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Valorization of Jackfruit Agro-waste in Wine Production with Physicochemical and Enological Characterization

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ABSTRACT

Background: Jackfruit (*Artocarpus heterophyllus* Lam.) is a nutrient-rich tropical fruit, but substantial portions like rind, core and undeveloped perigones are discarded, contributing to agro-waste. Valorising these byproducts into wine offers a sustainable approach to reduce waste and produce functional beverages.

Methods: Twenty-one wine formulations were prepared using varying proportions of jackfruit rind, perigones and bulbs. Fermentation was conducted for 15 days with *Saccharomyces cerevisiae* MTCC 170 (5%). Wines were analysed for physicochemical properties (pH, TSS, sugars, alcohol, antioxidant activity), sensory attributes and volatile compounds using GC-MS/MS.

Result: Wines showed pH 3.21-4.22, TSS 6-8 °Brix, alcohol 8-12%, antioxidant activity 50% and total sugars <4%. Sensory evaluation indicated high acceptability, with *Koozha* wines displaying fruity flavour and *Varikka* wines richer in esters. Aging decreased pH and TSS while increasing acidity and alcohol. GC-MS/MS identified varietal-specific volatiles: isopentyl acetate and isoamyl isovalerate in *Koozha* and isobutyl acetate and isopentyl hexanoate in *Varikka* wines, reflecting the influence of rind and perigone composition on aroma development.

Key words: Aroma profile, Byproduct valorisation, Fermentation, Jackfruit wine, *Koozha,* Sustainability, *Varikka*.

INTRODUCTION

Fermentation technology is a metabolic process that transforms perishable raw materials into value-added products such as wine, cider, beer and champagne through the anaerobic conversion of plant-derived carbohydrates by yeast, producing ethanol and carbon dioxide as by-products (Formenti *et al.,* 2014). In recent years, fruit-based fermentation has gained increasing attention as an eco-innovative approach for valorising surplus or waste fruits into functional beverages, thereby contributing to sustainable food systems (Yuan *et al.,* 2024). Apart from grapes, fruits such as apple, plum, pomegranate, apricot, kinnow, guava, mango and litchi have been widely utilized for wine production (Saranraj and Ramesh, 2019).

Fruit wines are appreciated not only for their sensory attributes but also for their bioactive composition and potential health benefits. They contain antioxidants and phenolic compounds that help mitigate oxidative stress and promote cardiovascular wellness (Bensi *et al.,* 2025). Recent studies emphasize that fermentation parameters, yeast selection and technological innovations can significantly enhance the bioactive profile, aroma complexity and stability of fruit wines (He *et al.,* 2024; Tan *et al.,* 2024). Such advances in fermentation biotechnology are driving the development of novel fruit wines with improved quality and nutritional value.

Jackfruit (*Artocarpus heterophyllus*) is a tropical fruit valued for its distinctive flavour and rich nutrient content but remains largely underutilized. During processing, a substantial portion of the fruit including the rind, core, undeveloped perigones and seeds is discarded as agro-waste. These by-products are highly perishable and seasonal, posing disposal challenges for the food industry and contributing to environmental pollution (Rashmi *et al.,* 2011). Recent research underscores the potential of jackfruit waste for biotransformation into energy, bioactive compounds and fermented products within a zero-waste framework (Sarangi *et al.,* 2023; Geetha *et al.,* 2015). The integration of such valorisation strategies supports circular bioeconomy principles and aligns with current trends in sustainable waste management (Niculescu and Ionete, 2023).

Therefore, the present study focuses on developing wine from jackfruit processing waste, aiming to explore its potential as a value-added product that simultaneously mitigates agro-waste challenges and promotes sustainable utilization of underexploited tropical resources.

MATERIALS AND METHODS

The experiment was carried out in 2022 at the Laboratory of Community Science and Nutrition, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India.

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Source of materials

Two jackfruit varieties, *Koozha* and *Varikka* (*Artocarpus heterophyllus*), were sourced from the Instructional Farm, College of Agriculture, Vellayani, Trivandrum, India. The yeast strain *Saccharomyces cerevisiae* MTCC 170 was obtained from the Microbial Type Culture Collection (MTCC), Chandigarh. All analytical-grade chemicals and reagents were procured from HiMedia Laboratories, Mumbai, India.

Table 1: Treatments for wine production from jackfruit parts.

Treatments	Jack fruit juice components (%)	
	Rind and perigones (RP)	Bulbs (B)
	***Koozha* type**	
T_1	100	-
T_2	-	100
T_3	50	50
T_4	60	40
T_5	70	30
T_6	80	20
T_7	90	10
	***Varikka* type**	
T_8	100	-
T_9	-	100
T_{10}	50	50
T_{11}	60	40
T_{12}	70	30
T_{13}	80	20
T_{14}	90	10
	*** Blended *Koozha and Varikka* type**	
T_{15}	100	-
T_{16}	-	100
T_{17}	50	50
T_{18}	60	40
T_{19}	70	30
T_{20}	80	20
T_{21}	90	10

Must and inoculum preparation

Fully ripe jackfruits of both varieties were cleaned and defective parts removed. The rind and undeveloped perigones were separated and blended with fruit bulbs in varying proportions as shown in Table 1 to produce 21 treatment combinations. The must was ameliorated with cane sugar to achieve 20° Brix and the pH adjusted to 4.0 using citric acid. It was then sterilized with 100 ppm potassium metabisulfite and stored at 4°C overnight.

The inoculum was prepared by culturing *S. cerevisiae* MTCC 170 in YEPD broth at ambient temperature (28°C) for 48 hours to achieve an active cell suspension for inoculation (Jagadeesh *et al.,* 2022).

Processing of wine

Fermentation was carried out following the method of Kocher (2011) with modifications. The prepared must was inoculated with 5% (v/v) yeast culture and incubated at 28±2°C for 15 days in 100 ml Erlenmeyer flasks fitted with fermentation traps to monitor CO_2 evolution. The 15-day fermentation period was selected based on preliminary trials indicating complete sugar utilization and stable physicochemical parameters beyond this duration, ensuring optimal flavour and alcohol development without off-flavour formation. The complete experimental setup is illustrated in Fig 1.

Each treatment was conducted in triplicate to ensure reproducibility. Fermentation was deemed complete when CO_2 release ceased and a constant TSS value was recorded. The fermented wine was filtered through sterile muslin cloth to remove coarse particles.

Fig 1: Experimental set up for wine production (Anaerobic).

Siphoning

Post-fermentation, wines were siphoned carefully to remove sediment without using fining agents. This step aided in clarification, reduced tannin harshness and enhanced the overall aroma and appearance. The clarified wines were transferred into sterilized glass bottles and hermetically sealed.

Organoleptic evaluation

Sensory evaluation was conducted by a trained panel using the American Wine Society's 20-point scale, assessing appearance (3), aroma (6), taste/texture (6), aftertaste (3) and overall impression (2). Each coded sample was presented under controlled laboratory conditions to minimize bias.

Physicochemical analysis

- **pH-** Measured using a digital pH meter.
- **Total soluble solids (TSS)-** Determined by a refractometer 0-32° Brix scale (Gomez *et al.,* 2022).
- **Titratable acidity-** Estimated by titration with standard NaOH (Rekha *et al.,* 2012).
- **Reducing sugar-** Determined by the Lane and Eynon method (Gandhi *et al.,* 2017).
- **Total sugar-** Measured by the anthrone colorimetric method (Tavares *et al.,* 2010).
- **Alcohol content-** Determined by dichromate oxidation (Sadasivam and Manickam, 2008).
- **Antioxidant activity-** Evaluated using the DPPH radical scavenging method (Chandraprabha *et al.,* 2025).

Storage studies

The best-performing wine treatments, as determined by sensory evaluation, were stored at ambient temperature (28±2°C) for six months to assess stability and shelf-life.

Microbial examination

Total yeast count was evaluated using the serial dilution technique on yeast extract potato dextrose agar (Bhagavathi *et al.,* 2017).

Volatile flavour compounds-GC-MS/MS analysis

For aroma profiling, 5 ml of each wine sample was mixed with 2 g $MgSO_4$, 0.5 g NaCl and 5 ml acetonitrile. The mixture was vortexed and centrifuged at 6000 rpm for 15 minutes and 1 ml of the supernatant was analysed using a GC-MS/MS system (TSQ 8000, Thermo Scientific). Helium served as the carrier gas at 1 ml/min. The oven temperature was programmed from 40°C to 250°C at 5°C/min.

Compound identification was performed by comparing mass spectra with the NIST MS Search 2.0 library using a similarity index threshold of ≥85%, retention index matching

Table 2: Effect of alcoholic fermentation of jackfruit components on pH, acidity, TSS and ascorbic acid.

Treatments		Ph	Acidity (%)	TSS (°Brix)	Ascorbic acid (mg/100 g)
Koozha	T_1	3.90±0.00^{ghi}	1.12±0.02^{e}	8.23^{k}	15.23±0.45^{a}
	T_2	3.45±0.08^{b}	1.45±0.02^{k}	7.39^{def}	32.5±0.43^{i}
	T_3	3.72±0.11^{cd}	1.33±0.01^{i}	7.59^{fg}	34.23±0.32^{j}
	T_4	3.84±0.02^{efg}	1.10±0.01^{e}	7.84^{hi}	30.28±0.59^{h}
	T_5	3.93±0.014^{ghi}	1.04±0.02^{d}	7.97^{ij}	27.56±0.03^{f}
	T_6	4.01±0.08^{i}	0.92±0.02^{b}	7.99^{ij}	22.32±0.68^{d}
	T_7	4.12±0.02^{j}	0.87±0.01^{a}	8.08^{jk}	17.00±0.48^{b}
Varikka	T_8	3.87±0.04^{fgh}	1.05±0.00^{d}	7.98^{ij}	22.56±0.59^{d}
	T_9	3.33±0.00^{b}	1.32±0.00^{i}	6.45^{b}	45.32±0.42^{p}
	T_{10}	3.84±0.05^{efg}	1.27±0.01^{h}	6.77^{c}	43.78±0.81^{o}
	T_{11}	3.88±0.12^{fgh}	1.17±0.03^{f}	6.92^{c}	40.05±0.08^{m}
	T_{12}	3.89±0.12^{ghi}	1.11±0.01^{e}	7.24^{de}	36.44±0.12^{k}
	T_{13}	3.99±0.07^{hi}	0.97±0.02^{c}	7.41^{ef}	34.78±1.13^{j}
	T_{14}	4.16±0.11^{j}	0.90±0.01^{ab}	7.70^{gh}	31.12±0.99^{h}
Blended	T_{15}	3.77±0.01^{def}	1.16±0.02^{f}	7.76^{gh}	18.34±0.24^{c}
Koozha	T_{16}	3.21±0.03^{a}	1.39±0.01^{j}	6.12^{a}	41.56±1.33^{n}
and	T_{17}	3.65±0.02^{c}	1.37±0.04^{j}	6.51^{b}	38.75±0.33^{l}
Varikka	T_{18}	3.74±0.11^{cde}	1.14±0.01^{g}	6.78^{c}	34.07±0.09^{j}
type	T_{19}	3.88±0.01^{fgh}	1.11±0.00^{f}	6.95^{c}	29.23±0.15^{g}
	T_{20}	3.92±0.13^{ghi}	1.06±0.03^{d}	7.19^{d}	27.55±0.88^{f}
	T_{21}	4.22±0.01^{j}	0.96±0.00^{c}	7.39^{def}	25.67±0.54^{e}
CD (0.05)		0.110	0.031	0.198	0.880

^{a,b,c,} Means with the different letter within the column are significantly different (P<0.05).
Values are Mean±S.D (from 3 determinations).

(±10 units) and fragmentation pattern confirmation (Gopalakrishnan *et al.,* 2019).

Statistical analysis

All experiments were conducted in triplicate. Data were analyzed using one-way ANOVA in SPSS and treatment means were compared using Duncan's Multiple Range Test ($p<0.05$).

RESULTS AND DISCUSSION

Characterization of wine produced from *Koozha* and *Varikka* jackfruit

pH

The pH of jackfruit wines ranged from 3.21 to 4.22, showing significant variation among treatments ($p<0.05$) as shown in Table 2. The highest pH (4.22) was recorded in the blend containing 90% rind and perigones with 10% bulbs. Treatments with higher rind and perigone proportions exhibited elevated pH values, likely due to their relatively low organic acid content compared to the bulb fraction. Similar observations were reported by Panda *et al.* (2016) for jackfruit wine and Maragatham and Panneerselvam (2011) for guava wine (pH 4.06). However, wines with higher pH may show reduced stability and increased turbidity during aging (Alves *et al.,* 2025).

Acidity

Acidity influences wine taste, colour, microbial stability and fermentation efficiency. Wines containing higher proportions of fruit bulbs exhibited greater titratable acidity (0.8-1.4%) than those dominated by rind and perigones, as shown in Table 2. This increase is attributed to the higher concentration of organic acids such as citric and malic acids in the pulp, as well as CO_2 release and phosphate metabolism during yeast fermentation. Comparable acidity levels were reported for banana (1.1%) and pawpaw wines (1.3%) by Idise and Odum (2011) and Egwim *et al.* (2013).

Total soluble solids (TSS)

A gradual decline in TSS was observed during fermentation, reflecting sugar utilization by yeast. Wines prepared from rind and perigones exhibited higher initial TSS than bulb-based wines, due to higher polysaccharide and fiber content, as presented in Table 2. Final TSS values ranged from 6° to 8° Brix, with the highest in T1 (100% *Koozha* rind + perigones) and the lowest in T16 (50% *Koozha* bulb + 50% *Varikka* bulb). Similar TSS reductions were noted in papaya, banana and citrus wines (Gavimath *et al.,* 2012).

Ascorbic acid

Ascorbic acid content varied between 15.23 and 45.32 mg/100 g, with higher concentrations in bulb-rich

Table 3: Effect of alcoholic fermentation of jackfruit components on reducing sugar, total sugar, alcohol, antioxidant activity and colour.

Treatments		Reducing sugar (%)	Total sugar (%)	Alcohol (%)	Antioxidant (%)	Colour (OD value)
Koozha	T_1	0.98±0.01^{c}	2.78±0.02^{c}	10.23±0.19^{ef}	52.67±1.32^{l}	0.194^{a}
	T_2	1.72±0.03^{m}	3.73±0.11^{i}	12.44±0.04^{k}	32.23±0.04^{b}	0.301^{k}
	T_3	1.69±0.00^{lm}	3.75±0.04^{i}	11.50±0.21^{i}	42.12±0.48^{fg}	0.327^{ij}
	T_4	1.68±0.03^{lm}	3.69±0.01^{i}	10.41±0.12^{fg}	45.32±1.07^{h}	0.244^{e}
	T_5	1.55±0.01^{hi}	3.55±0.06^{gh}	9.54±0.11^{c}	48.65±1.22^{j}	0.286^{m}
	T_6	1.49±0.00^{fg}	3.51±0.05^{fgh}	9.21±0.20^{b}	50.56±0.86^{k}	0.232^{d}
	T_7	1.42±0.00^{de}	3.49±0.02^{fgh}	10.15±0.33^{ef}	50.90±0.38^{k}	0.237^{de}
Varikka	T_8	0.79±0.01^{a}	2.55±0.02^{a}	10.22±0.06^{hi}	46.78±0.79^{i}	0.221^{c}
	T_9	1.61±0.01^{jk}	3.51±0.01^{fgh}	11.95±0.39^{j}	30.12±0.06^{a}	0.329^{m}
	T_{10}	1.58±0.00^{ij}	3.47±0.10^{efg}	12.56±0.21^{k}	35.33±0.81^{c}	0.278^{hi}
	T_{11}	1.53±0.03^{gh}	3.45±0.11^{ef}	10.17±0.01^{ef}	38.24±1.14^{d}	0.301^{k}
	T_{12}	1.46±0.01^{ef}	3.41±0.03^{def}	9.75±0.03^{cd}	39.19±0.47^{d}	0.259^{f}
	T_{13}	1.43±0.00^{de}	3.37±0.00^{de}	10.02±0.05^{de}	41.71±1.30^{f}	0.312^{l}
	T_{14}	1.41±0.03^{d}	3.32±0.04^{d}	9.83±0.31^{cd}	41.99±0.28^{fg}	0.268^{g}
Blended	T_{15}	0.88±0.02^{b}	2.65±0.01^{b}	10.94±0.34^{h}	43.12±1.29^{g}	0.217^{c}
Koozha	T_{16}	1.65±0.05^{kl}	3.69±0.03^{i}	11.11±0.14^{j}	32.58±0.35^{b}	0.313^{l}
and	T_{17}	1.61±0.03^{jk}	3.58±0.109^{h}	9.05±0.25^{b}	35.12±0.83^{c}	0.270^{g}
Varikka	T_{18}	1.57±0.00^{hij}	3.57±0.02^{h}	10.51±0.22^{g}	38.82±0.71^{d}	0.209^{b}
type	T_{19}	1.56±0.04^{hi}	3.53±0.11^{gh}	8.92±0.21^{b}	40.45±0.02^{e}	0.272^{gh}
	T_{20}	1.53±0.04^{gh}	3.48±0.10^{fgh}	8.59±0.01^{a}	41.56±0.19^{ef}	0.289^{j}
	T_{21}	1.50±0.02^{fg}	3.45±0.06^{efg}	9.53±0.16^{c}	44.33±0.90^{h}	0.271^{g}
CD (0.05)		0.039	0.095	0.293	1.155	0.008

[a,b,c,] Means with the different letter within the column are significantly different ($P<0.05$).

Values are Mean±S.D (from 3 determinations).

treatments, as shown in Table 2. The bulb fraction, being rich in vitamins and phenolics, contributed to increased antioxidant potential. Comparable results were reported for guava wine (Kocher and Pooja, 2011). The higher ascorbic acid stability in wines, compared to juice, is due to the protective effects of low pH and flavonoids that limit oxidation and browning reactions (Ray *et al.,* 2012).

Reducing sugar

Reducing sugar decreased progressively throughout fermentation, corresponding to yeast metabolic activity and CO_2 evolution. *Koozha* wines ranged from 0.98-1.72%, *Varikka* from 0.79-1.61% and blends from 0.88-1.65%, as shown in Table 3. These results agree with Egwim *et al.,* (2013), who observed a similar decline in banana and pawpaw wines following active fermentation.

Total sugar and alcohol yield

Total sugar content, an indicator of fermentation efficiency, ranged between 2.55% and 3.69% (Table 3). Treatment T8 (100% *Varikka* rind + perigones) showed the lowest total sugar, while T3 (50% *Koozha* rind/perigone + 50% bulb) recorded the highest. The progressive sugar reduction across treatments confirms effective yeast metabolism and ethanol conversion (Panda *et al.,* 2016).

Alcohol content varied between 8% and 12% (v/v) depending on the treatment composition, as shown in Table 3. Wines with higher bulb proportions generally produced greater alcohol yields. This can be attributed to the elevated fermentable sugar concentration and more favourable nutrient balance in the bulb fraction, which enhances yeast growth and ethanol productivity. Conversely, rind- and perigone-rich musts likely contained higher fiber and lower soluble sugar content, limiting substrate availability for fermentation. Similar correlations between substrate sugar content and ethanol yield have been reported for litchi and pineapple wines (Qi *et al.,* 2017). The MTCC 170 yeast strain exhibited an ethanol tolerance of up to 12%, consistent with previous findings.

Antioxidant activity

Antioxidant activity ranged from 30% to 52% and varied significantly among treatments, as depicted in Table 3. Wines incorporating underutilized parts (rind and perigones) exhibited higher antioxidant potential, possibly due to the presence of phenolic compounds, flavonoids

Table 4: Organoleptic evaluation of wine developed from the combination of rind, perigone and bulbs of jackfruit (*Koozha* and *Varikka* type).

Treatments	Appearance 3 max	Aroma/ bouquet 6 max	Taste/ texture 6 max	Aftertaste 3 max	Overall impression 2 max	Total score 20 max
			***Koozha* type**			
T_1	2.9	4.1	2.5	2.2	1.2	12.1
T_2	2.9	6.0	5.3	2.0	1.5	17.9
T_3	2.6	5.5	4.1	2.1	1.5	15.4
T_4	3.0	6.0	5.3	2.0	1.8	18.2
T_5	2.7	5.3	4.6	2.3	1.5	14.5
T_6	2.5	4.7	3.8	2.3	1.7	12.5
T_7	2.5	3.5	3.9	2.4	1.5	12.6
			***Varikka* type**			
T_8	2.5	4.3	4.4	1.9	1.3	14.4
T_9	2.6	5.1	5.2	2.1	1.5	16.5
T_{10}	2.8	4.2	5.2	2.1	1.5	15.9
T_{11}	2.5	4.5	4.5	1.5	1.4	14.4
T_{12}	2.8	5.0	5.3	1.9	1.5	16.5
T_{13}	2.5	4.3	4.5	1.5	1.5	14.3
T_{14}	2.5	3.5	5.1	1.1	1.3	13.5
			Blended *Koozha* and *Varikka* type			
T_{15}	2.5	4.3	4.3	1.5	1.4	14
T_{16}	2.7	4.6	5.2	2.2	1.5	16.2
T_{17}	2.5	4.5	4.5	1.5	1.5	14.5
T_{18}	2.5	4.4	4.1	2.3	1.5	14.8
T_{19}	3.0	5.1	5.3	2.5	1.5	17.4
T_{20}	2.5	4.0	3.5	2.3	1.3	13.6
T_{21}	2.5	4.6	3.5	1.5	1.2	13.3
KW values	82.20	78.82	84.47	81.79	92.47	87.53
χ^2				31.410		

and tannins concentrated in these tissues. *Koozha* wine combinations (T1-T7) showed superior antioxidant levels compared to *Varikka* and blended wines. Comparable results were reported by Jagtap *et al.* (2011) for jackfruit wines with high DPPH radical scavenging activity.

Colour

Wine colour depends largely on the tannin and pigment composition derived from the fruit matrix. The highest colour intensity (0.328) was observed in T14 of the *Varikka* type, prepared with 90% rind + perigones and 10% bulbs, as indicated in Table 3. Blending enhanced colour vibrancy due to the synergistic contribution of pigments from both varieties. Reddy *et al.* (2014) reported a similar enhancement in mango wine, where polyphenolic interactions intensified coloration.

Organoleptic evaluation

Wines from *Koozha* (T4), *Varikka* (T12) and blended (T19) treatments received the highest appearance scores (3.0) for their brilliant yellow hue, as indicated in Table 4. Aroma scores were highest in T4 (*Koozha*: 60% rind + perigone, 40% bulb), characterized by distinct fruity and floral notes. Aftertaste scores ranged from 1.5 to 2.0, with T4 and T2 showing the most balanced profiles. Overall, T4 (18.4/20, extraordinary), T12 (16.5/20, excellent) and T19 (17.6/20, excellent) were the top-performing wines, reflecting the sensory preference for *Koozha* wines. The enhanced sensory quality may be due to the balanced acidity, higher alcohol yield and greater volatile compound formation during fermentation. Similar improvements with aging have been reported in guava (Kocher and Pooja, 2011) and pineapple wines (Qi *et al.,* 2017).

Storage studies-effect of ageing on the quality of jackfruit wine

The top-performing wines-T4 (*Koozha*: 60% rind/perigone + 40% bulb), T12 (*Varikka*: 70% rind/perigone + 30% bulb) and T19 (Blended: 70% rind/perigone + 30% bulb)-were selected for storage studies. After six months at ambient conditions, a gradual decline in pH and increase in acidity were observed, attributed to organic acid formation (lactic, acetic). These changes enhanced flavour balance and

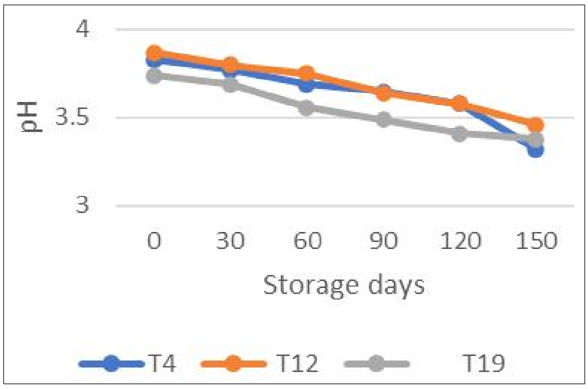

Fig 2: Changes in pH of jackfruit wine during ageing.

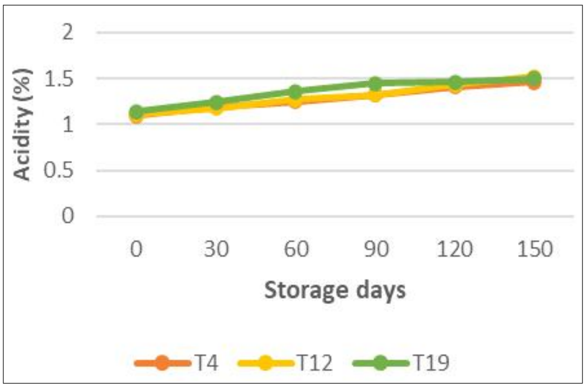

Fig 3: Changes in acidity of jackfruit wine during ageing.

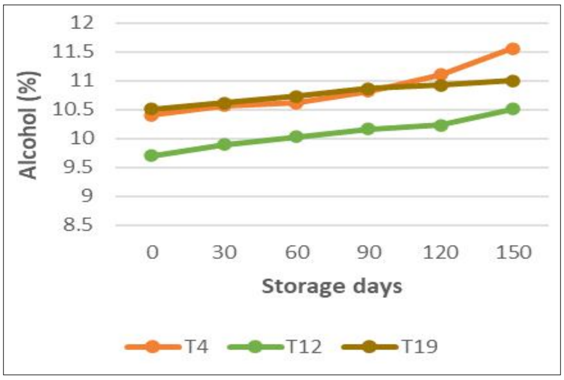

Fig 4: Changes in alcohol of jackfruit wine during ageing.

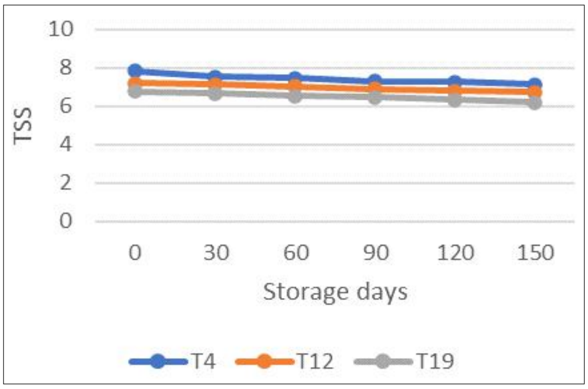

Fig 5: Changes in TSS content of jackfruit wine during ageing.

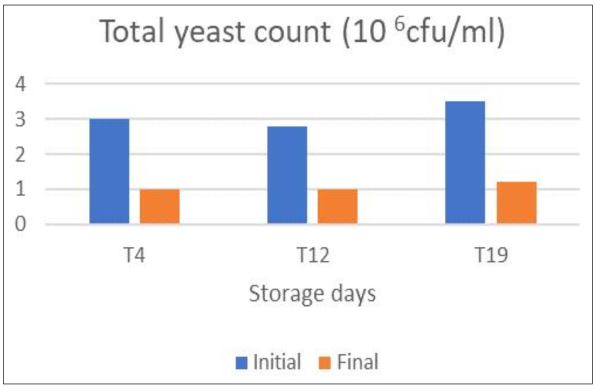

Fig 6: Changes in yeast content of jackfruit wine during ageing.

product stability. Wines derived from bulb-rich treatments exhibited more pronounced changes, likely due to higher residual sugars that continued mild fermentation during storage. A slight rise in alcohol content (11-13% v/v) was observed, consistent with typical *Saccharomyces* fermentation dynamics. Yeast populations declined due to substrate depletion and elevated ethanol levels, contributing to microbial stability. The observed changes in wine quality during storage are graphically presented in Fig 2-6. These results align with ageing patterns in papaya

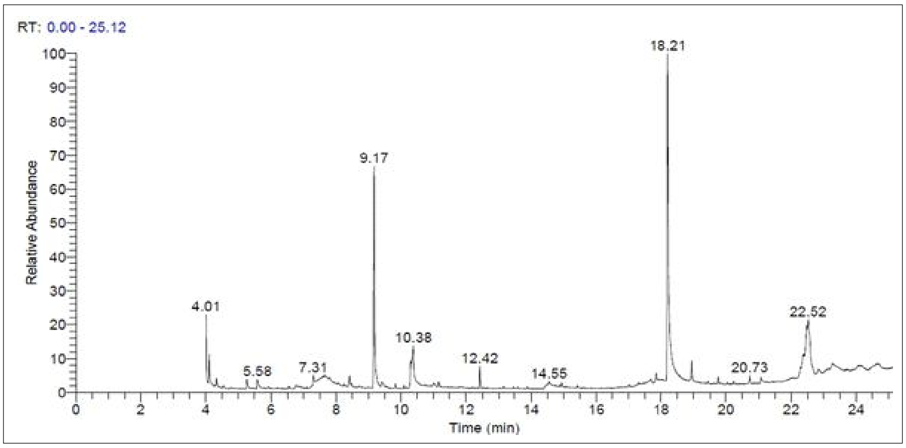

Fig 7: GC-MSMS chromatogram of *Koozha* jackfruit wine from rind with perigones and bulbs (T_4).

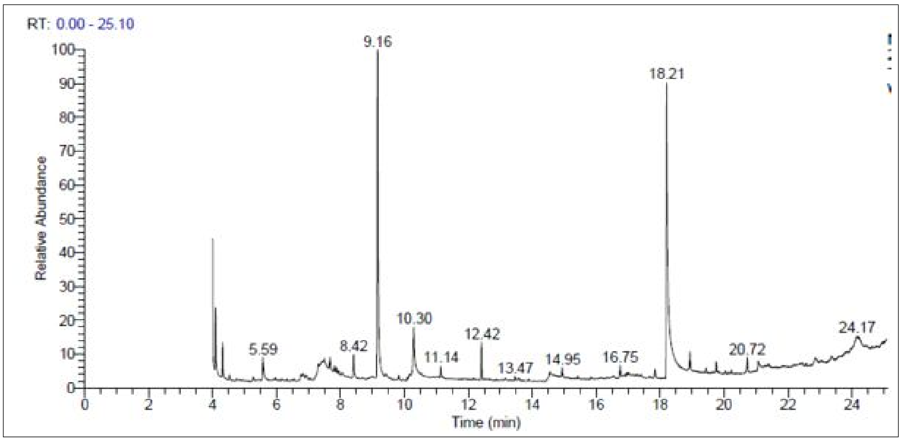

Fig 8: GC-MSMS chromatogram of *Varikka* jackfruit wine from the components like rind with perigone and bulbs (T_{12}).

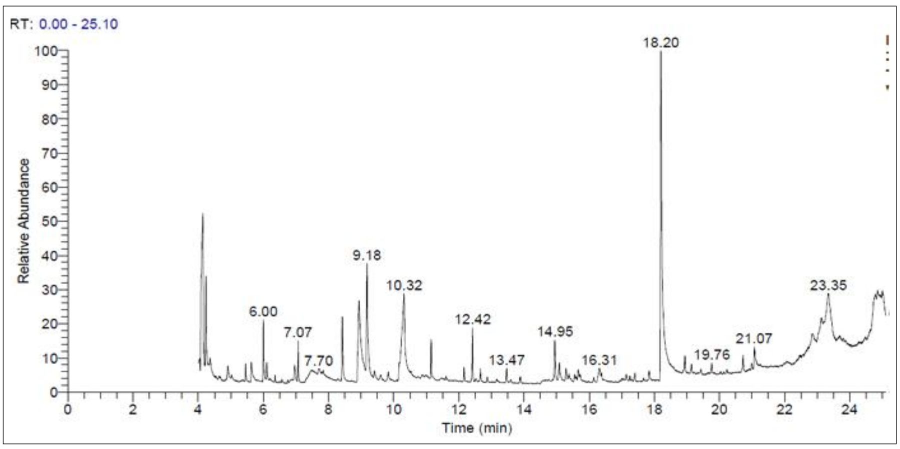

Fig 9: GC-MSMS chromatogram of wine from the blended *Koozha* and *Varikka* components.

(Pampangouda *et al.,* 2021), guava (Kocher and Pooja, 2011) and mango wines (Reddy *et al.,* 2014).

Volatile flavour compounds (GC-MS/MS analysis)

Chromatographic analysis revealed diverse volatile profiles across the best-performing wines (Fig 7-9). *Koozha* wines showed high concentrations of phenylethyl alcohol (15.5%), along with esters such as butanedioic acid, hexadecanoic acid and linoleic acid ethyl ester, contributing to floral and fruity notes. Bioactive compounds like (+)-ascorbic acid 2,6-dihexadecanoate were detected in blended *Koozha* wines, enhancing antioxidant and aromatic characteristics. *Varikka* wines were dominated by propanoic acid 2-hydroxyethyl ester (1.46%), butanedioic acid diethyl ester (4.56%) and 3-hydroxy-dodecanoic acid ethyl ester (1.24%), contributing to a characteristic fruity aroma (Teodosiu *et al.,* 2019). The blended wine exhibited a distinctive tart flavour and vibrant colour, enriched by volatile esters such as acetic acid 2-phenylethyl ester, n-amyl isovalerate and benzyl alcohol. Acidic compounds influenced flavour balance, where inadequate acidity can yield a flat sensory profile (Peng *et al.,* 2013; Nan *et al.,* 2019).

CONCLUSION

This study demonstrated that underutilized jackfruit components rind and perigones blended with fruit bulbs can be effectively used to produce functional, antioxidant-rich wines. Distinct differences were observed between *Koozha* and *Varikka* varieties: *Koozha* wines showed higher acidity, antioxidant activity and superior sensory appeal, while *Varikka* wines exhibited smoother taste and balanced acidity. The proportion of rind and perigones significantly influenced fermentation and aroma formation, with higher levels enhancing pH and the production of esters and higher alcohols contributing to fruity and floral notes. Conversely, bulb-rich blends favoured sugar conversion and alcohol yield. Overall, the study highlights the potential of valorising jackfruit waste into value-added wines, offering a sustainable approach to waste utilization and novel beverage development.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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