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Influence of different combinations of wall materials on physical attributes of karonda (*Carissa carandus* L.) fruit juice powder by spray drying

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Abstract
Karonda is a known underutilized fruit valued for its nutritional content. It contains several essential nutrients and bioactive compounds that contribute to its health benefits. The present investigation assessed various wall materials for their effectiveness in spray-dried microencapsulation of karonda juice, with the goal of improving encapsulation efficiency for further use. Karonda fruit juice was mixed with different wall materials *viz*., maltodextrin, fructo-oligosaccharide, inulin and skimmed milk powder at two level of concentration (10% and 20%). The resulted karonda sprayed powder were characterized for physical stability. Maltodextrin exhibited the highest encapsulation efficiency, followed by skimmed milk powder, whereas fructo-oligosaccharide produced the lowest efficiency and showed reduced physical stability. Among 8 treatments, wall material as maltodextrin with 20 per cent recorded higher yield (powder recovery), quick solubility, more bulk density and recorded minimum moisture content in the fresh powder, minimum water activity which indicating biological safety, registered less particle density, less hygroscopicity, lower hausner ratio and carr's index which indicates good flowing property of powder.

Keywords: Karonda, encapsulation, wall materials, spray drying, completely randomized design

Introduction
Karonda (*Carissa carandas* L.), commonly known as the "Christ Thorn Tree," is a member of the family Apocynaceae. It is a dichotomously branched evergreen shrub characterized by a short stem and sharp thorns. The species is notably hardy and drought-tolerant, capable of growing under varied soil and climatic conditions, and performs well even on marginal or rainfed lands. In India, *Carissa carandas* is cultivated across several states including Maharashtra, Bihar, West Bengal, Odisha, Gujarat, Madhya Pradesh, Rajasthan, and Uttar Pradesh (Sawant *et al*., 2003) [27], while it occurs sporadically in other regions of the country. Beyond India, the species adapts well to tropical and subtropical climates such as those of South Africa, Australia, Malaysia, Sri Lanka, Bangladesh, and Myanmar.

Karonda fruits are sour and astringent, acidic to sweet in taste with a peculiar aroma, and are not popular as a fresh fruit due to its high pectin content. Ripe fruits find use in the processing industry for the preparation of preserves. The fruits are a rich source of iron having 150 mg/ 100 g of fruits and vitamin C (17.94 mg/ 100 g), and thus have antiscorbutic properties and are useful in prevention of anaemia (Bose *et al*., 2011) [4].

Encapsulation is a technique employed to protect, stabilize, and control the release of bioactive or functional food ingredients. Encapsulation or wall materials are typically composed of starches, modified starches, proteins, gums, lipids, or various combinations of these components. The substance enclosed within a microcapsule is termed the core, internal phase, or fill, while the surrounding layer is commonly known as the shell, coating, or membrane. Encapsulation of food ingredients can be achieved through several techniques such as spray drying, freeze drying, fluidized bed coating, extrusion, molecular inclusion, and coacervation.

In Encapsulation technology, the sensitive bioactive compounds are packaged within a secondary material for delivery into food products. Keeping the above facts in mind, the current research focuses on microencapsulation of karonda fruit juice through spray drying technology.

It is conceptualized that spray drying is the most efficient and mechanical method for encapsulation of bioactive food ingredients converting stable microcapsule formulations into powders. It is often considered the preferred method for producing encapsulated bioactive ingredients because it provides greater convenience and operational flexibility. Encapsulation facilitates the incorporation and homogeneous distribution of bioactive ingredients within food formulations. Encapsulation of karonda juice aid in trapping of the bioactive molecules, the present research aimed at standardization of encapsulating the bioactive compounds of karonda fruit juice through spray drying with different wall materials.

Materials and Methods

Geographical location of the samples

Geographically, Bengaluru lies in the southeastern part of Karnataka, positioned at 12°58′ N latitude and 77°34′ E longitude, with an elevation of approximately 900 meters above mean sea level. Average rainfall of this zone was found to be 970 mm with a relative humidity ranged between 65 per cent. The mean temperature was nearly around 30 to 35 °C during summer.

Experimental details

Fresh karonda fruits used in this experiment were procured from the Regional Horticulture Research and Extension Centre (RHREC) UHS campus, Bengaluru, which is situated in the same campus where experiment was conducted. Fruits were washed with hot water for latex removal, pulped, extracted juice from pulp added wall materials (maltodextrin, fructo-oligosaccharide, inulin and skimmed milk powder) at 10 and 20 percent, homogenised and subjected for spray drying. Collected samples were subjected for physical analysis. The data collected on physical parameters were statistically analyzed in a Completely Randomized Design (CRD).

Spray drying process

Spray drying is a technique that turns liquid to powder form. Liquid product is atomized in a hot gas current to instantaneously obtain a powder. The atomizer in the drying chamber converts the liquid feed to millions of fine particles, thus increasing surface area of fine liquid for faster drying. The solvent in the feed is vaporized immediately by the hot gas in the chamber. The vaporization procedure rapidly removes the moisture so that the product is dried gently to obtain fine powder. Karonda juice powder was obtained by subjecting to spray drying at feed flow of 15 rpm and 170 ˚C temperature with 10 and 20 percent of maltodextrin, fructo-oligosaccharide, inulin and skimmed milk powder separately.

Powder recovery (%)

The recovery percentage of karonda powder was determined by comparing the weight of the karonda blend prior to spray drying with the weight of the final powder, and the result was expressed as a percentage.

$$\text{Powder recovery (\%)} = \frac{\text{Weight of the powder}}{\text{Weight of the initial blend}} \times 100$$

Moisture content (%)

The moisture content of the spray-dried karonda powder was measured using an electronic moisture analyzer (Sartorius MA 35) by drying the sample at 130°C until a constant weight was achieved, and the result was expressed as a percentage.

Water activity (a_w)

The water activity of the karonda spray dried powder were measured using an electric water activity meter (Rotronic hydrolab).

Particle density (g/ml)

Particle density was determined according to the procedure described by Jinapong *et al.* (2008) [17]. Approximately one gram of spray-dried powder was placed in a 10 mL graduated cylinder sealed with a glass stopper. Five milliliters of petroleum ether were added, and the mixture was gently shaken to ensure complete suspension of the particles. The inner wall of the cylinder was subsequently rinsed with an additional 1 mL of petroleum ether, and the combined volume of solvent and suspended particles was recorded. The particle density was then computed using the following equation:

$$\text{Particle density (g/ml)} = \frac{\text{Weight of the powder}}{\text{Total volume of petroleum ether and suspended particles (ml)} - 6} \times 100$$

Solubility (%)

The solubility of the spray-dried powder was determined following the method of Eastman and Moore (1984) [11]. One gram of the sample was dispersed in 100 mL of distilled water and blended at 1550 rpm for 5 min. The mixture was transferred into centrifuge tubes and centrifuged at 3000 rpm for 5 min, after which it was allowed to stand undisturbed for 30 min. From the clear supernatant, 25 mL was carefully withdrawn, placed in pre-weighed Petri dishes, and dried in an oven at 105 °C for 5 h. Solubility (%) was expressed based on the difference in weight before and after drying.

$$\text{Solubility (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Hygroscopicity (%)

Hygroscopicity was evaluated following the procedure of Cai and Corke (2000) [5], with slight modifications. Approximately 1 g of the sample was kept in a sealed chamber at 25 °C over a saturated sodium chloride solution, maintaining 75.29% relative humidity (RH). After one week of equilibration, the samples were reweighed, and hygroscopicity was expressed as grams of moisture absorbed per 100 g of dry matter.

Wettability (s)

Wettability was assessed following the procedure outlined by Vissotto *et al*. (2010) [33]. One gram of the powder sample was carefully placed on the surface of 400 mL of distilled water maintained at 25 °C, and the time taken for the sample to become completely immersed was recorded.

Bulk density (g/ml)

Bulk density was analyzed by gently adding 20 g of spray dried powder into a 10 ml empty dry graduated cylinder and the bulk density was determined using the formula as stated below (Jangam and Thorat, 2010) [16].

$$\text{Bulk density (g/ml)} = \frac{\text{Weight of powder (g)}}{\text{Volume of powder (ml)}}$$

Tapped density (g/ml)

Tapped density was analyzed by gently adding 20 g of spray dried powder into a 10 ml empty dry graduated cylinder and then tapped for 100 times from a height of about 2 inches in tapped density analyzer. The tapped density was determined using the formula as stated below (Jangam and Thorat, 2010) [16].

$$\text{Tapped density (g/ml)} = \frac{\text{Weight of powder (g)}}{\text{Tapped volume of powder (ml)}}$$

Hausner ratio

The Hausner ratio was determined by dividing the tapped density of the powder by its bulk density, as described by Alanazi *et al*. (2008) [2].

$$\text{Hausner ratio} = \frac{\text{Tapped density}}{\text{Bulk density}}$$

Carr index (%)

Carr's Index was determined following Malamatris *et al*. (1994) [21] as the percentage ratio between the difference of tapped and bulk densities to the tapped density.

$$\text{Carr index (\%)} = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}} \text{ X } 100$$

Statistical analysis

The data recorded on the physical properties of karonda spray dried powder and karonda chewable tablet were subjected to statistical analyses in completely randomized design using ICAR research complex for Goa (Web Agri Stat Package 2.0). Data interpretation was performed using an analysis of variance (F-test) at a significance level of $p = 0.01$. When the F-test indicated significance, critical difference (CD) values were computed to compare treatment means.

Results and Discussion

Powder recovery (%)

Yield of the spray dried karonda juice powder can be expressed in percentage (Table 1). Percentage of microencapsulated karonda powder ranges from 5.35-20.63 per cent. Minimum powder yield was found in the treatment FOS10 (5.35%), while, maximum yield of the spray dried powder was found in the treatment MD20 (20.63%). Powder yield can be affected by the concentrations of wall materials where the higher concentration, the higher process yield (Baldelli *et al*., 2024) [3]. Process yield reflects the efficiency of heat and mass transfer mechanisms taking place during spray drying. A reduction in yield can occur when the powder melts or adheres to the dryer walls, often due to the presence of sucrose in the fruit material. Therefore the amount of powder production also reduced (Chegini and Ghobadian, 2007) [9]. The result obtained here was in accordance with the above statement. Similar result was reported by Suzhihaque *et al*. (2015) [30] in pine apple powder. An increase in maltodextrin concentration resulted in a corresponding rise in powder yield.

Moisture content (%)

Moisture content is a key attribute of both raw materials and finished products, as it influences their nutritional quality as well as behavior during handling, storage, and processing. It directly indicates the tendency of particle to agglomerate or to lump. The karonda spray dried powder should have a moisture ≤5 per cent to reduce the potential of oxidation reduction. In the present study, the moisture content of karonda spray dried powder was in the range of 4.30 per cent to 4.54 per cent in all the wall materials used for spray drying (Table 1). Minimum moisture content was found in the treatment MD20 (4.30%), while, maximum moisture content of the spray dried powder was found in the treatment IN10 (4.54%).

An inlet air temperature of 170 °C enhanced the rate of moisture removal, leading to a lower moisture content in the resulting microcapsules. Comparable observations were reported by Tsatsop *et al*. (2024) [32] in pineapple powder, Goula *et al*. (2005b) [13] in tomato pulp, Chegini and Ghobadian (2007) [9] for orange juice powder, and Quek *et al*. (2007) [24] for watermelon juice powder.

Generally increase in wall material concentration results in lower moisture content of the product. Higher concentration of wall materials resulted in the lowest moisture content in karonda spray dried powder in the present study. This may be due to increase in the total solids with increase in wall material concentration, moisture content of the produced powder decreased (Abadio *et al*., 2004) [1]. The increased maltodextrin concentration 20 per cent resulted less moisture content (4.30%) whereas, higher moisture content was observed in treatment with 10 per cent fructo-oligosaccharide as wall material. This phenomenon may be attributed to the reduced drying rate caused by crust formation on the droplet surface and the migration of unbound water toward the droplet interior, which occurs due to the presence of sugars (Santhalakshmy *et al*., 2015) [26]. These results were similar to those of Quek *et al*. (2007) [24] in watermelon powder; Kha *et al*. (2010) [18] in gac powder and all the published data demonstrates that addition of encapsulating material have decreased the moisture content.

Water activity (a_w)

Water activity represents the amount of unbound or free water in a food system that supports biochemical and microbiological reactions. A higher value indicates greater availability of water for such reactions, leading to a reduced shelf life. The spray-dried karonda powder samples exhibited initial water activity around 0.30, which is considered suitable for maintaining microbial stability (Quek *et al*., 2007) [24].

n this study, the water activity of spray-dried karonda powder ranged between 0.226 and 0.246 (Table 1). The lowest value was recorded for the MD20 treatment (0.226), whereas the highest was observed in IN10 (0.246). Reduced water activity in karonda spray dried powder is due to the presence of less moisture present in it. Similar results of reduced aw were reported by Baldelli *et al*. (2024) [3] in Mango, Orange and Strawberry, Oliveira *et al*. (2015) [22] in mandacaru fruit powders and Costa *et al*. (2014) [10] in passion fruit powder.

Higher concentration of wall materials resulted in the lowest a_w in karonda spray dried powder. This may be due to increase in the total solids with increase in wall material concentration, a_w of the powder decreased (Abadio *et al*., 2004) [1]. The encapsulated karonda juice powder obtained from all treatments exhibited water activity values ranging between 0.226 and 0.246, indicating that the powders were biochemically and microbiologically stable. Comparable water activity levels were reported for spray-dried watermelon powder (0.30) by Quek *et al*. (2007) [24], açaí powder by Tonon *et al*. (2009) [31], and jamun juice powder by Santhalakshmy *et al*. (2015) [26].

Table 1: Influence of wall materials on powder recovery (%), moisture content (%) and water activity (aw) of karonda spray dried powder

Treatments	Powder recovery (%)	Moisture (%)	Water activity (aw)
T_1 - Maltodextrin 10%	18.37±0.15[b]	4.37±0.13	0.229±0.009
T_2 - Maltodextrin 20%	20.63±0.15[a]	4.30±0.23	0.226±0.009
T_3 - FOS 10%	5.35±0.40[f]	4.33±0.23	0.235±0.010
T_4 - FOS 20%	8.43±0.20[e]	4.54±0.10	0.233±0.008
T_5 - Inulin 10%	10.43±0.58[d]	4.54±0.25	0.246±0.019
T_6 - Inulin 20%	13.47±0.35[c]	4.41±0.09	0.232±0.007
T_7 - SMP 10%	18.23±0.05[b]	4.47±0.20	0.245±0.010
T_8 - SMP 20%	20.40±0.45[a]	4.38±0.20	0.234±0.015
S.Em±	0.19	0.11	0.006
C. D. at 1%	0.81	NS	NS

*Significant at $p= 0.01$

Values with different alphabets in the same column indicate significant differences at $p= 0.01$

Probability level according to Duncan's multiple range test

FOS- Fructo oligo saccharide, SMP- Skimmed milk powder

Particle density (g/ml)

Particle density of microencapsulated karonda juice powder was observed in a range of 1.11-6.67 g/ml in present study (Table 2). A range of 5.17-5.23 g/ml was observed by Santhalakshmy *et al*. (2015) [26] in jamun juice powder. Highest particle density was found in the treatment FOS10 (6.67 g/ml) and lowest density was found in MD20 (1.11 g/ml). Wall material concentration significantly affects the particle density of obtained powder, the increase of wall material concentration increases in particle density as it adds bulkiness in karonda powder.

Solubility (%)

Solubility is one of the most reliable indicators for assessing the behaviour of powders in aqueous systems (Caparino *et al*., 2012) [7]. The solubility of the karonda juice powder ranged from 93.56 to 98.49% (Table 2). A similar range was reported in lemon juice powder (97.20-98.47) by Rohini *et al*. (2024) [25]; in mango juice powder (90-95%) by Cano-Chauca *et al*. (2005) [6] and Caparino *et al*. (2012) [7]; in jamun juice powder (87.67 to 99.67%) by Santhalakshmy *et al*. (2015) [26]; in acai powder (32.08 to 96.12%) by Tonon *et al*. (2009) [31].

Solubility of karonda juice powder (93.56%) is minimum in the treatment FOS10 and is shown highest in MD20 (98.49%). Generally, solubility is more with the produce dried at more temperature, Increasing the drying air temperature generally leads to an increase in particle size, thereby reducing the time required for the powder to dissolve. Moreover, lower the powder moisture content, more stable the powder. The results here are following the similar trend and are in similar lines as reported by Phoungchandang and Sertwasana (2010) [23] in ginger powder; Santhalakshmy *et al*. (2015) [26] in jamun juice powder; Goula and Adamopoulos (2008) [14] in tomato powder.

Moreover, the higher concentration of wall materials in the formulation resulted in greater solubility compared to treatments with lower wall material levels. Similar findings were reported by Santhalakshmy *et al.* (2015) [26] in spray-dried jamun juice powder. This improvement can be attributed to the presence of maltodextrin, an amorphous and non-crystalline compound with superior water solubility. The highest solubility per cent was found in treatment with maltodextrin. The findings were similar with the results of Cano-chauca *et al.* (2005) [6] in mango powder; Loksuwan (2007) [20] in microencapsulation of ß-carotene; Cai and Corke (2000) [5] in amaranthus.

Hygroscopicity (%)

An increase in hygroscopicity generally leads to reduced flowability of powders, as moisture absorption promotes the formation of liquid bridges and enhances capillary forces between particles (Fitzpatrick, 2005; Scoville and Peleg, 1981) [12, 28]. Conversely, powders with low hygroscopicity demonstrate improved flow properties.

Significantly highest hygroscopicity of powder (20.43%) was registered in treatment Inulin10, however minimum was recognized in treatment MD20 (18.32%) (Table 2). The current study conveyed that higher the concentration of wall material lower the hygroscopicity of the obtained spray dried powder there by it preserves free flowability of the powder. Parallel results were documented by Tsatsop *et al.* (2024) [32] in Pineapple. More hygroscopicity in lower wall material concentration is due to presence of fruit sugar which leads to stickiness in powder.

Wettability(s)

Wettability is an important physical property of spray-dried powders and refers to their ability to be penetrated by a liquid under the influence of capillary forces (Hogekamp and Schubert, 2003) [15].

Wettability of karonda juice powder ranged in between 3.27 s to 122.33 s in fresh powder (Table 2). A similar range was reported by Santhalakshmy *et al.* (2015) [26] in jamun juice powder and by Ferrari in black berry powder. Lowest value for wettability was found in FOS10 (3.27s) and highest value was found in SMP20 (122.33s). Wettability is directly related to particle size, because larger particles show more space between them, being more easily penetrated by water and quickly wet. On the other hand, smaller particles are less porous, making more difficult the liquid penetration into the food matrix.

Table 2: Influence of wall materials on particle density (g/ml), solubility (%), hygroscopicity (%) and wettability (s) of karonda spray dried powder

Treatments	Particle density (g/ml)	Solubility (%)	Hygroscopicity (%)	Wettability (s)
T_1 - Maltodextrin 10%	1.11±0.06^{d}	97.47±0.19^{c}	19.20±0.05^{d}	49.73±0.52^{d}
T_2 - Maltodextrin 20%	1.78±0.23^{cd}	98.49±0.20^{a}	18.32±0.16^{f}	86.42±0.17^{c}
T_3 - FOS 10%	4.70±0.33^{b}	93.56±0.27^{f}	20.20±0.05^{b}	3.27±0.06^{f}
T_4 - FOS 20%	6.67±0.15^{a}	94.53±0.13^{e}	19.34±0.13^{d}	4.17±0.06^{f}
T_5 - Inulin 10%	1.58±0.13^{cd}	95.69±0.05^{d}	20.43±0.20^{a}	3.75±0.18^{f}
T_6 - Inulin 20%	3.05±0.45^{bc}	95.94±0.10^{d}	19.72±0.07^{c}	15.26±0.05^{e}
T_7 - SMP 10%	1.26±0.15^{cd}	97.57±0.07^{c}	19.33±0.07^{d}	96.97±1.17^{b}
T_8 - SMP 20%	1.85±0.26^{cd}	97.96±0.04^{b}	18.75±0.05^{e}	122.33±1.08^{a}
S.Em±	0.60	0.09	0.06	0.34
C. D. at 1%	2.50	0.37	0.27	1.43

*Significant at $p = 0.01$
Values with different alphabets in the same column indicate significant differences at $p = 0.01$
Probability level according to Duncan's multiple range test
FOS- Fructo oligo saccharide, SMP- Skimmed milk powder

Bulk density (g/ml) and Tapped density (g/ml)

Bulk density of microencapsulated karonda juice powder was observed in the range of 0.17-0.41 g/ml similar results were found in lemon juice powder by Rohini *et al.* (2024) [25]. Highest Bulk density was found in the treatment MD20 (0.41 g/ml) and lowest was found in IN10 (0.17 g/ml) (Table 3). Wall material concentration significantly affects the bulk density of obtained powder.

Tapped density of microencapsulated karonda juice powder was observed in a range of 0.22-0.60 g/ml (Table 3), similar results were found in *Escontria chiotilla* fruit powder (Carpintero-Tepole *et al*., 2024) [8]. Highest tapped density was found in the treatment FOS20 (0.60 g/ml) and lowest density was found in IN10 (0.22 g/ml). Wall material concentration significantly affects the tapped density of obtained powder.

Ferrari *et al.* (2012) reported higher bulk density values for spray-dried blackberry powder when a mixture of maltodextrin and gum arabic was used as the carrier material. Heavier particles tend to occupy interstitial spaces more efficiently, thereby reducing overall volume and increasing bulk density. Similarly, Chegini and Ghobadian (2005) [9] observed that spray-dried powders with higher solid contents exhibited greater bulk weight and density. These observations align with the findings of the present study, where karonda juice powders produced with higher wall material concentrations (20%) demonstrated increased solid content and, consequently, higher bulk density.

Lower bulk density indicates a higher amount of entrapped air within the powder matrix, which increases the likelihood of oxidation and reduces storage stability (Lewis, 1987) [19]. Powders with lower bulk density also require greater packaging volume. In the present study, karonda juice powder with lower moisture content exhibited a more compact structure.

Hausner ratio

The Hausner ratio is in the range of 1.18 to 1.66. Lowest ratio was found in MD20 (1.18) which represented good/free flow of powders which is good for further process (Table 3). Highest ratio was found in FOS10 (1.66) which represented very poor flow of powders. Karonda spray dried powder treated with 20 percent wall materials showed lowest hausner ratio compared to 10 per cent wall materials.

Srivatsa *et al.* (2020) [29] Free flow nature of powders is due to less hygroscopic of spray dried powder, while very poor flow nature of powder is due to hygroscopic and stickiness of powder which was seen in treatments having 10 percent wall materials in it.

Carr's index (%)

The Carr's index of all treatments ranged from 15.06 per cent to 39.54 per cent. Lowest index was found in MD20 (15.06%) which represented good/free flow of powders (Table 3). Highest index was found in FOS10 (39.54%) which represented very poor flow of powders. Karonda spray dried powder treated with 20 percent wall materials showed lowest index compared to 10 per cent wall materials.

This may be due to less hygroscopic and free flow nature of the spray dried powders which exhibited this property. Similar results were interpreted by Carpintero-Tepole *et al.* (2024) [8] in *Escontria chiotilla* fruit powder;

Table 3: Influence of wall materials on bulk density (g/ml), tapped density (g/ml), hausner ratio and carr index (%) of karonda spray dried powder

Treatments	Bulk density (g/ml)	Tapped density (g/ml)	Hausner ratio	Carr index (%)
T_1 - Maltodextrin 10%	0.28±0.05^{c}	0.34±0.05^{c}	1.21±0.05^{bc}	17.48±3.64^{cd}
T_2 - Maltodextrin 20%	0.41±0.01^{a}	0.49±0.01^{b}	1.18±0.01^{c}	15.06±1.866^{d}
T_3 - FOS 10%	0.28±0.09^{c}	0.47±0.02^{b}	1.66±0.12^{a}	39.54±2.61^{a}
T_4 - FOS 20%	0.39±0.02^{b}	0.60±0.04^{a}	1.56±0.06^{a}	35.84±2.56^{a}
T_5 - Inulin 10%	0.17±0.01^{e}	0.22±0.05^{d}	1.32±0.05^{b}	24.13±2.94^{b}
T_6 - Inulin 20%	0.27±0.08^{c}	0.34±0.01^{c}	1.27±0.07^{bc}	21.35±3.83^{bc}
T_7 - SMP 10%	0.37±0.01^{b}	0.47±0.02^{b}	1.28±0.01^{bc}	21.98±1.95^{bc}
T_8 - SMP 20%	0.21±0.04^{d}	0.25±0.07^{d}	1.24±0.06^{bc}	19.11±1.23^{bcd}
S.Em±	0.008	0.01	0.03	1.96
C. D. at 1%	0.03	0.05	0.16	8.11

*Significant at $p = 0.01$
Values with different alphabets in the same column indicate significant differences at $p = 0.01$
Probability level according to Duncan's multiple range test
FOS- Fructo oligo saccharide, SMP- Skimmed milk powder

Conclusion

Karonda spray dried powder with the wall material maltodextrin (20%) was found to be best in producing the karonda juice powder with better yield, best physical properties in terms of good flowing property and stability of powder. Karonda spray dried powder with the wall material fructo oligo saccharide and inulin were found lower yield, hygroscopic, sticky/caking in storage.

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