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ASSESSMENT OF PHYSICAL AND CHEMICAL PARAMETERS OF JACKFRUIT SEED FLOUR BASED GULAB JAMUN MIX

D.P. Sahana[1*], Y. Kantharaj[1], Jyoti M. Rathod[2], H.S. Chaitanya[3], Lakshmana[4], H. Bindu[1] and B.M. Amrutha Varshini[1]

[1]Department of Postharvest Management, College of Horticulture, Mudigere (Karnataka), India.
[2]Department of Food and Nutrition, College of Agricultural Sciences, Iruvakki (Karnataka), India.
[3]Department of Horticulture, ZAHRS, Brahmavara (Karnataka), India.
[4]Retired Professor, Brahmavara Udupi (Karnataka), India.
*Corresponding author E-mail : dpsonu27k@gmail.com
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ABSTRACT

The present investigation entitled "Assessment of physical and chemical parameters of jackfruit seed flour based gulab jamun mix" was conducted at the Department of Postharvest Management, College of Horticulture, Mudigere, during 2024–25. The experiment was laid out in a Completely Randomized Design (CRD) with twelve treatments and three replications. Treatments were formulated by varying proportions of Jackfruit Seed Flour (JSF), Refined Wheat Flour (RWF), Skimmed Milk Powder (SMP) and Other Ingredients (OI). Among the treatments, T_5 (40% JSF + 10% RWF + 35% SMP + 15% OI) recorded the most desirable physical properties with the lowest moisture content (5.65%), shortest frying time (4.92 min) and minimal oil absorption (80.58%), along with superior nutritional composition comprising fat (12.96%), protein (17.97%), fiber (1.15%), carbohydrate (52.75%), calcium (70.15 mg 100 g^{-1}) and potassium (64.83 mg 100 g^{-1}).

Key words : Jackfruit seed flour, Gulab jamun mix, Skimmed milk powder, Refined wheat flour.

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) is a widely cultivated tropical fruit tree in many regions. India ranks as the second largest producer and often regarded as the jackfruit's motherland. The total area under jackfruit cultivation in India is approximately 1,85,800 hectares with a production of around 3.28 million metric tons and an average productivity of 17.70 metric tons per hectare (Anonymous, 2024-25). The fruit is valued not only for its sweet, fleshy pulp but also for its seeds, known as cotyledons which are a rich source of essential nutrients. Jackfruit seeds contain high levels of starch (22%), protein (11.85%), dietary fiber (3.19%) and important minerals such as calcium, magnesium, potassium and iron (Swami *et al.*, 2012).

Additionally, they provide vitamins including vitamin A, B_1, B and C. Due to their nutritional profile, jackfruit seeds have been associated with multiple health benefits such as lowering the risk of heart attacks, regulating blood sugar levels, improving digestive health and enhancing immune function (Rodriguez *et al.*, 2021). Traditionally, these seeds are consumed either boiled or roasted. In recent years, their flour has been increasingly incorporated into a wide range of food products including bakery items, salads, ice creams, jams and beverages, thereby serving as a nutritious alternative ingredient (Zhang *et al.*, 2021).

Maida or refined wheat flour, is commonly used in Indian sweets but has notable health risks. It is often bleached with potassium bromate, a genotoxic carcinogen. Its high glycemic index increases the risk of diabetes, obesity, cardiovascular diseases and other chronic conditions. Regular consumption is also linked to digestive problems like bloating and constipation as well as metabolic imbalances (Evangeline, 2023).

Gulab jamun is a traditional Indian sweet with significant cultural, social and economic importance. It is usually prepared from khoa (a milk-based product) and refined wheat flour. However, the limited shelf life of khoa and its seasonal scarcity especially during dry periods it creates the challenges for consistent production. To overcome this, Ghosh *et al.* (1986) developed instant gulab jamun premix, typically composed of skimmed milk powder, refined wheat flour, ghee and baking powder. These premixes offer convenience and produce gulab jamun with similar texture, flavour and appearance to the traditional version, making them popular in both industrial and household level.

The current study involves substituting refined wheat flour with jackfruit seed flour in the gulab jamun premix, owing to the adverse effects associated with refined wheat flour.

Materials and Methods

The present study was carried out during 2024–25 at the Department of Postharvest Management, College of Horticulture, Mudigere. The experiment was laid out in a Completely Randomized Design (CRD) with twelve treatments and three replications.

Procedure for preparation of jackfruit seed flour based gulab jamun mix

Roasting the refined wheat flour and jackfruit seed flour

↓

Addition of malic acid and sodium bicarbonate to the roasted mixture followed by homogenisation

↓

Melting the fat and ghee

↓

Addition of melted ghee, fat and milk powder to the prepared mixture followed by homogenisation

↓

Sieving

↓

Packed and Stored

The moisture content was determined by the AOAC (1975) method. Oil absorption capacity was estimated following the procedure of Beuchat (1977). Change in weight during frying and soaking of gulab jamun was measured using a weighing scale, while volume expansion was determined using a vernier caliper. Microbial count, protein, crude fiber, calcium and potassium contents were estimated as per Ranganna (1978). Fat content was analyzed according to AOAC (1980), while carbohydrate was calculated according to the method of Gopalan *et al.* (1985).

Results

Data depicted in Table 2 represents the moisture content, frying time, oil absorption capacity and microbial count of jackfruit seed flour based gulab jamun mix. The minimum moisture content is vital for preserving product quality. In the present study, the lowest moisture content was recorded in T_6 (5.33%) followed by T_{12} (5.54%) and T_5 (5.65%), while the highest was observed in T_7 (7.12%) followed by the control (T_1) of 6.91 per cent.

Frying time is an important processing parameter and a shorter duration is generally desirable. The minimum frying time was observed in T_6 (4.77 minutes) which was statistically on par with T_5 (4.92 minutes), while the maximum was recorded in T_7 (6.12 minutes), which was statistically similar to T_8 (5.95 minutes) and followed by T_9 (5.79 minutes), T_{10} (5.63 minutes) and T_1 (5.57 minutes).

Oil absorption capacity of the formulations ranged from 80.25 to 81.94 per cent. The least oil absorption was recorded in T_6 (80.25%) followed by T_{12} (80.52%) and T_5 (40% JSF + 10% RWF + 35% SMP + 15% OI), which recorded 80.58 per cent, whereas the greatest was

Table 1 : Treatment details.

Treatments	Jack fruit seed flour (%)	Refined wheat flour (Maida) (%)	Skimmed milk powder (%)	*Other ingredients (%)
T_1	0	50	35	15
T_2	10	40	35	15
T_3	20	30	35	15
T_4	30	20	35	15
T_5	40	10	35	15
T_6	50	0	35	15
T_7	0	50	40	10
T_8	10	40	40	10
T_9	20	30	40	10
T_{10}	30	20	40	10
T_{11}	40	10	40	10
T_{12}	50	0	40	10

***Other ingredients**: Hydrogenated fat, Ghee, Sodium bicarbonate (Baking soda), Malic acid

Table 2 : Effect of varied concentration of jackfruit seed flour on the moisture content, frying time, oil absorption capacity and microbial count of gulab jamun mix.

Treatments	Moisture content (%)	Frying time (min)	Oil absorption capacity (%)	Microbial count (CFU × $10^4 ml^{-1}$)
T_1	6.91^b	5.57^{cde}	81.78^b	0.00
T_2	6.59^d	5.41^{def}	81.46^d	0.00
T_3	6.29^f	5.24^{fg}	81.13^f	0.00
T_4	5.98^h	5.09^{gh}	80.83^g	0.00
T_5	5.65^i	4.92^{hi}	80.58^h	0.00
T_6	5.33^l	4.77^i	80.25^i	0.00
T_7	7.12^a	6.12^a	81.94^a	0.00
T_8	6.80^c	5.95^{ab}	81.65^c	0.00
T_9	6.50^e	5.79^{bc}	81.34^e	0.00
T_{10}	6.19^g	5.63^{cd}	81.08^f	0.00
T_{11}	5.86^j	5.48^{def}	80.80^g	0.00
T_{12}	5.54^k	5.33^{efg}	80.52^h	0.00
S. Em ±	**0.01**	**0.09**	**0.02**	**0.00**
CD @ 1%	**0.04**	**0.34**	**0.08**	**NS**

Table 3 : Effect of varied concentration of jackfruit seed flour on the raw, fried and soaked weights (g) and volumes (mm) of gulab jamun.

Treatments	Change in weight (g)			Change in volume (mm)		
	Raw	Fry	Soak	Raw	Fry	Soak
T_1	6.00^a	5.19^a	14.30G”	20.00^a	25.48^a	32.95G”
T_2	6.00^a	5.18^a	14.16H”	20.00^a	25.47^a	32.90œ”
T_3	6.00^a	5.19^a	14.01 ”	20.00^a	25.48^a	32.84H”
T_4	6.00^a	5.18^a	13.86°	20.00^a	25.47^a	32.79I”
T_5	6.00^a	5.19^a	13.72²	20.00^a	25.48^a	32.74 ”
T_6	6.00^a	5.17^a	13.57á	20.00^a	25.46^a	32.68M”
T_7	6.00^a	5.18^a	14.37C”	20.00^a	25.47^a	32.99C”
T_8	6.00^a	5.17^a	14.24œ”	20.00^a	25.46^a	32.94G”
T_9	6.00^a	5.19^a	14.09I”	20.00^a	25.48^a	32.89œ”
T_{10}	6.00^a	5.18^a	13.93M”	20.00^a	25.47^a	32.83H”
T_{11}	6.00^a	5.19^a	13.80q	20.00^a	25.48^a	32.79I”
T_{12}	6.00^a	5.18^a	13.65O”	20.00^a	25.47^a	32.72 ”
S. Em ±	**0.02**	**0.04**	**0.02**	**0.02**	**0.05**	**0.008**
CD @ 1%	**NS**	**NS**	**0.06**	**NS**	**NS**	**0.032**

observed in T_7 (81.94 %) followed by T_1 at 81.78 per cent. At the initial stage of microbial count, no colony-forming units (CFU) were detected.

Table 3 illustrates the changes in weight and volume of gulab jamun prepared from jackfruit seed flour. In all treatments, the gulab jamun samples initially weighed at 6 g. After frying, the maximum weight was obtained in T_1 (5.19 g), whereas T_6 (5.17 g) recorded the minimum, with no statistically significant variation among the treatments. Upon soaking the fried gulab jamun in sugar syrup, all the treatments showed an increase in weight with the range of 13.57 to 14.37g. T_7 reaching the highest value (14.37 g) followed by T_1 (14.30 g) and that of T_5 recorded 13.72 g while the lowest soaking weight was observed in T_6 (13.57 g).

In all treatments, the initial volume of gulab jamun samples was consistently measured at 20 mm. After frying, the highest volume was recorded in T_1 (25.48 mm), while the lowest was observed in T_6 (25.46 mm) with no statistically significant differences among the treatments. Immersion of fried gulab jamun in sugar syrup resulted in a further increase in volume across all samples with the

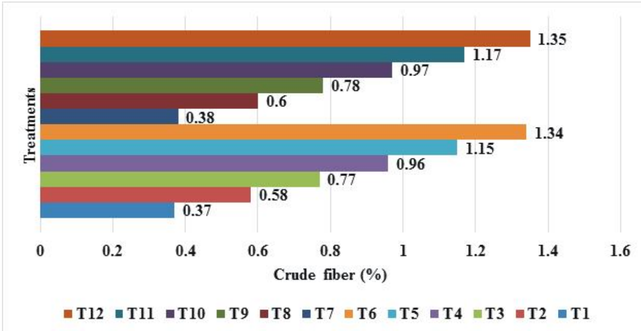

Fig. 1 : Effect of varied concentration of jackfruit seed flour on the crude fiber content of gulab jamun mix.

The effect of jackfruit seed flour incorporation on the fat, protein, carbohydrate, calcium and potassium content of gulab jamun mix is represented in Table 4. The fat content in the premix ranged from 12.11 to 13.20 per cent. T_6 recorded the highest fat content (13.20%), which was statistically similar with T_{12} (13.01%) and T_5 (40% JSF + 10% RWF + 35% SMP + 15% OI) at 12.96 per cent. The lowest fat content was observed in T_7 (12.11%), which was statistically on par with T_8 (12.25%) and T_1 (12.30%).

For protein content, the highest value was recorded

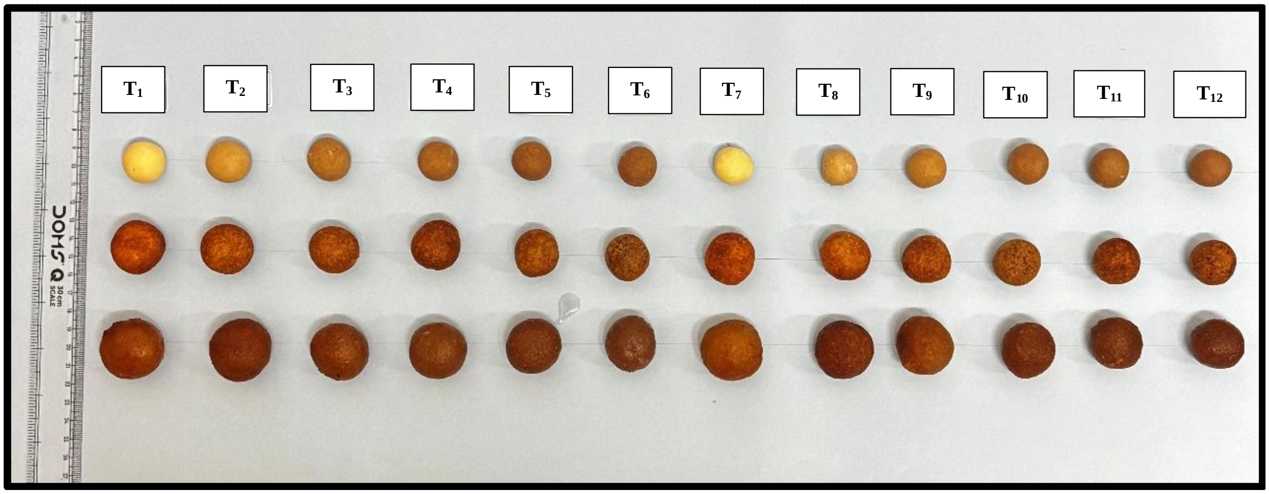

Plate 1 : Effect of varied concentration of jackfruit seed flour on the volume expansion of gulab jamun.

Table 4 : Effect of varied concentration of jackfruit seed flour on the fat, protein, carbohydrate, calcium and potassium content of gulab jamun mix.

Treatments	Fat (%)	Protein (%)	Carbohydrate (%)	Calcium (mg 100 g^{-1})	Potassium (mg 100 g^{-1})
T_1	12.30^{cd}	16.39^{c}	51.47^{i}	67.15^{l}	62.15^{l}
T_2	12.41^{bcd}	16.56^{c}	51.79^{gh}	67.90^{j}	62.82^{h}
T_3	12.56^{abcd}	16.88^{c}	52.06^{ef}	68.65^{h}	63.48^{g}
T_4	12.72^{abcd}	17.71^{ab}	52.31^{d}	69.40^{f}	64.15^{f}
T_5	12.96^{abc}	17.97^{a}	52.75^{b}	70.15^{d}	64.83^{d}
T_6	13.20^{a}	18.25^{a}	52.95^{a}	70.90^{b}	65.49^{b}
T_7	12.11^{d}	16.74^{c}	51.70^{h}	67.80^{k}	62.60^{k}
T_8	12.25^{d}	16.94^{c}	51.91^{fg}	68.55^{i}	63.27^{i}
T_9	12.35^{bcd}	17.10^{bc}	52.17^{de}	69.30^{g}	63.93^{g}
T_{10}	12.51^{bcd}	17.89^{a}	52.54^{c}	70.05^{e}	64.60^{e}
T_{11}	12.74^{abcd}	18.14^{a}	52.93^{av}	70.80^{c}	65.28^{c}
T_{12}	13.01^{ab}	18.52^{a}	53.10^{a}	71.55^{a}	65.94^{a}
S.Em±	**0.20**	**0.25**	**0.07**	**0.02**	**0.03**
CD @ 1%	**0.80**	**0.99**	**0.26**	**0.07**	**0.12**

range of 32.68 to 32.99 mm. T_7 recorded the maximum value (32.99 mm) followed by T_1 (32.95 mm) and that of T_5 recorded 32.74 mm while the minimum increase was noted in T_6 (32.68 mm).

in T_{12} (18.52%), which was statistically comparable to T_6 (18.25%), T_{11} (18.14%), T_5 (17.97%) and T_{10} (17.89%). The lowest protein content was observed in the T_1 (16.39%). Carbohydrate content ranged in between

51.47 to 53.10 per cent. T_{12} recorded the highest carbohydrate content (53.10%), which was statistically comparable to the T_6 (52.95%) and T_{11} (52.93%) and the lowest value was observed in T_1 (51.47%).

A statistically significant difference was observed among treatments with respect to calcium and potassium content. The highest calcium content was recorded in T_{12} (71.55 mg $100g^{-1}$) followed by T_6 (70.90 mg $100g^{-1}$), T_{11} (70.80 mg $100g^{-1}$) and T_5 (40% JSF + 10% RWF + 35% SMP + 15% OI) of 70.15 mg $100g^{-1}$, while the lowest was noted in T_1 (67.15 mg $100g^{-1}$). In terms of potassium content, T_{12} showed the highest value (65.94 mg $100g^{-1}$) followed by T_6 (65.49 mg $100g^{-1}$), T_{11} (65.28 mg $100g^{-1}$) and T_5 (64.83 mg $100g^{-1}$) and the lowest potassium content was observed in T_1 (62.15 mg $100g^{-1}$).

Fig. 1 depicts the crude fiber content jackfruit seed flour based gulab jamun mix. T_{12} recorded the highest crude fiber content (1.35%), which was statistically comparable to T_6 (1.34%) followed by T_{11} (1.17%) and T_5 (1.15%), while the lowest crude fiber content was observed in the T_1 (0.37%).

Discussion

Low moisture content reduces the microbial growth, thereby enhancing the shelf life and preserving the product quality. In this study the lowest moisture content was observed in T_6 (5.33%) followed by T_{12} (5.54%) and T_5 (5.65%), due to the higher levels of jackfruit seed flour, which is low in moisture and rich in dry solids. Similar findings were reported by Aziz *et al.* (2016) in butter cake and Khan *et al.* (2016) in composite cake, all formulated with jackfruit seed flour. In contrast, the highest moisture content was recorded in T_7 (7.12%) followed by T_1 (6.91%), likely resulting from the higher milk powder content, which enhances water retention, as also noted by Suresha *et al.* (2018) in bottle gourd halwa and Rizqiati *et al.* (2024) in kefir powder, both incorporating milk powder.

The shortest frying time was observed in T_6 (4.77 min), which was statistically comparable to T_5 (4.92 min), likely due to the lower moisture content of jackfruit seed flour, which accelerates the faster moisture evaporation during frying. Similar trends have been reported by Abraham and Jayamuthunagai (2014) in pasta incorporated with jackfruit seed flour, Gunarathna *et al.* (2024) in jackfruit seed flour-based snacks and Teo *et al.* (2024) in the roasting of jackfruit seed flour. Conversely, the longest frying time occurred in T_7 (6.12 min), which was statistically comparable to T_8 (5.95 min), likely due to the higher milk powder content, which increases batter viscosity and slows heat and moisture transfer, as observed by Soni *et al.* (2020) in milk crisp and Sain *et al.* (2024) in gulab jamun.

The least oil absorption was recorded in T_6 (80.25%) followed by T_{12} (80.52%) and T_5 (80.58%), likely due to the incorporation of jackfruit seed flour, which promotes a more compact and less porous structure during frying, thereby limiting excessive oil uptake. Similar findings were reported by Gunarathna *et al.* (2024) in jackfruit seed flour-based snacks. In contrast, the highest oil absorption was observed in T_7 (81.94%) which was attributed to the higher milk powder content, which increases porosity and facilitates the greater oil penetration, as noted by Soni *et al.* (2020) in milk crisp and Sain *et al.* (2024) in gulab jamun.

After frying, gulab jamun loses weight due to moisture evaporation but soaking in sugar syrup leads to rehydration and weight gain. T_7 recorded the highest weight (14.37 g) and volume (32.99 mm), likely due to the porous and granular structure of refined wheat flour and higher milk powder levels which enhance syrup absorption, as reported by Sain *et al.* (2024). In contrast, the lowest soaking weight and volume were observed in T_6 (13.57 g and 32.68 mm) due to the less porous structure and lower swelling capacity of jackfruit seed flour which limits the syrup uptake. Similar trends were noted by Islam *et al.* (2015) in biscuits, Maurya (2017) in biscuits and Akter *et al.* (2020) in cake, all prepared with jackfruit seed flour incorporation.

T_6 recorded the highest fat content (13.20%), which was statistically similar to T_{12} (13.01%) and T_5 (12.96%), likely due to the intrinsic lipid content of jackfruit seed flour. Similar findings were reported by Aziz *et al.* (2016) in butter cake and Khan *et al.* (2016) in composite cake, all prepared with jackfruit seed flour. Conversely, the lowest fat content was observed in T_7 (12.11%), which was statistically comparable to T_8 (12.25%) and T_1 (12.30%), due to reduced addition of hydrogenated fat and ghee in their formulations.

The highest protein content was recorded in T_{12} (18.52%), which was statistically comparable to T_6 (18.25%), T_{11} (18.14%) and T_5 (17.97%), due to the naturally high protein content of jackfruit seed flour. Similar trends were reported by Hossain *et al.* (2014) in bread and Arpit and David (2015) in chocolate cake prepared with jackfruit seed flour. The inclusion of milk powder also enhanced protein levels, as noted by Suresha *et al.* (2018) in fresh bottle gourd halwa, Vashistha *et al.* (2019) in instant kheer mix and Khadka and Timsina (2024) in yogurt. The lowest protein content was observed in the control (16.39%) due to the absence of jackfruit seed flour and lower milk powder proportion.

The highest carbohydrate content was observed in T_{12} (53.10%), likely due to the inclusion of milk powder, which is naturally rich in carbohydrates, as reported by Suresha *et al.* (2018) in fresh bottle gourd halwa and Rizqiati *et al.* (2024) in kefir powder. In contrast, T_1 had the lowest carbohydrate content (51.47%), attributed to the higher proportion of refined wheat flour, which has a lower intrinsic carbohydrate content compared to jackfruit seed flour. Similar observations were reported by Aziz *et al.* (2016) in butter cake and Molu *et al.* (2022) in nutri spreads prepared with jackfruit seed flour.

The highest calcium and potassium contents were recorded in T_{12} (71.55 mg/ 100 g^{-1} and 65.94 mg/ 100 g^{-1}, respectively), due to the inherent richness of jackfruit seed flour and the inclusion of milk powder. Similar trends were reported by Maskey *et al.* (2020) in cookies and Gaol *et al.* (2021) in muffins. Elevated mineral levels with addition of milk powder align with findings by Akal and Yetisemiyen (2016) in fermented cream, Khadka and Timsina (2024) in yogurt and Suresha *et al.* (2018) in fresh bottle gourd halwa. The lowest calcium (67.15 mg/ 100 g^{-1}) and potassium (62.15 mg/ 100 g^{-1}) contents were observed in T_1, due to the absence of jackfruit seed flour and the lower level of milk powder.

T_{12} recorded the highest crude fiber content (1.35%), which was statistically comparable to T_6 (1.34%), due to the higher inclusion of jackfruit seed flour, which is naturally rich in dietary fiber. Similar results were reported by Maurya (2017) in noodles and Gomes and Costa (2019) in muffins, all prepared with jackfruit seed flour. The addition of milk powder did not increase fiber content, as it contains negligible dietary fiber (Anonymous, 2009). The lowest fiber content was observed in T_1 (0.37%) due to the absence of jackfruit seed flour in this formulation.

Conclusion

Among twelve formulations, T_5 (40% jackfruit seed flour + 10% refined wheat flour + 35% skimmed milk powder+15% other ingredients) recorded the most desirable physical characteristics with the lowest moisture content (5.65%), shortest frying time (4.92 minutes) and the minimal oil absorption (80.58%) compared with the T_1 (control). The nutritionally enriched gulab jamun mix (T_5) exhibited significantly higher levels of fat (12.96%), protein (17.97%), dietary fiber (1.15%), carbohydrate (52.75%), calcium (70.15 mg 100 g^{-1}) and potassium (64.83 mg 100 g^{-1}) in comparison to the conventional gulab jamun mix prepared with refined wheat flour (T_1).

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