Plant-Based Probiotic Beverage from Date Juice: A Preliminary Study on Fermentation-Related and Sensory Characteristics

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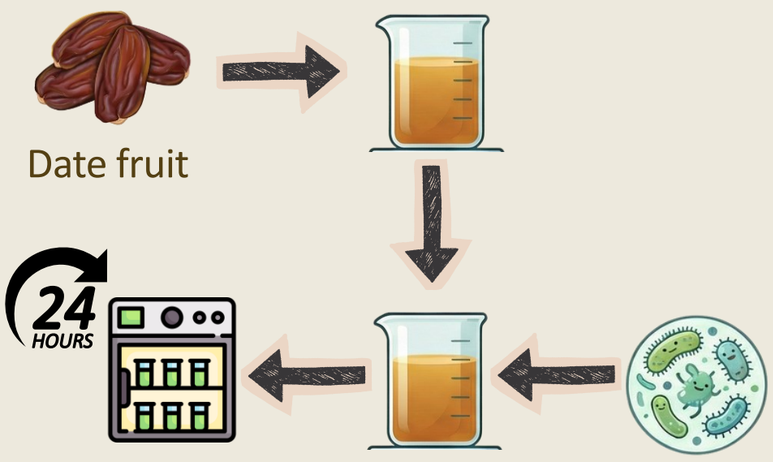
Introduction

The increasing demand for plant-based and clean-label probiotic beverages has driven interest in non-dairy fermentation substrates. Date palm fruit (*Phoenix dactylifera* L.) is naturally rich in fermentable sugars, phenolic compounds, and antioxidants[1], making it a promising matrix for probiotic delivery and the production of functional probiotic beverages. Using date juice without added sugars aligns with current trends toward simply formulated, minimally processed functional drinks.

Objectives

To develop a plant-based probiotic beverage from date juice fermented with *Lactobacillus plantarum* and to evaluate the effects of fermentation, juice concentration and probiotic inoculum level on fermentation-related characteristics and sensory outcomes.

Materials and methods



Results and Discussion

After 24 h of fermentation, FDJ showed a significant decrease in **pH** across all formulations, confirming lactic acid fermentation. The greatest reduction occurred at the lowest juice concentration, while **TSS** remained unchanged. **Probiotic viability** increased from 7 to 8 log CFU/mL at 10 mg/100 mL inoculum and remained at ~8 log CFU/mL at higher inoculum levels, exceeding the minimum requirement for probiotic products (≥6 log CFU/mL)[2].

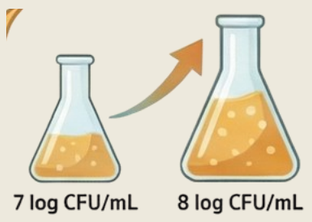


Table 1 Change in pH value, total soluble solids (TSS) and total Lactic acid bacteria count of date juice (DJ) and fermented date juice (FDJ) with *Lactobacillus plantarum* at 10 and 50 mg/100 ml inoculation

Inoculum (mg/ 100 ml)	Date juice Concentration (% w/w)	pH		Total soluble solids (g/100 ml)		Lactic acid bacteria count (Log CFU/ml)	
		DJ	FDJ	DJ	FDJ	DJ	FDJ
10	20	5.85 ± 0.02 ^{Aa}	4.18 ± 0.01 ^{Bb}	15.80 ± 0.06 ^{Ac}	15.90 ± 0.06 ^{Ac}	7.75 ± 0.02 ^{Ba}	8.10 ± 0.03 ^{Aa}
	25	5.79 ± 0.01 ^{Aa}	4.40 ± 0.03 ^{Bab}	18.30 ± 0.06 ^{Ab}	18.30 ± 0.06 ^{Ab}	7.78 ± 0.05 ^{Aa}	8.01 ± 0.06 ^{Aa}
	30	5.64 ± 0.03 ^{Ab}	4.47 ± 0.08 ^{Ba}	20.60 ± 0.06 ^{Aa}	20.60 ± 0.06 ^{Aa}	7.67 ± 0.02 ^{Ba}	8.12 ± 0.03 ^{Aa}
50	20	5.82 ± 0.01 ^{Aa}	3.69 ± 0.01 ^{Bc}	14.00 ± 0.10 ^{Ac}	13.85 ± 0.05 ^{Ac}	8.34 ± 0.02 ^{Aa}	8.22 ± 0.03 ^{Aa}
	25	5.76 ± 0.02 ^{Ab}	3.75 ± 0.01 ^{Bb}	16.70 ± 0.10 ^{Ab}	16.55 ± 0.05 ^{Ab}	8.33 ± 0.01 ^{Aa}	8.23 ± 0.01 ^{Aa}
	30	5.60 ± 0.01 ^{Ac}	3.80 ± 0.01 ^{Ba}	19.45 ± 0.05 ^{Aa}	19.30 ± 0.00 ^{Aa}	8.29 ± 0.02 ^{Aa}	8.22 ± 0.02 ^{Ba}

Mean ± SEM (n = 3). Uppercase letters indicate fermentation effects; lowercase letters indicate concentration effects ($P < 0.05$).

Sensory acceptability: Liking scores did not differ significantly among FDJ samples.

Table 2 Preliminary sensory acceptability of FDJ using 9-points hedonic scale

Inoculum (mg/ 100 ml)	Date juice Conc. (% w/w)	Appearance	Odor	Flavor	Taste	Texture	Overall acceptability
10	20	7.36 ± 1.12 ^{A}	6.09 ± 1.64^{A}	6.27 ± 2.01^{A}	5.91 ± 2.07^{A}	6.91 ± 1.14^{A}	6.25 ± 1.93^{A}
	25	6.34 ± 1.12 ^{A}	6.00 ± 1.61^{A}	5.64 ± 1.86^{A}	5.73 ± 1.74^{A}	6.55 ± 1.51^{A}	5.80 ± 1.69^{A}
	30	6.34 ± 1.96^{A}	6.55 ± 1.29^{A}	6.64 ± 1.69^{A}	6.27 ± 1.56^{A}	6.64 ± 1.01^{A}	6.10 ± 2.42^{A}
50	20	7.00 ± 1.55^{A}	6.09 ± 1.45^{A}	6.73 ± 1.35^{A}	6.27 ± 1.56^{A}	7.00 ± 1.10^{A}	6.70 ± 1.95^{A}
	25	6.91 ± 1.04 ^{A}	6.82 ±0.99^{A}	6.82 ±0.98^{A}	7.00 ± 1.18^{A}	7.27 ±0.65^{A}	7.20 ±0.92^{A}
	30	6.09 ± 1.45^{A}	6.09 ± 1.45^{A}	6.91 ± 1.04^{A}	6.91 ± 1.22^{A}	7.27 ± 1.01^{A}	7.25 ± 1.18^{A}

Mean ± SEM (n = 11); different uppercase letters indicate significance ($P < 0.05$).

JAR analysis: FDJ with 50 mg/100 mL inoculum at 25–30% (w/w) achieved optimal sweetness and sourness (≥70% "just-right" responses; Net Effect near 0), supporting its selection for further study

Table 3 Just-About-Right (JAR) scale results for sweetness and sourness of FDJ with different inoculum levels

Inoculum (mg/ 100 ml)	Date juice Conc. (%w/w)	Sweetness					Sourness				
		Too Little (%)	Just Right (%)	Too Much (%)	Total	Net effect	Too Little (%)	Just Right (%)	Too Much (%)	Total	Net effect
10	20	0.00	63.64	36.36	100	36.36	100.00	0.00	0.00	100	-100
	25	0.00	50.00	50.00	100	50	70.00	20.00	10.00	100	-60
	30	0.00	20.00	80.00	100	80	85.00	15.00	0.00	100	-85
50	20	45.45	54.55	0.00	100	-45.45	0.00	54.55	45.45	100	45.45
	25	0.00	**100.00**	0.00	100	0	30.00	30.00	40.00	100	10
	30	10.00	**70.00**	20.00	100	10	10.00	**70.00**	20.00	100	10

Conclusion

This study demonstrates that date juice is a viable plant-based substrate for probiotic fermentation without added sugars or additives. Its natural nutrients, combined with probiotic activity, highlight the potential for clean-label functional beverages. An optimal inoculum level was identified for further studies, with future work focusing on metabolite profiling and bioactive compound characterization to clarify functional benefits of probiotic date juice.

References

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