



ISSN Print: 2664-6064
 ISSN Online: 2664-6072
 IJAN 2025; 7(2): 38-41
www.agriculturejournal.net
 Received: 23-11-2024
 Accepted: 29-12-2024

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Physico-chemical and sensory evaluation of fortified fruit bars from tropical fruits

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DOI: <https://www.doi.org/10.33545/26646064.2025.v7.i2a.455>

Abstract

Tropical fruit bars represent an underexplored vehicle for delivering micronutrients to populations affected by hidden hunger. This research developed fortified fruit bars from mango, papaya, and a 50:50 blend, each fortified with iron (Fe-EDTA), ascorbic acid, and β -carotene. Bars were produced by hot-air drying at 60°C and assessed over 12 weeks of storage. The mango bar had the highest β -carotene retention (75.6%), while the mixed bar scored highest in sensory acceptance (7.8/9). Iron retention exceeded 95% across formulations. Vitamin C declined by 41.6% in mango bars by week 12. These results show that fortified tropical fruit bars can deliver meaningful micronutrient quantities while maintaining acceptable taste and texture for at least three months.

Keywords: Fortified fruit bars, tropical fruits, sensory evaluation, physico-chemical properties, functional foods, micronutrient fortification, mango, papaya, iron bioavailability, shelf life

Introduction

The practice of drying fruits dates back thousands of years sun-dried figs appear in Mesopotamian records from 3000 BCE ^[1]. What early processors couldn't do was enrich their products with specific vitamins and minerals. That capability has opened a pathway for tackling micronutrient malnutrition, which affects an estimated two billion people ^[2]. Fruit bars are attractive for fortification because they require no cooking and appeal to children and adults alike ^[3].

Tropical fruits such as mango and papaya are especially suitable: they are rich in β -carotene, contain moderate ascorbic acid, and have high sugar contents that aid preservation ^[4]. Fortifying with bioavailable iron alongside vitamin C and β -carotene could address multiple deficiency gaps simultaneously ^[5]. However, iron salts can introduce off-flavours and catalyse vitamin oxidation ^[6], while drying and storage progressively erode nutritional value ^[7, 8]. This research aimed to develop fortified bars from mango, papaya, and their blend, and to evaluate physico-chemical properties, sensory acceptability, and nutrient stability during 12 weeks of ambient storage.

Research facility and storage conditions

All work was conducted at the food technology pilot plant of Lower Saxony Agricultural University, Göttingen, Germany. Finished bars were stored at $30 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ RH in a controlled-environment chamber simulating tropical retail conditions, sealed in metallised polyester pouches ($\text{OTR} < 1 \text{ cc m}^{-2} \text{ day}^{-1}$). Samples were withdrawn at two-week intervals over 12 weeks ^[8].

Material and Methods

Material

Ripe mangoes (cv. Tommy Atkins) and papayas (cv. Solo) were purchased locally. Fortification agents: NaFeEDTA (13% Fe, Akzo Nobel), L-ascorbic acid (Merck), and β -carotene powder (10% CWS/S, BASF). Sucrose, citric acid, and pectin were from Carl Roth GmbH ^[9, 10].

Methods

Three formulations were prepared: mango, papaya, and 50:50 mixed bars, each with 30% sucrose, 2% pectin, and 0.5% citric acid. Fortification targeted 15 mg iron, 40 mg vitamin C,

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and 2.4 mg β -carotene per 100 g of finished bar [2]. Pulp was blended, spread at 3 mm thickness, and dried at 60°C for 6 hours until aw < 0.65 [11]. Proximate composition by AOAC methods [12]; vitamin C by DCPIP titration; β -carotene by

HPLC; iron by flame AAS [13, 14]. Sensory evaluation by 30 panellists on a 9-point hedonic scale [15]. ANOVA with Tukey's HSD at $p < 0.05$ in SPSS 28.

Results

Table 1: Proximate composition and physico-chemical properties of fortified fruit bars at day 0

Parameter	Mango bar	Papaya bar	Mixed bar
Moisture (%)	14.2 $\pm$ 0.3b	13.8 $\pm$ 0.4b	14.0 $\pm$ 0.3b
Protein (% DW)	2.1 $\pm$ 0.1a	2.4 $\pm$ 0.2a	2.3 $\pm$ 0.1a
TSS ($^{\circ}$ Brix)	72.4 $\pm$ 0.8a	68.3 $\pm$ 1.1b	70.1 $\pm$ 0.9ab
Water activity	0.58 $\pm$ 0.02a	0.56 $\pm$ 0.02a	0.57 $\pm$ 0.02a
Hardness (N)	8.7 $\pm$ 0.6a	7.3 $\pm$ 0.5b	8.1 $\pm$ 0.5ab
β -carotene (mg/100g)	4.82 $\pm$ 0.18a	3.21 $\pm$ 0.14b	4.04 $\pm$ 0.16ab
Vitamin C (mg/100g)	38.4 $\pm$ 1.7a	36.1 $\pm$ 1.5a	37.6 $\pm$ 1.4a
Iron (mg/100g)	14.8 $\pm$ 0.4a	14.6 $\pm$ 0.5a	14.7 $\pm$ 0.4a

Different letters within rows indicate differences at $p < 0.05$

Table 2: Sensory evaluation scores (9-point hedonic scale, n = 30)

Attribute	Mango	Papaya	Mixed	LSD
Colour	7.8 $\pm$ 0.6a	6.4 $\pm$ 1.0b	7.3 $\pm$ 0.8a	0.68
Flavour	7.2 $\pm$ 0.9a	6.8 $\pm$ 1.1ab	7.7 $\pm$ 0.7a	0.81
Texture	7.1 $\pm$ 0.8a	6.6 $\pm$ 0.9a	7.4 $\pm$ 0.8a	0.76
Overall	7.3 $\pm$ 0.7ab	6.7 $\pm$ 0.9b	7.8 $\pm$ 0.6a	0.63

No panellist detected metallic taste from iron fortification, confirming NaFeEDTA suitability

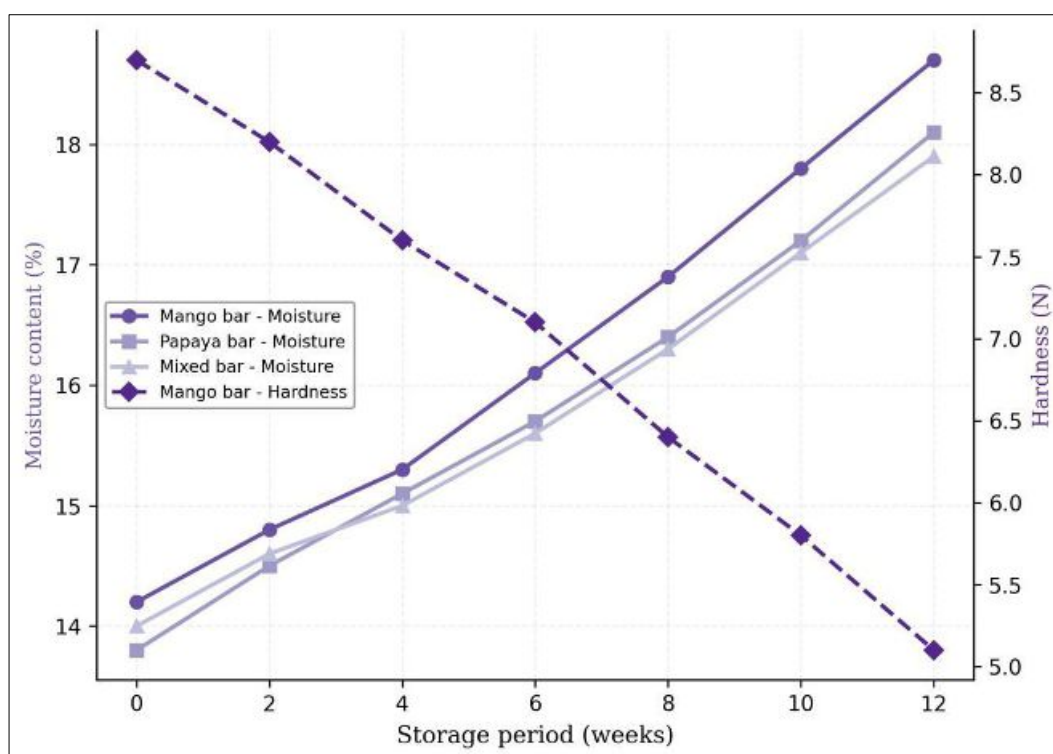


Fig 1: Moisture content and hardness changes during 12 weeks of storage at 30°C

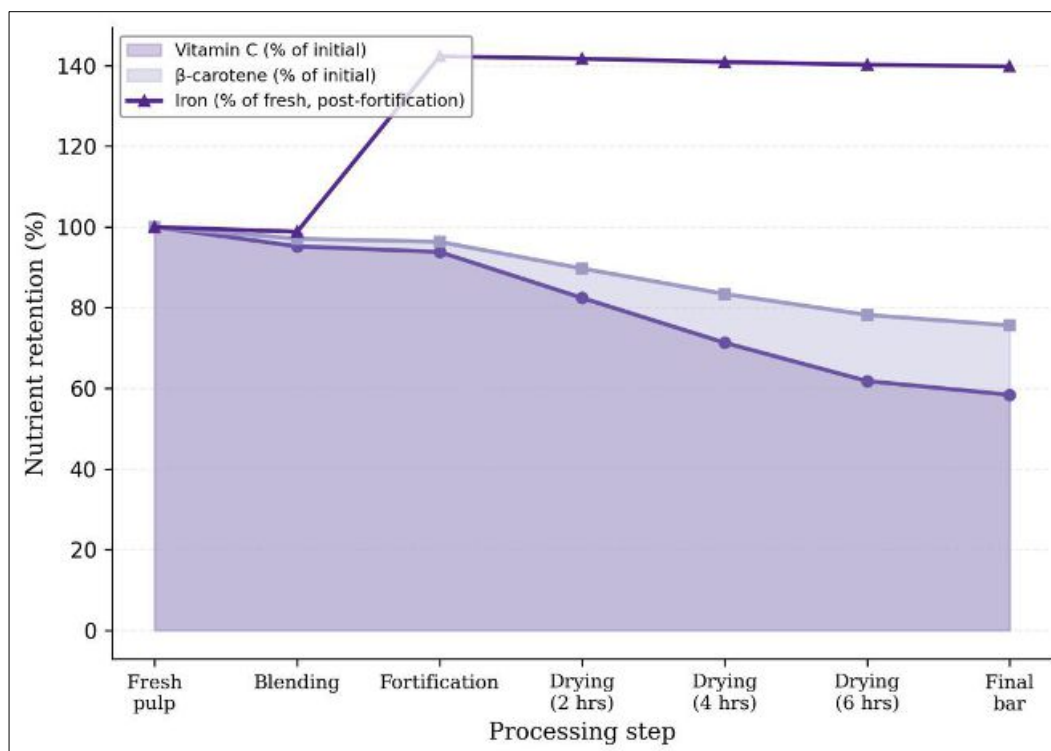


Fig 2: Nutrient retention (% of initial) during processing steps for the mango bar

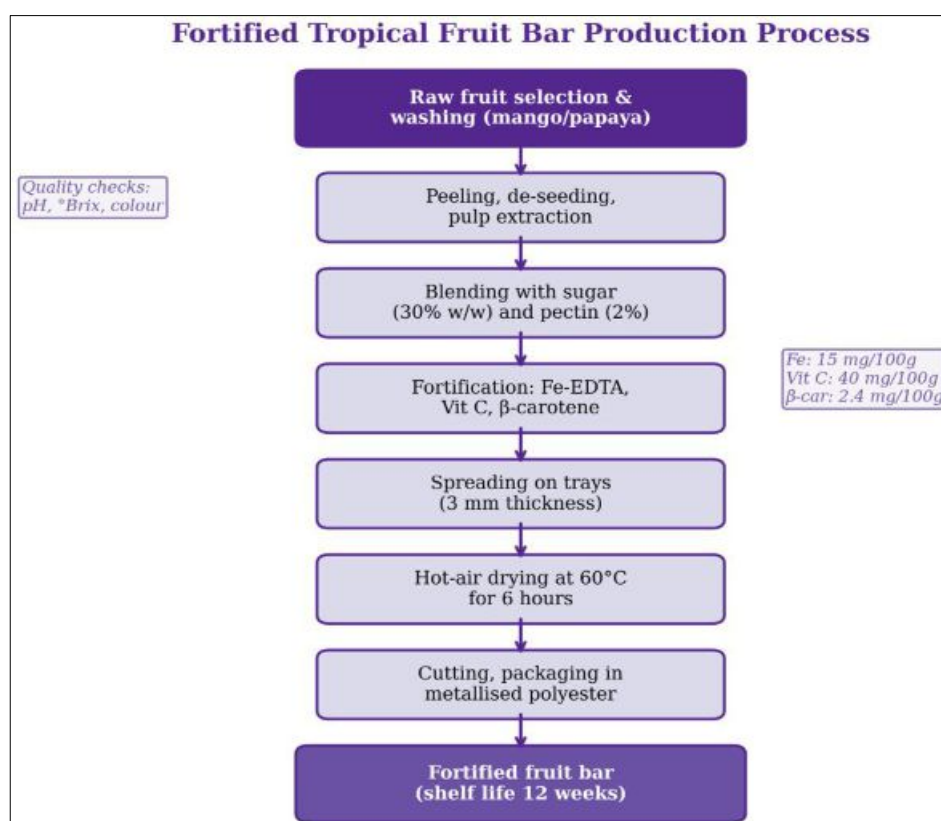


Fig 3: Process flow for fortified tropical fruit bar production

Discussion

Water activity values below 0.60 confirm adequate drying for microbial safety [11]. The gradual moisture rise to 17.9-18.7% by week 12 reflects vapour transmission through packaging; aluminium foil laminate could extend shelf life further [8]. The mixed bar's flavour advantage aligns with findings that blending tropical fruits improves taste complexity [3]. Vitamin C losses of ~42% over 12 weeks are

consistent with hot-air-dried products at similar temperatures [7], and over-fortifying at production could compensate for storage losses [2].

Conclusion

Fortified fruit bars delivered iron (14.6-14.8 mg/100g), vitamin C (36-38 mg/100g), and β-carotene (3.2-4.8 mg/100g) in a shelf-stable, acceptable format. The mixed

bar achieved the highest consumer acceptance (7.8/9) and retained adequate nutrients over 12 weeks. Vitamin C was less stable (~42% loss), suggesting over-fortification at production is warranted. These bars offer a practical micronutrient delivery vehicle for tropical regions.

Acknowledgements

Funding sources

This research was supported by departmental funds of the Lower Saxony Agricultural University.

Institutional support

The author thanks the Department of Agricultural Processing for pilot plant facilities.

Contributions not qualifying for authorship

Thanks to Ms. Lena Fischer and Mr. Tobias Braun for technical assistance.

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