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Processing and value addition of *Madhuca longifolia* as a Jaggery based functional immunity booster balls

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Abstract

Madhuca longifolia (Mahua) is an important Non-Timber Forest Product (NTFP) widely used by tribal communities as a source of Alcohol as a local drink, food, medicine, and Livelihood. The flowers are rich in natural sugars, phenolic, vitamins, and minerals, as well high potential for functional food development. The present study aimed to process a Mahua flowers into a Jaggery-based immunity booster ball by combining them with medicinal herbs including Tikhur (*Curcuma angustifolia*), Ashwagandha (*Withania somnifera*), Shatavari (*Asparagus racemosus*), and Babul gum (*Acacia nilotica*). The objective included the assessment of Physico-chemical, and nutritional qualities of processed Jaggery based Immunity Booster Balls, using Completely Randomized Design (CRD) with seven treatments and three replications. The Physico-chemical and nutritional quality analyses were carried out after manufacture of the product at 30 days interval up to 150 days. The results revealed that Treatment T₆ achieved the highest sensory acceptability in colour, aroma, texture, and taste. Moisture content slightly increased during storage, while total sugars decreased and reducing sugars increased. Protein and Fat % decreased with the increasing storage period. The study concludes that Jaggery-based Immunity Booster Balls represent a nutritionally valuable, shelf-stable functional food with strong potential for commercialization and livelihood enhancement in forest-based communities.

Keywords: Mahua flowers, non-timber forest products, functional food, immunity booster

Introduction

A prominent minor forest product, *Madhuca longifolia* is indigenous to the Indian subcontinent, which includes different states of India, Sri Lanka, Myanmar, and Nepal. It belongs to the Sapotaceae family. This multipurpose tree is essential to indigenous cultures' way of life since it provides three basic needs: fuel, food, and fodder. It is widely distributed throughout many Indian states and goes by a number of colloquial names, including Illipi (South), Mahul (Orissa), and Mahua or Mowarh (North). Its name, Madhuka in Sanskrit, comes from the word "madhu," which means "honey," and refers to the remarkably high sugar content (66-72% of dry weight) of its blossoms (Chand and Mahapatra, 1983) ^[1].

Madhuca longifolia is a perennial tree with a maximum height of 70 feet. It can continue to bear fruit for up to 60 years, starting between the ages of 8 and 15 when ripe, the fruits are ovoid, fleshy, and greenish-yellow in colour, while the blooms are tiny, fleshy, and pale white. Mahua trees are an important source of income for needy populations because they usually start blossoming in the lean agricultural season (March-April). The flowers' meaty corollas are a great source of natural sugars, vitamins, and minerals and can be eaten. (Sinha *et al.*, 2017) ^[2]

The sustainable hygienic collection method of Mahua (*Madhuca longifolia*) flowers for edible purposes is crucial to ensure their safety, taste and nutritional value. The *Curcuma angustifolia*, often known as the Tikhur, is a medicinal rhizome that grows in the forest of Madhya Pradesh and Chhattisgarh. It has therapeutic usefulness as an antipyretic, diuretic, and heart tonic (Ravindran, 2007) ^[3] fresh tikhur rhizomes are used by primitive tribes like, Abhujmaria to make starchy flour that is effective in treating gastric ulcers and has cooling qualities.

The Ashwagandha Known as winter cherry or Indian ginseng, *Withania somnifera* is a valuable medicinal herb which is utilized in many formulations of Ayurvedic medicine.

Its name, which is derived from the Sanskrit words "ashwa" (horse) and "gandha" (fragrance), represents the notion that eating its root gives a power of horse. The main therapeutic component of the plant part is its roots, which include sedative, anti-inflammatory, and nervous system-tonic properties.

Another significant herb in Ayurveda is *Asparagus racemosus*, also known as the Shatavari. Traditional medicine system primarily utilized the roots. Shatavari is recognized in contemporary Ayurvedic traditions as an aphrodisiac, rejuvenator, and galactagogue (increasing milk production). It is also categorized as a "medhya" herb, which means it improves memory, intelligence, and learning. (Orwa *et al.*, 2009) [4] The dried exudate gum from babul tree (*Acacia nilotica*) trunks and branches is known as acacia gum. This gum, which has been used for millennia as a binding ingredient in food and medicine, is very nutritious. It is an essential component of nutritious meals for nursing moms in the Indian subcontinent.

Mahua flowers are expected to have a big impact on the food and beverage industry going forward as the market for natural and health-conscious goods keeps expanding after COVID-19. This study was carried out to create an immunity-boosting ball called. The Immunity Booster ball recipe is developed in order to better utilization of mahua flowers during the off-season while maintaining quality and

meeting storage requirements. To assess the, Physico-chemical, and nutritional qualities of processed Jaggery based Immunity Booster Balls.

Materials and Methods

The study was conducted during 2023-24 in the Department of Forestry, College of Agriculture, IGKV, Raipur, (C.G). The formulation of Jaggery based Immunity Booster Balls enriched with Mahua (*Madhuca longifolia*) which is a base material and fortified with adaptogenic and immunomodulatory herbs used in Ayurvedic system of medicine. Seven distinct formulations (T1 to T7) were prepared by varying the concentration of Mahua, Tikhur (*Curcuma angustifolia*), and Jaggery, while maintaining constant levels of other ingredients like Ashwagandha, Satavar, Babool gum, dry fruit, Ghee and Elaichi. Each treatment was designed to explore the synergistic effects of these components on palatability, texture, and potential therapeutic efficacy. The experiment was designed in Completely Randomized Design (CRD) with 3 replications. The storage period of the Immunity Booster Balls were studied for 0 to 1 month interval till 150 days under normal room temperature. The smart packaging plastic containers used for marketing purpose. The completely randomized design (CRD) is used with 7 treatments and 3 replications were used for this experiment.

Ingredient Composition Mahua-Enriched Jaggery Based Immunity Booster Balls.

S. No.	Ingredient	T ₁ (g)	T ₂ (g)	T ₃ (g)	T ₄ (g)	T ₅ (g)	T ₆ (g)	T ₇ (g)
1	Mahua (<i>Madhuca longifolia</i>)	30	35	40	45	50	55	60
2	Satavar (<i>Asparagus racemosus</i>)	3	3	3	3	3	3	3
3	Ashwagandha (<i>Withania somnifera</i>)	3	3	3	3	3	3	3
4	Tikhur (<i>Curcuma angustifolia</i>)	26	23	20	17	14	11	8
5	Babool Gum (<i>Acacia nilotica</i>)	3	3	3	3	3	3	3
6	Jaggery	14	12	10	8	6	4	2
7	Dry Fruit (e.g., almonds, raisins)	10	10	10	10	10	10	10
8	Ghee	10	10	10	10	10	10	10
9	Elaichi (Cardamom)	1	1	1	1	1	1	1

Results and Discussion

The chemical analysis of Immunity booster balls analysed for Total sugar, Fat %, Protein % showed decreasing trend with the increasing storage period, whereas Reducing sugar and moisture% showed increasing trend with the increasing storage period from 0 to 1 month interval up to 150 days 6 month from the date of manufacture product.

The highest moisture content was recorded in T₄ (6.38) and the minimum was recorded for T₅ (4.18). Jaggery-based formulations consistently showed lower moisture values, reflecting the crystalline structure of jaggery, which is less hygroscopic (Bukya *et al.*, 2018) [15]. This reduced moisture retention may contribute to slightly better microbial safety but also results in harder texture during prolonged storage, a challenge observed in other jaggery-based sweets (Saikia and Islam, 2020) [6].

The highest Total sugar was recorded for T₆ (37.08) and minimum was recorded for the T₁ (29.29). The higher sugar levels in jaggery-based reflect jaggery's natural crystalline matrix, which retains sweetness longer and reduces hygroscopic losses (Bukya *et al.*, 2018) [15]. Previous studies on storage of traditional sweets (Pandey and Sangwan, 2018; Verma and Patel, 2023) [7, 8] confirm that jaggery retains sugars more effectively during long-term storage, though at the cost of firmer texture. Packaging again plays a

critical role, with vacuum-sealed or nitrogen-flushed packs helping to minimize sugar hydrolysis and extend shelf life (Jha *et al.*, 2013) [9].

The highest reducing sugar was recorded in T₇ (3.38) and minimum was recorded for T₁ (2.77). Jaggery-based formulations exhibited consistently higher reducing sugar levels which can be attributed to jaggery's richer sugar matrix and greater availability of sucrose for hydrolysis (Bukya *et al.*, 2018) [15]. These findings are consistent with (Jha *et al.*, 2013) [9], who reported that packaging and storage conditions significantly influenced sugar conversion dynamics in dairy-based sweets, with nitrogen-flushed packaging extending stability. The similar trend was observed in this study

The highest Fat % was recorded for T₆ (10.83) and minimum was recorded for the T₅ (9.49). Jaggery-based formulations exhibited slightly lower fat percentages and greater susceptibility to lipid degradation likely due to compositional differences in the sugar matrix that influence oxidative stability (Bukya *et al.*, 2018) [15]. These findings are consistent with (Bajwa *et al.*, 2005) [10], who noted slower physicochemical changes in fat-containing sweets under cooler storage.

The highest protein % was recorded for T₆ (5.91) and minimum was recorded for the T₁ (5.49). Jaggery-based

products exhibited consistently lower protein retention compared suggesting that jaggery's crystalline sugar matrix is less effective in protecting proteins from hydrolysis and denaturation (Bukya *et al.*, 2018) [15]. These findings align with Raval (2013) [11], who reported increased protein degradation in sweets stored under warmer, humid conditions.

Bacterial Count was recorded highest in T₂ (47) and lowest in T₃ (40). Jaggery-based formulations became more susceptible to bacterial contamination. This vulnerability is consistent with the nutrient-rich profile of jaggery, which provides fermentable sugars, minerals, and trace elements that act as substrates for bacterial growth (Bakhara *et al.*, 2016) [12]. Similar observations have been reported in cereal- and legume-based laddus, where formulation balance strongly influenced microbial safety during storage (Pandey and Sangwan, 2018) [7].

Fungal count recorded highest in T₅ (49) and lowest in T₁ (42). Similar fungal build-up after 3-4 months of storage has been reported in other cereal- and fruit-based laddus (Wadhwan and Bansal, 2018; Sudha *et al.*, 2022) [15, 14]. Improved packaging strategies such as vacuum sealing, temperature control, or incorporation of natural antifungal

agents (e.g., clove oil, cinnamon extract) are recommended to extend storage stability and consumer safety (Sudha *et al.*, 2022) [14].

Organoleptic Evaluation recorded highest overall acceptability for treatment T₆ (19.24) and lowest for treatment T₁ (14.08). These findings are consistent with previous studies indicating that optimized combinations of Mahua and complementary ingredients can yield products with strong sensory stability and consumer acceptance (Rohan *et al.*, 2022) [13].

Table 1: Physico-Chemical analysis of Immunity Booster Balls during storage

Treatments	Total Sugar %	Reducing Sugar %	Moisture %	Fat %	Protein %
T ₁	29.29	2.77	5.50	10.51	5.49
T ₂	30.74	2.87	5.00	11.16	5.56
T ₃	32.22	3.02	4.41	10.51	5.63
T ₄	33.61	3.12	6.38	9.49	5.70
T ₅	34.90	3.24	4.18	9.49	5.77
T ₆	37.08	3.38	6.17	10.83	5.91
T ₇	36.06	3.38	4.75	10.16	5.84

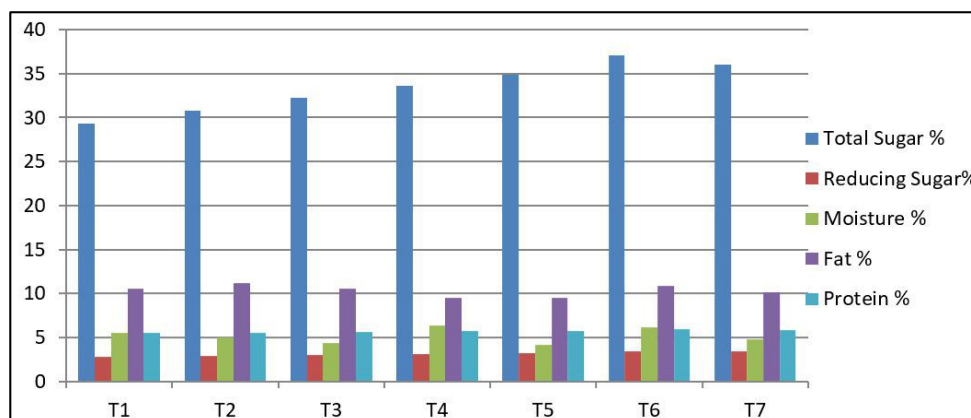


Fig 1: Mean physico-chemical and nutritional analysis of Jaggery Based Immunity Booster Balls *Madhuca longifolia* over storage period of 6 months (January-June)

Table 2: Effect of storage duration on Bacterial Load of Jaggery based Immunity Booster Balls

Treatment	0 Days	30 Days	60 Days	90 Days	120 Days	150 Days	Mean
T ₁	NG	NG	NG	2	11	27	40
T ₂	NG	NG	NG	1	19	20	40
T ₃	NG	NG	NG	3	10	29	42
T ₄	NG	NG	NG	1	13	26	40
T ₅	NG	NG	NG	3	18	20	41
T ₆	NG	NG	NG	4	11	25	40
T ₇	NG	NG	NG	1	12	27	40

Table 3: Effect of storage duration on fungal load of Jaggery based Immunity Booster Balls

Treatment	0 Days	30 Days	60 Days	90 Days	120 Days	150 Days	Mean
T ₁	NG	NG	NG	2	20	23	45
T ₂	NG	NG	NG	1	18	24	43
T ₃	NG	NG	NG	2	15	25	42
T ₄	NG	NG	NG	3	12	29	44
T ₅	NG	NG	NG	3	16	28	47
T ₆	NG	NG	NG	1	18	26	45
T ₇	NG	NG	NG	1	17	25	43

Table 4: Effect of storage on the organoleptic evaluation of Jaggery based Immunity Booster Balls

Treatment	Colour	Grittiness	Aroma	Taste	Overall Acceptability
T ₁	3.71	3.66	3.8	3.63	14.08
T ₂	4.73	4.80	4.78	4.58	18.42
T ₃	4.52	4.58	4.61	4.49	17.61
T ₄	4.32	4.36	4.40	4.23	16.70
T ₅	4.13	4.13	4.17	4.01	15.93
T ₆	4.96	4.93	4.98	4.84	19.24
T ₇	3.93	3.98	3.98	3.85	15.10





Conclusion

It can be concluded that among all the treatments, Treatment 6 was the best and most accepted. The final product i.e., Jaggery based immunity booster balls were stored and acceptable up to 60 days from the day of preparation. There was a decreasing trend in all chemical parameters of Jaggery based Immunity Booster Balls as the storage period increases. Except reducing sugar and moisture, it showed vice-versa trend. The bacterial and fungal load showed decreasing trend with increasing storage period.

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