Plant Archives Vol. 25, No. 2, 2025 pp. 2478-2484 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.354

STANDARDIZATION OF INGREDIENTS FOR DEVELOPMENT OF KOKUM RIND POWDER CHEWABLE TABLETS

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(Date of Receiving-26-07-2025; Date of Acceptance-02-10-2025)

ABSTRACT

This study focused on developing and standardizing kokum (*Garcinia indica* Choisy) rind powder chewable tablets by finding the optimal combination of ingredients. Tablets were prepared using kokum rind powder, sucrose, mannitol, starch, talc and natural flavouring agents through wet granulation method by using Factorial Completely Randomized Design (FCRD) and were evaluated for their physico-chemical, functional and sensory properties. Among the different treatment combinations, $K_1S_2M_2$ (500 mg kokum rind powder + 300 mg sucrose + 150 mg mannitol) exhibited the highest hardness (5.23 kg cm{ ²), lowest friability (0.16 %), fastest disintegration (21.45 min) and lowest water activity (0.48). Sensory evaluation using a 5-point hedonic scale also showed that this formulation was the most preferred, scoring the highest score for sourness, sweetness, flavour, texture and overall acceptability (4.83). These results indicated that the balanced combination of kokum rind powder, sucrose and mannitol in $K_1S_2M_2$ treatment combination produced tablets with excellent stability, mechanical strength and consumer appeal, highlighting its potential as a value-added kokum-based nutraceutical product.

Key words : Kokum rind powder, Chewable tablets, Disintegration time, Hardness, Wet granulation.

Introduction

Kokum (*Garcinia indica* Choisy.) is an indigenous fruit-bearing tree of the Clusiaceae family, naturally found in the tropical evergreen forests of the Western Ghats and North-Eastern states of India. In India, its production is estimated at 10,200 metric tonnes from 2,200 hectares, with an average productivity of 8.50 t ha^{-1} (Nayak *et al*., 2010). Kokum has diverse culinary, pharmaceutical and industrial applications. Traditionally, its rinds and leaves have been used in Ayurveda and folk medicine to manage inflammation, rheumatic pain and gastrointestinal disorders. Nutritionally, kokum is rich in B-complex vitamins and minerals such as potassium, manganese and magnesium, which support heart health and help to regulate blood pressure. The fruit is naturally very acidic (pH 1.5 to 2.0) and contains moisture (80%), protein (1%), tannin (1.70 %), total ash (2.57%), pectin (0.90%), total sugars (4.10 %), crude fat (1.40%) and ascorbic acid (>0.06%) (Nayak *et al*., 2010). It is also rich in anthocyanins (~2.40%), which provide the red pigment and hydroxycitric acid (4.10 to 4.60 per cent in leaves and 10.30 to 12.70 per cent in rinds), a bioactive compound known for its anti-obesity effects. Additionally, kokum contains polyisoprenylated benzophenones like garcinol and isogarcinol (~1.50%), which exhibit antioxidant, anti-carcinogenic, antimicrobial, anti-ulcer and anti-glycation activities (Yamaguchi *et al*., 2000).

Kokum is processed into several value-added products such as syrup, juice concentrate, salted rind, ready-to-serve beverages, butter, dried rind powder, honey and

wine (Nayak *et al*., 2010). In recent years, kokum has also been processed into powder or granular forms, which exhibits high hygroscopicity. Therefore, careful handling and special packaging are required during marketing, transportation, handling and storage. However, alternative techniques like ccompaction of fruit powder into the shape of tablets are more suitable to overcome the post-processing problems regarding storage, transportation and quality degradation (Zea *et al*., 2013). Tablets represent a unit dose, solid preparation that contains one or more active ingredients and it is the most popular and widely used dosage form of drug administration. Tableting reduces the surface area and bulk volume of the powder, improves chemical and physical stability, prolongs shelf life, lowers transportation and storage costs and enhances product presentation and consumer acceptance (Yusof *et al*., 2012 and Renu *et al*., 2015). Chewable tablets, specifically, are designed to be broken and chewed before ingestion, disintegrating smoothly in the mouth with a pleasant taste and without leaving any bitterness. In recent years, fruit-based chewable tablets have gained significant attention for their stability, ease of handling and greater consumer acceptability from both industrial and nutritional perspectives.

Materials and Methods

The experiment was conducted in the Department of Postharvest Management, College of Horticulture, Mudigere and National College of Pharmacy, Shivamogga during the year 2024-2025. Fruits were cleaned, washed, sorted and seeds were separated from the rinds. The fruit rinds were dried by using electric tray drier (55-60ºC) for about 18 to 24 hours to remove moisture content. Dried rinds were pulverized by using mixer grinder and sieved to obtain fine powder. Excipients including sucrose, mannitol, starch (binder), talc (lubricant) were procured from Karnataka Fine Chem, laboratory chemical suppliers, Bengaluru and flavouring agents (cumin and black pepper extracts) were procured from Spice drop, natural liquid extracts, Universal Oleoresins, Kochi.

Treatment combinations used for the preparation of kokum rind powder chewable tablets

T_1 ($K_1S_1M_1$): 400 mg kokum rind powder + 250 mg sucrose + 100 mg mannitol

T_2 ($K_1S_1M_2$): 400 mg kokum rind powder + 250 mg sucrose + 150 mg mannitol

T_3 ($K_2S_1M_1$): 400 mg kokum rind powder + 300 mg sucrose + 100 mg mannitol

T_4 ($K_2S_1M_2$): 400 mg kokum rind powder + 300 mg sucrose + 150 mg mannitol

T_5 ($K_1S_2M_1$): 500 mg kokum rind powder + 250 mg sucrose + 100 mg mannitol

T_6 ($K_1S_2M_2$): 500 mg kokum rind powder + 250 mg sucrose + 150 mg mannitol

T_7 ($K_2S_2M_1$): 500 mg kokum rind powder + 300 mg sucrose + 100 mg mannitol

T_8 ($K_2S_2M_2$): 500 mg kokum rind powder + 300 mg sucrose + 150 mg mannitol

K - Kokum rind powder, S - Sucrose, M - mannitol

Standard operating procedure for developing kokum rind powder chewable tablets by wet granulation method

Tablets were prepared by first weighing the required ingredients according to the formulations and triturated using mortar and pestle. All the chemicals of known quantity were weighed and sieved using a sieve of mesh size of 60 mm to ensure uniform particle size. The powders were then triturated using a mortar and pestle to obtain a homogenous mixture. A known quantity of corn starch was weighed, mixed with a measured amount of water and boiled until a thick paste was formed and it was expressed as per cent w/v. The prepared starch paste was then mixed with the weighed ingredients and triturated until a dough-like mass was formed. This dough was passed through a sieve with a mesh size of 16 mm to form spiral structures, which were oven dried at a temperature of 55 ± 5°C until complete moisture removal. The dried material was then passed through sieves with mesh sizes of 22 and 44 to obtain granules and fines, respectively. After collecting the granules, they were weighed and the required quantities of lubricants, glidants and flavouring agents were calculated and added to the granules. Pre-compression evaluation of the blend was performed, including tests for bulk density, tapped density, Hausner ratio, Carr's index and angle of repose. Tablets were compressed using 12.6 mm flat-faced punches, with each tablet weighing 900 mg.

Post-evaluation parameters of tablets/Tablet parameters

Uniformity of weight (g)

The weight variation test was performed by weighing 10 tablets individually calculating the average weight and comparing the individual tablet weights to the average (Chandrakant *et al*., 2018).

Hardness (kg cm^{-2})

Hardness is the resistance of the tablet against the applied force till it breaks. A tablet was placed between the two anvils, the force was applied to the anvils and

crushing strength that just causes the tablet to break. The hardness of each tablet was tested using Monsanto hardness tester.

Friability (%)

Friability is an indicator of the mechanical strength of tablets. For the test, six tablets were accurately weighed and placed in a plastic friability chamber rotating at 25 rpm for 100 revolutions, with each revolution dropping the tablets from a height of six inches. After completion of the cycle (4 minutes), the tablets were removed, dedusted and reweighed (Sumalatha and Reddy, 2017).

Disintegration time

Tablet disintegration was determined in the Tablet Disintegration Tester using both simple buffer and viscous media containing simulated gastric fluid (pH ≈ 1.2) or 0.1 N HCl. Tests were carried out in 800 ml of the investigated media at 37 ± 0.50°C. Rapid disintegration indicates efficient tablet dispersion and enhancing dissolution (Parojcic *et al*., 2007).

Water activity (a_w)

A small amount of powdered tablet sample was filled into the holder up to the mark indicated and then placed inside the water activity meter. The end point was indicated by three beep sounds displaying the water activity readings digitally.

Sensory evaluation

Sensory evaluation is a scientific method used to measure, analyze and interpret the characteristics of food products as perceived by the human senses such as sight, smell and taste. Sensory evaluation was performed by using a 5-point hedonic scale with the help of semi-trained panelists. The panelists evaluated the samples for specific sensory attributes such as sourness, sweetness, spiciness, texture and flavour. Based on these individual attributes, scores were assigned and the overall acceptability of each treatment was determined by considering the responses recorded on the hedonic scale.

Statistical analysis

The prepared chewable tablets were analyzed using Factorial Completely Randomized Design (FCRD) in M-STAT software. Three factors were used (kokum (K), sucrose (S) and mannitol (M)) with each having two levels.

Results and Discussion

Effect of ingredients concentration physical parameters of kokum rind powder chewable tablets

Uniformity of weight (g) : Uniformity of weight is an important quality control parameter employed to evaluate the uniformity of dosage units in tablet formulations (Table 1). All the individual ingredients, kokum rind powder (K), sucrose (S) and mannitol (M) did not show any significant differences for uniformity of weight. In kokum rind powder (K), K_1 recorded the maximum weight of 9.02 g, whereas K_2 showed the minimum weight of 9.00 g. For sucrose (S) both S_1 and S_2 registered weight of 9.01 g, while in mannitol (M), both M_1 and M_2 exhibited weight of 9.01 g. With respect to interactions, no significant effect was observed for weight of the tablets, in kokum rind powder-sucrose (KS) combination, K_1S_1 and K_1S_2 showed the highest weight (9.02 g), while K_2S_1 and K_2S_2 registered the lowest weight (9.00 g). In kokum rind powder-mannitol (KM) interaction, K_1M_1 and K_2M_2 attained the maximum weight (9.02 g), whereas K_2M_1 showed the minimum weight of 9.00 g. For sucrose-mannitol (SM), S_1M_1, S_1M_2 and S_2M_2 exhibited the maximum weight (9.01 g), whereas the minimum weight (9.00 g) was observed in S_2M_1. Across the treatment combinations, no significant differences were recorded. $K_1S_2M_2$ exhibited the weight of 9.01 g, which was statistically on par with remaining treatment combinations. $K_1S_2M_1$ recorded the maximum weight (9.03 g) and $K_2S_2M_1$ recorded the minimum weight (9.00 g). Uniformity of weight in chewable tablets depends on powder flow and packing during compression. Sucrose and mannitol improved weight consistency due to their crystalline nature, enhancing flow, bulk density, and reducing clumping. Mannitol, being non-hygroscopic, minimized moisture uptake and sticking, while sucrose acted as both filler and binder, aiding cohesion and uniform die filling. Kokum rind powder alone showed fair flow due to its fibrous particles, but its blend with sucrose and mannitol improved distribution. Starch enhanced binding, reduced voids and minimized variability in tablet weight. Similar findings by Juppo *et al*. (1995) highlighted the role of excipient selection in achieving superior weight uniformity.

Hardness (kg cm^{-2}) : Hardness of chewable tablets reflects their mechanical resistance to external stress during handling, transportation and storage. With respect to individual ingredients statistically no significant differences were noticed (Table 1). In kokum rind powder (K), K_2 exhibited the higher hardness of 4.79 kg cm^{-2}, whereas K_1 recorded the lowest hardness of 4.47 kg cm^{-2}. For sucrose (S), greater hardness of 4.99 kg cm^{-2} was observed in S_2 and lesser hardness of 4.28 kg cm^{-2} was recorded in S_1. In case of mannitol (M), M_1 reached the higher hardness of 4.67 kg cm^{-2}, whereas M_2 exhibited a comparatively lower hardness value of 4.59 kg cm^{-2}.

Table 1 : Effect of ingredients concentration on physical parameters of kokum rind powder chewable tablets.

Treatments	Uniformity of weight (g)	Hardness (kg cm^{-2})	Friability (%)	Disintegration time (min)	Water activity (a_w)
Ingredients (K)					
K_1	9.02^{a}	4.47^{a}	0.23^{a}	22.47^{a}	0.49^{a}
K_2	9.00^{a}	4.79^{a}	0.17^{b}	22.56^{a}	0.50^{a}
S. Em ±	**0.07**	**0.37**	**0.004**	**0.25**	**0.01**
CD @ 1%	**NS**	**NS**	**0.01**	**NS**	**NS**
Ingredients (S)					
S_1	9.01^{a}	4.28^{a}	0.18^{b}	22.97^{a}	0.50^{a}
S_2	9.01^{a}	4.99^{a}	0.21^{a}	22.07^{a}	0.49^{a}
S. Em ±	**0.07**	**0.28**	**0.004**	**0.25**	**0.01**
CD @ 1%	**NS**	**NS**	**0.01**	**NS**	**NS**
Ingredients (M)					
M_1	9.01^{a}	4.67^{a}	0.21^{a}	22.46^{a}	0.50^{a}
M_2	9.01^{a}	4.59^{a}	0.18^{b}	22.58^{a}	0.49^{a}
S. Em ±	**0.06**	**0.40**	**0.004**	**0.25**	**0.01**
CD @ 1%	**NS**	**NS**	**0.01**	**NS**	**NS**
Interaction (K×S)					
K_1S_1	9.02^{a}	4.00^{b}	0.21^{b}	23.03^{a}	0.49^{a}
K_1S_2	9.02^{a}	4.94^{a}	0.24^{a}	21.92^{b}	0.49^{a}
K_2S_1	9.00^{a}	4.55^{a}	0.15^{d}	22.91^{ab}	0.51^{a}
K_2S_2	9.00^{a}	5.03^{a}	0.18^{c}	22.22^{ab}	0.50^{a}
S. Em ±	**0.08**	**0.25**	**0.004**	**0.46**	**0.01**
CD @ 1%	**NS**	**0.70**	**0.01**	**1.38**	**NS**
Interaction (K×M)					
K_1M_1	9.02^{a}	4.55^{a}	0.28^{a}	22.72^{a}	0.50^{a}
K_1M_2	9.01^{a}	4.38^{a}	0.18^{b}	22.22^{a}	0.48^{b}
K_2M_1	9.00^{a}	4.79^{a}	0.15^{c}	22.19^{a}	0.50^{a}
K_2M_2	9.02^{a}	4.79^{a}	0.18^{b}	22.94^{a}	0.50^{a}
S. Em ±	**0.08**	**0.41**	**0.003**	**0.46**	**0.01**
CD @ 1%	**NS**	**NS**	**0.01**	**NS**	**0.03**
Interaction (S×M)					
S_1M_1	9.01^{a}	4.45^{ab}	0.18^{b}	22.79^{a}	0.51^{a}
S_1M_2	9.01^{a}	4.10^{b}	0.18^{b}	23.13^{a}	0.49^{a}
S_2M_1	9.00^{a}	4.89^{a}	0.25^{a}	22.12^{a}	0.49^{a}
S_2M_2	9.01^{a}	5.08^{a}	0.17^{b}	22.03^{a}	0.49^{a}
S. Em ±	**0.08**	**0.27**	**0.003**	**0.46**	**0.01**
CD @ 1%	**NS**	**0.78**	**0.01**	**NS**	**NS**
Interaction (K×S×M)					
$K_1S_1M_1$	9.02^{a}	4.46^{e}	0.23^{b}	23.05^{a}	0.50^{bc}
$K_1S_1M_2$	9.02^{a}	3.55^{f}	0.19^{c}	22.99^{ab}	0.49^{cd}
$K_1S_2M_1$	9.03^{a}	4.65^{d}	0.33^{b}	22.40^{ab}	0.51^{abc}
$K_1S_2M_2$	9.01^{a}	5.23^{a}	0.16^{d}	21.45^{b}	0.48^{d}
$K_2S_1M_1$	9.01^{a}	4.45^{e}	0.13^{e}	22.55^{ab}	0.52^{a}
$K_2S_1M_2$	9.01^{a}	4.65^{d}	0.17^{c}	23.28^{a}	0.50^{bc}
$K_2S_2M_1$	9.00^{a}	5.12^{b}	0.18^{c}	21.84^{ab}	0.49^{cd}
$K_2S_2M_2$	9.01^{a}	4.94^{c}	0.19^{c}	22.60^{ab}	0.51^{ab}
S. Em ±	**0.12**	**0.01**	**0.005**	**0.66**	**0.01**
CD @ 1%	**NS**	**0.03**	**0.01**	**1.95**	**0.02**

Among the interaction of kokum rind powder-sucrose (KS), K_2S_2 (5.03 kg cm^{-2}) was statistically on par with K_1S_2 and K_2S_1, whereas K_1S_1 recorded statistically the minimum hardness of 4.00 kg cm^{-2}. In kokum rind powder-mannitol (KM) interaction, no significant differences was observed, both K_2M_1 and K_2M_2 showed the higher hardness (4.79 kg cm^{-2}), while K_1M_2 displayed the lowest hardness (4.38 kg cm^{-2}). Within sucrose-mannitol (SM) interaction, S_2M_2 reached the maximum hardness (5.08 kg cm^{-2}), which was statistically on par with S_2M_1 and S_1M_1, whereas S_1M_2 recorded statistically the lower hardness of 4.10 kg cm^{-2}. Across all the treatment combinations, $K_1S_2M_2$ statistically demonstrated the higher hardness (5.23 kg cm^{-2}), which was followed by $K_2S_2M_1$ (5.12 kg cm^{-2}), whereas $K_1S_1M_2$ exhibited the lowest value (3.55 kg cm^{-2}). Overall, the treatment combinations showed statistically significant variations in hardness. The hardness of chewable tablets was mainly influenced by the compressibility and binding properties of excipients. Sucrose and mannitol enhanced hardness of the tablets due to their crystalline structure, enabling strong particle bonding, while sucrose also acted as a binder promoting cohesion. Starch contributed through partial deformation and swelling, improving interparticle adhesion. Kokum rind powder provided structural reinforcement by interlocking within the matrix and talc reduced friction for uniform compaction. Similar observations were reported by Khairnar *et al*. (2024) and Debnath *et al*. (2019), emphasizing the role of binders in improving compact strength and tablet quality.

Friability (%) : Friability is a critical evaluation parameter that determines the ability of tablets to withstand mechanical stresses during handling, transportation and storage. It reflects the tendency of tablets to chip, crumble or break when subjected to abrasion and impact (Table 1). All the treatment combinations exhibited friability values within the acceptable limits ranging from 0.10 to 1.00 per cent. Among the individual ingredients effect, kokum rind powder (K) at K_1 level showed significantly the maximum friability per cent of 0.23, whereas K_2 registered the lower friability (0.17 %). In case of sucrose (S), S_2 exhibited statistically the maximum friability (0.21 %), whereas S_1 registered the minimum friability (0.18 %). In mannitol (M), M_1 displayed the greater friability (0.21 %), whereas M_2 registered the lower friability (0.18 %). Within the interaction effects, in kokum rind powder-sucrose (KS) interaction, K_1S_2 statistically exhibited the highest friability (0.24 %), whereas K_2S_1 recorded the lowest friability (0.15 %). In kokum rind powder-mannitol (KM), K_1M_1 statistically exhibited the greater friability (0.28 %), whereas K_2M_1 displayed the lowest friability (0.15 %). For sucrose-mannitol (SM), S_2M_1 demonstrated the higher friability (0.25 %) and the lowest friability (0.18 %) was observed in S_2M_2 which was statistically similar with S_1M_1 and S_2M_2. Across the treatment combinations, $K_1S_2M_2$ maintained friability (0.16%) within the acceptable limit, however the maximum friability was observed in $K_1S_2M_1$ (0.33%), which was followed by $K_1S_1M_1$ (0.23%), whereas the least friability value of 0.13 per cent was attained by $K_2S_1M_1$. Overall, the treatment combinations exhibited statistically significant differences in friability. The friability of chewable tablets depends on how well the powder blend sticks together during compression. Sucrose and mannitol helped to strengthen the tablets by binding the particles, while starch added extra mechanical support. Kokum rind powder worked with other ingredients to reinforce the structure and talc reduced friction during punching. Even small amounts of flavouring agents like cumin and black pepper helped to distribute stress, all of which together lowered friability. These observations are in line with Jacob *et al*. (2007), who reported that tablets with mannitol and microcrystalline cellulose showed very low friability.

Disintegration time : Disintegration time refers to the duration required for a tablet to break down into smaller granules or particles under specified *in vitro* conditions thereby facilitating the release of the active ingredient for absorption (Table 1). Across the individual ingredient levels, no significant effect was observed. In kokum rind powder (K), K_2 exhibited the longest disintegration time of 22.56 minutes, whereas K_1 recorded the shortest disintegration time of 22.47 minutes. For sucrose (S), S_1 showed the maximum disintegration time of 22.97 minutes, while S_2 registered the minimum disintegration time of 22.07 minutes. In case of mannitol (M), M_2 attained the maximum disintegration time of 22.58 minutes, whereas M_1 reached the minimum disintegration time of 22.46 minutes. Across the interaction effects, in kokum rind powder-sucrose (KS), K_1S_1 exhibited the longest disintegration time of 23.03 minutes, which was statistically on par with K_2S_1 and K_2S_2, whereas K_1S_2 reached the shortest disintegration time of 21.92 minutes. In kokum rind powder-mannitol (KM) combination no significant difference was observed, although K_2M_2 recorded the highest disintegration time of 22.94 minutes, whereas K_2M_1 displayed the lowest values of 22.19 minutes. In sucrose-mannitol (SM) combination, S_1M_2 demonstrated the higher disintegration time of 23.13 minutes, whereas S_2M_2 recorded the lower disintegration time of 22.03 minutes. Among the treatment

combinations, $K_1S_2M_2$ recorded the shortest disintegration time of 21.45 minutes which was considered more desirable when compared to the other combinations and was statistically on par with $K_2S_2M_1$, $K_2S_2M_2$ and $K_2S_1M_1$, while the longest disintegration time was observed in $K_2S_1M_2$ (23.28 minutes). The chewable tablets disintegrated depending on the solubility, porosity and swelling behaviour of their ingredients. Sucrose and mannitol, being highly soluble, dissolved quickly and created pathways for water to penetrate, speeding up disintegration. Starch helped by swelling and partially forming a gel, making it easier for the tablets to break apart. The fibrous kokum rind powder absorbed water and increased porosity, further aiding the process. Small amounts of talc reduced sticking without affecting water absorption. Overall, these observations matched the findings of Khairnar *et al*. (2024), who highlighted how binders improve tablet cohesion, strength, and quality and Prakash *et al*. (2011), who studied *Terminalia chebula* fruit powder tablets and observed disintegration times of approximately 10 ± 2.5 minutes for the direct compression method and 12 ± 1.5 minutes for the wet granulation method.

Water activity (a_w) : Water activity (a_w) is a critical parameter, as it reflects the availability of free water which support microbial growth, chemical reactions and enzymatic activity. The lower water activity enhances product stability, extends shelf life and improves microbial safety, whereas higher values increase the risk of spoilage and reduces the storage quality (Table 1). Among the individual ingredient levels, the differences were minimal and statistically non-significant, within the kokum rind powder (K) levels, K_2 exhibited slightly the higher water activity (0.50), whereas K_1 showed marginally the lower water activity (0.49). Between the sucrose (S) levels, S_1 recorded a marginally the higher water activity (0.50), while S_2 recorded slightly the lower water activity (0.49). In case of mannitol levels, M_1 exhibited slightly the higher water activity (0.50) relative to M_2 (0.49). In the interaction effects, in case of kokum rind powder-sucrose (KS) interaction, no significant variations were noticed, both K_1S_1 and K_1S_2 exhibited the lowest water activity (0.49), which was statistically similar with K_2S_1 and K_2S_2. In kokum rind powder-mannitol (KM), significantly the lowest water activity was recorded in K_1M_2 (0.48), while the highest water activity (0.50) was observed in K_1M_1, K_2M_1 and K_2M_2. For sucrose-mannitol (SM) interaction, the maximum water activity was noted in S_1M_1 (0.51), which was statistically on par with S_1M_2, S_2M_1 and S_2M_2. The water activity of the treatment combinations ranged between 0.48 and 0.52. The treatment combination

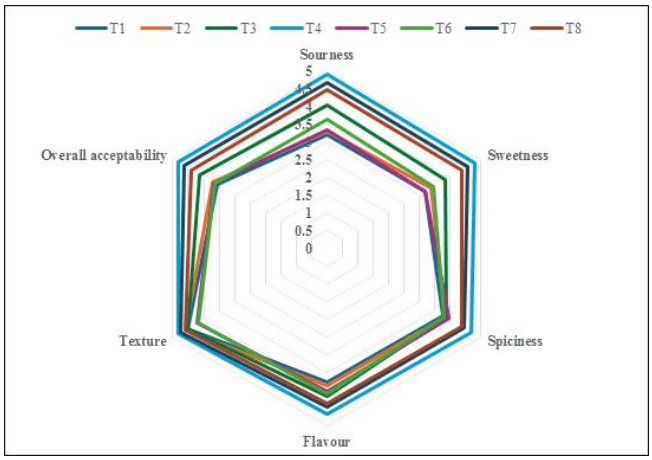

Fig. 1 : Effect of ingredients concentration on sensory parameters of kokum rind powder chewable tablets.

$K_1S_2M_2$ recorded the lowest water activity value (0.48), which was statistically on par with $K_2S_2M_1$ and $K_1S_1M_2$, whereas the highest water activity was observed in $K_2S_1M_1$ (0.52). The ingredients in the chewable tablets played a key role in reducing water activity and improving stability. Sucrose and mannitol bound free water through hydrogen bonding and their crystalline structure, limiting water available for microbial or chemical degradation. Starch absorbed moisture and formed a gel-like network, keeping water in a bound state, while kokum rind powder, rich in polysaccharides and fibres, trapped moisture within its fibrous matrix. Talc, being hydrophobic, further prevented water from entering the tablet from the environment. Together, these components lowered water activity and enhanced both chemical and microbiological stability, consistent with findings by Veronica *et al*. (2020) on starch as a moisture scavenger and Shukla *et al*. (2016) on sucrose reducing bulk water mobility.

Sensory evaluation is a scientific method used to measure, analyse and interpret the characteristics of food products as perceived by the human senses. A 5-point hedonic scale was employed to quantify the degree of acceptability for different sensory attributes. In Fig. 1. among all the treatment combinations, T_4 ($K_1S_2M_2$) showed the highest score for sourness (4.88), sweetness (4.80), spiciness (4.70), flavour (4.66) and texture (4.82) with a acceptability score of 4.83. In kokum rind powder chewable tablets, the sensory quality was shaped by how each ingredient contributed to taste and mouthfeel and kokum rind powder gave the tablets their natural sour and tangy flavour. Sucrose balanced this acidity with sweetness, while mannitol added not only mild sweetness but also a pleasant cooling effect that made the tablets more enjoyable to chew. Starch played a supportive role by diluting strong flavours and keeping the taste smoother and talc, though tasteless, improved texture by reducing

any gritty feel. The addition of cumin and black pepper extracts brought a gentle spicy aromatic flavour that complemented the tanginess of kokum. Altogether, these ingredients worked together to soften the sourness, enhanced sweetness and created a more balanced flavour profile, which helped to maintain good sensory acceptability. Parallel results were demonstrated by Khayum (2020), who developed chewable tablets from jamun seed powder, Chandan *et al*. (2023) optimized kokum fruit effervescent tablets, Ramya and Anitha (2021) worked on kokum value-added products and evaluated their sensory attributes and Bhusnure *et al*. (2015) investigated the formulation strategies for taste-masking of chewable tablets.

Conclusion

The study was carried out to develop and evaluate kokum rind powder chewable tablets by standardizing suitable ingredient combinations. All the formulations prepared in the experiment met the acceptable quality standards for weight uniformity, hardness, friability, disintegration and water activity. Among the different treatments, $K_1S_2M_2$ performed the best as it showed higher hardness (5.23 kg $cm^{-2)}$, minimum friability (0.16 %), disintegration time (21.45 minutes) and lower water activity (0.48), which together ensured better strength and stability of the tablets. Sensory evaluation also revealed that this treatment combination received the highest scores for flavour, sweetness, sourness, spiciness and texture, making it more acceptable (4.83) to consumers. The balanced contribution of kokum rind powder, sucrose and mannitol in treatment combination $K_1S_2M_2$ created a pleasant taste and mouthfeel. Therefore, $K_1S_2M_2$ was identified as the most suitable and promising formulation for the preparation of kokum rind powder chewable tablets.

Acknowledgement

The authors would like to acknowledge the Department of Pharmaceutics, National College of Pharmacy, Shivamogga, Karnataka, India, for providing access to laboratory facilities and instrumentation essential for this research.

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