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Enhancing quality attributes of optimized kokum (*Garcinia indica* Choisy) fruit effervescent tablets

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Abstract
The objective of this study was to assess the quality attributes of kokum fruit effervescent tablets. The optimized kokum effervescent tablet formulations had 1.20 g tablet weight, 4.40 mm thickness, 16.06 mm diameter with hardness of 0.105 kg cm^{-2}. Tablets showed water activity of (a_w) 0.389, 1.01 mg anthocyanin content, 4.20 mg ascorbic acid, 0.24 mg AAE antioxidant activity and 1.81 w/w% Hydroxy Citric Acid content. All the formulations had good microbiological stability.

Keywords: Kokum, effervescent tablet, quality

1. Introduction
Tableting of food products has emerged as a notable technique in the food industry, allowing for the creation of solid unit doses containing active ingredients. Tablets, widely employed for drug administration, can be formulated from powders, granules, pellets, or coated units. Vivid drying methods are utilized to obtain fruit powders, including tray, spray, freeze, drum, foam mat, and vacuum freeze-drying. The processing of fruit powders into effervescent tablets offers distinct advantages. These include improved physical and chemical stability, an appealing appearance, rapid dissolution, controlled release of active ingredients, and convenience during storage, transportation, and consumption (Yusof *et al.*, 2011) [11].
Kokum (*Garcinia indica* Choisy) is a valuable tree species found in Western Ghats of India. It has high moisture content (80%) and contains protein (1%), tannin (1.7%), pectin (0.9%), total sugars (4.1%), and fat (1.4%). Notably, kokum fruit exhibits the highest concentration of anthocyanins (2.4 g/100 g) compared to other natural sources (Nayak *et al.*, 2010) [6]. Kokum rind contains approximately 20-30% of (-)-HCA on a dry weight basis (Swami *et al.*, 2014) [10]. Hydroxycitric acid consumption has been linked to reduced appetite, inhibition of fat synthesis, decreased food intake, and weight loss (Jena *et al.*, 2002) [5].
Effervescent tablets are gaining popularity within the food industry, primarily due to their suitability for creating fizzy drinks. These tablets dissolve rapidly, providing a pleasant taste experience compared to regular tablets. The preparation of effervescent tablets using kokum fruit enables the production of instant nutrient rich fizzy drinks. The physical, chemical, and microbiological quality attributes of these tablets significantly impact packaging, transportation, and storage considerations.

2. Material and Methods
2.1 Preparation of kokum fruit effervescent tablets
Tablets were prepared by using specified quantity of kokum fruit powder, effervescent combination and other additives (Table 1). Known weight of powdered ingredients *viz.*, kokum fruit powder, citric acid, sodium bicarbonate, sucrose and sodium starch glycolate passed through sieve no. 60, collected in mortar and homogenized. Cumin extract, black pepper extract and freshly prepared starch paste (10% w/v) were added to the homogenised powder blend and kneaded to impart adhesiveness to the powder blend. The wet mass was passed through sieve no. 10 and then dried in the hot air oven at 50 °C for about 6h to retain with 5% w/v moisture. The dried granules were milled and passed through sieve no. 18 *versus* sieve no. 44. The granules passed through sieve no.18 and retained over 44 were collected. About 10 percent of the fines (passed through sieve no. 44) were also added to the above granules. Finally, the granules were lubricated using magnesium stearate for about five min. Then, 1200 mg of lubricated granules were compressed using 16mm flat-faced punches on tablet punching

machine. The prepared tablet formulations were packed in PVC vails and stored in stability chamber for further studies

Table 1: Formulations of optimal kokum fruit effervescent tablets

Ingredients	Formulations		
	OET_1	OET_2	OET_3
Kokum powder (mg)	300	300	300
Sucrose (mg)	216	216	216
Sodium bicarbonate (mg)	239.36	272.81	271.50
Citric acid(mg)	100	200	200
Starch paste (mg)	60	60	60
Cumin (drop)	1	1	1
Black pepper extract (drop)	1	1	1
Magnesium stearate (mg)	24	24	24
Sodium starch glycolate (mg)	250	250	250

2.2 Quality analysis
2.2.1 Physico-chemical quality
2.2.1.1 Uniformity of weight (g)
Ten tablets were weighed individually and the average weight was determined to check for uniformity in weight of a tablet.

2.2.1.2 Diameter and thickness (mm)
The diameter and thickness of the selected 10 tablets from each formulation were determined by using digital vernier caliper and average was taken.

2.2.1.3 Hardness (kg cm^{-2})
The resistance of tablet for shipping or breakage, under conditions of storage, transportation and handling before usage, depends on its hardness. The hardness of tablet of each formulation was tested using Monsanto hardness tester wherein 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 was measured.

2.2.1.4 Water activity (a_w)
The water activity of effervescent tablets was determined by using water activity meter.

2.2.1.5 Ascorbic acid (mg)
Ascorbic acid content was estimated titrimetrically using 2,6-dichlorophenolindophenol dye as per the AOAC procedure (Sadasivam and Manickam, 1992) [7].

2.2.1.6 Total anthocyanin content (mg)
Anthocyanin estimation was made as per the procedure cited in hand book of analysis and quality control with slight modifications (Srivastava and Sanjeevkumar, 1998) [9].

2.2.1.7 Total antioxidant activity (mg AAE)
The total antioxidant activity was determined by the FRAP method as explained by Benzie and Strain (1996) [2].

2.2.1.8 (-)-HCA (Hydroxycitric acid) content
The (-)-HCA (Hydroxycitric acid) content was determined by HPLC method as explained by Gogoi *et al*., 2014 [3].

2.2.2 Quantitative estimation of microbial population
The microbial load on kokum fruit effervescent tablets was estimated immediately after preparation and during storage period as per the method of Harrigan and Mc Cance (1966) [4].

2.3 Statistical analysis
The data was analysed using one way analysis. The level of significance used in "F" test and "t" test was p=0.01. Critical difference values were calculated whenever "F" test was significant.

3. Results and Discussion
3.1 Physico-chemical quality
Uniformity of weight (g), tablet thickness (mm) and tablet diameter (mm)
Uniformity of weight is an in-process test parameter which ensures consistency during compression. No significant differences in uniformity of weight, tablet thickness and tablet diameter was observed in all the three formulations due to compression of tablets with common die and uniform pressure. However, an average weight of 1.20 g, thickness of 4.40 mm and diameter of 16.06 mm was observed in the tablet (Table 2).

3.1.1 Tablet hardness (kg cm^{-2})
No significant difference was noticed with respect to tablet hardness due to low water activity (Table 2) increased the hardness of tablets. However, maximum hardness (0.108 kg cm^{-2}) was observed in OET_2, whereas, the formulation OET_1 recorded minimum hardness (0.100 kg cm^{-2}).

Table 2: Physical characteristics of optimal effervescent kokum tablet formulations

Formulations	Uniformity of weight (g)	Tablet thickness (mm)	Tablet diameter (mm)	Tablet hardness (kg cm^{-2})
OET_1	1.20	4.41	16.14	0.100
OET_2	1.20	4.40	16.02	0.108
OET_3	1.20	4.40	16.02	0.108
Mean	1.20	4.40	16.06	0.105
S.Em ±	0.004	0.006	0.022	0.004
C.D.@ 1%	NS	NS	NS	NS

NS: Non-significant

3.1.2 Water activity (a_w)
The data revealed no significant difference among the optimal formulations for water activity among the tablets from three formulations due to presence of low moisture content (1.04%). But, low water activity of 0.383 was observed in OET_3 followed by OET_2 (0.386) and OET_1 (0.400) (Table 3).

Table 3: Chemical composition of optimal effervescent kokum tablets (per tablet)

Formulations	Water activity (a_w)	Anthocyanin (mg)	Ascorbic acid (mg)	Antioxidants (mg AAE)	- (-HCA) w/w (%)
OET_1	0.400	1.06	4.28	0.241	1.85
OET_2	0.386	1.01	4.19	0.240	1.80
OET_3	0.383	0.97	4.20	0.239	1.78
Mean	0.389	1.01	4.22	0.240	1.81
S.Em ±	0.018	0.029	0.006	0.001	0.025
C.D.@ 1%	NS	NS	0.019	NS	NS

N.S: Non-significant

3.1.3 Anthocyanin content (mg tablet^{-1})
The results of anthocyanin content showed no significant difference among the optimal formulations. However, maximum anthocyanin content was recorded in OET_1 (1.06 mg) followed by OET_2 (1.01 mg) and OET_3 (0.97 mg).

3.1.4 Ascorbic acid (mg tablet^{-1}) and Antioxidants (mg AAE)
The ascorbic acid content of effervescent tablets presented a significant difference among the optimal formulations. Significantly maximum ascorbic acid content was recorded in OET_1 (4.28 mg), followed by OET_3 (4.20 mg) and OET_2 (4.19 mg).

No significant difference was however observed among the optimal formulations with respect to antioxidant activity. An average antioxidant activity of 0.240 mg AAE per tablet was noticed in all the optimal formulations. The anitioxidant activity is because of presence of ascorbic acid, tannins, phenols, etc. Similarly, the antioxidant activity was observed in effervescent tablets of tamarillo fruit (Arevalo *et al.*, 2021) [1].

3.1.5 (-HCA) content w/w (%)
The – (-HCA) content of effervescent tablets indicated no significant differences among the optimal formulations. However, an average of 1.81 percent of – (-HCA) content was recorded in all the formulations.

3.2 Microbial population
No significant difference in fungal population was recorded among the optimal formulations, whereas, significantly maximum total plate count was recorded in OET_2 (5 x 10^{-4} CFU/g) followed by OET_1 (4 x 10^{-4} CFU/g) and OET_3 (3 x 10^{-4} CFU/g). Yeast and mould population was not detected in all the formulations due to low water activity of tablets. A water activity value below 0.60 makes the food microbiologically stable and indicates no growth of spoilage organisms and pathogens. Similarly, the tablets prepared from pitaya, pineapple, mango and guava powders had water activity ranging from 0.29 to 0.33, indicating that they are microbiologically stable (Saifullah *et al.*, 2016) [8].

Table 4: Microbial analysis of optimal effervescent kokum tablet formulations

Formulation	Fungi No. X 10^{-2} (CFU g^{-1})	Total plate count No. X 10^{-4} (CFU g^{-1})	Yeast and mould No. X 10^{-4} (CFU g^{-1})
OET_1	1	4	ND
OET_2	0	5	ND
OET_3	0	3	ND
Mean	0.33	4	ND
S.Em ±	0.058	0.316	-
C.D.@ 1%	NS	0.985	-

N.S: Non-significant; ND: Not detected

4. Conclusion
Tableting has gained significant attention in the food industry as a means to develop convenient food products for consumers and efficiently manage food powders. Consequently, this study focused on the development of effervescent tablets. The kokum fruit effervescent tablets exhibited favourable physico-chemical characteristics and demonstrated microbiological stability. The findings of this study underscore the substantial potential for future advancements in effervescent kokum tablets and their viability for commercialization.

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