested its limited impact on overall acceptance variations.

4. Conclusion

The study identified significant variations in moisture content, pH, brix, and texture among formulations, with 100% concentration of papaya P100 and 100% concentration of tomato T100 (pure tomato) displaying elevated moisture levels, potentially limiting shelf life. Papaya's contribution to the higher jelly's redness and yellowness due to its higher carotenoids. Antioxidant assessments, including DPPH and ABTS assays and total phenolic content determination, underscored the considerable antioxidant potential in both papaya and tomato jellies. Papaya's significant role was evident in P100's approaching inhibition levels and higher phenolic content compared to pure papaya. Sensory evaluation elucidated distinct consumer preferences, favouring T25 (25% of tomato) for a balanced tomato flavour and P55 (55% of papaya) for superior colour and overall acceptance in papaya jelly. Texture emerged as a critical factor, inversely impacting overall acceptance with higher fruit concentrations. These findings emphasize the importance of achieving a balance concentration of the fruits in jelly formulations to enhance the desirable texture and to meet consumer preferences.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: ***study conception and design***, ***data collection***, ***analysis and interpretation of results***, *and* ***manuscript preparation:*** *Norasyikin Jumaatun, Munira Zainal Abidin. All authors reviewed the results and approved the final version of the manuscript.*

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