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Evaluation of custard apple pulp under different drying conditions

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Abstract
The pulp from the custard apple was peeled and preservative sare added to the pulp. This pulp was spread with auni form thickness on the tray and it was kept in a tray drier, solar cabinet drier and sun drying. In this present study we measured some of the physical properties like size, shape, hardness and chemical properties like moisture content, pH. Three replications are takenfor each of the sample and recorded. For drying the custard apple pulp we used different types of driers, the pulp was extracted from the fruit and chemicals (ascorbic acid (0.1%), maltodextrin (2%), sucrose (50.7%), Dicalcium phosphate (1%)) are add ed. to it. The pulp was spread on the trays of the drier and weight of the sample was taken for every one hour. The pulp was dried until we get constant weight. It was observed that the drying of the pulp was faster in tray drier than the solar cabinet drier.

Keywords: Pulp, moisture content, temperature, custard apple powder, tray drier, solar cabinet drier, sun drying

Introduction
Custard apple is most important fruit comes under the Annonaceae family grown in dry lands, tropical and sub tropical regions throughout the world. Custard apple grown under different climatic conditions like arid land and the production and estimated area is 1.36 lakh tons in 20,000 ha. It is grown in Andhra Pradesh, Assam, Maharashtra, Telangana, Karnataka, Bihar, Punjab, Rajasthan, Uttar Pradesh, Madhya Pradesh, Kerala, West Bengal, Gujarat, and Tamil Nadu. The cultivation area under custard apple is expected to increase significantly. Custard apple is a hardy crop that can be grown on marginal lands with minimum care and inputs. Custard apple plants start bearing at the age of four to six years and start decline after 12 to 15 years. Harvesting period of custard apple starts from August to November depending on the flowering period of the custard apple. The custard apples were harvested when the skin turns into the creamy yellow. The tree yields around 100 to 150 fruits per year and the fruit weigh 120 to 230 g (Aziz and Yusof, 1994) [1]. The custard apple has pulp, peel and seed in different proportion.

Fruit contains moisture content (70.5%), carbohydrate content (23.5%), protein content (1.6%), fat (0.4%), mineral matter content (0.9%), iron content 1.0%), calcium content (0.2%), phosphorus content (0.04%) and energy value of 104 Kcal/100g of edible portion (Gopalan *et al*., 2004) [4]. The edible content of the castor apple varies from 28-37% of the total fruit weight and seeds correspond to 23-40% (Sravanthi *et al*., 2014) [16]. Fruit is having a TSS of 26.40 B, pH 5.5, and tannins 0.5%. The fruits are having 2 to 3 days shelf life after ripening. The different methods of preservation of custard apple are tray drying, spray drying, foam drying and freezing drying (Quek *et al*., 2007) [15].

It is a highly nutritious fruit, packed with vitamin A, vitamin C, vitamin B, magnesium, potassium, copper, and plenty of dietary fibers. It is beneficial for cardiac disease, hyperthyroidism, diabetes, and cancer. The caster apple pulp due to its richness in minerals, fruit sugars, and vitamins is known to serve as a blood tonic. It is recognized as a base ingredient in different fruit products like ice creams, milk shakes, beverages due to its characteristics flavor, and taste. The flavor components of fresh pulp are due to the volatile compounds of terpenes namely germacrene-D, linalool, Benzyl alcohol, and spathulenol.

Drying is a traditional method of preservation of fruits and vegetables. Tray drying and solar cabinet drying used for drying of pulp. Maltodextrin used as a carrier agent could increase the total solid content in the feed and thus reduce the moisture content of the powder.

It was also found to alter the surface stickiness of low molecular weight sugars like glucose, sucrose fructose, and organic acids. Therefore, facilitated drying and reduced the stickiness of the tray dried powder.

Therefore, in order to explore the possibilities of utilizing the custard apple fruits for processing, an attempt was made to find out the suitable methods of preservation of pulp and preparation of custard apple powder by using a tray and Solar cabinet drying which can be used with milk powders, ice cream, bakery products. This project was undertaken to evaluate custard apple pulp physical and chemical properties and drying characteristics of custard apple pulp under different drying conditions.

Materials and Methods

Custard apple was procured from the local market, Sangareddy, Telangana, India. The drying characteristics and quality evaluation of custard apple pulp under different drying condition was conducted at College of Agricultural Engineering Sangareddy in year of 2022. The college is located at 15^0 N latitude and 78^0 E longitudes.

Preparation of custard powder from raw custard apples

A process for the preparation of dehydrated product from custard apple pulp, which comprises.

- Scooping of pulp from mature ripe fruits;
- Separation of seeds from pulp using a pulper;
- Mixing of pulp as obtained in step (b) with about 0.1% of ascorbic acid;
- Supplementation of pulp with maltodextrin (2%) and sucrose (57%) along with tricalcium phosphate (1%) as an anticaking agent
- Spreading in about 1 cm thick layer in stainless steel trays
- Drying under tray and solar drier to yield a dehydrated product free from bitterness, discoloration and development of off-flavours.

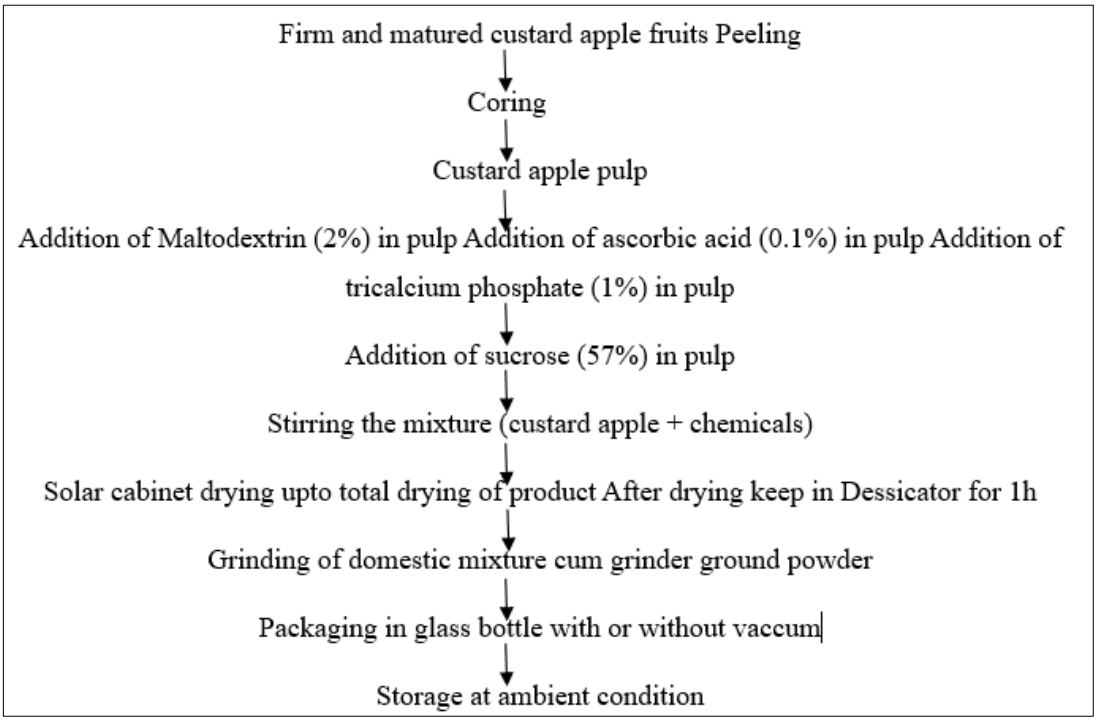

Fig 1. Preparation of custard apple powder by using solar cabinet dryer

Fig 2: Pulp content of a custard apple fruit

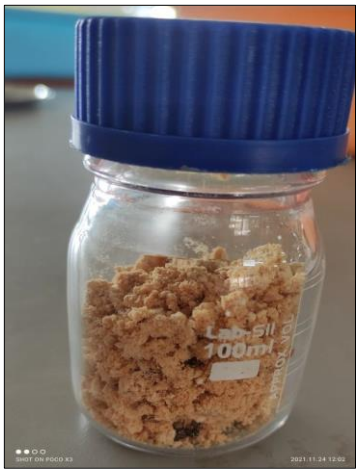

Fig 3: Custard powder

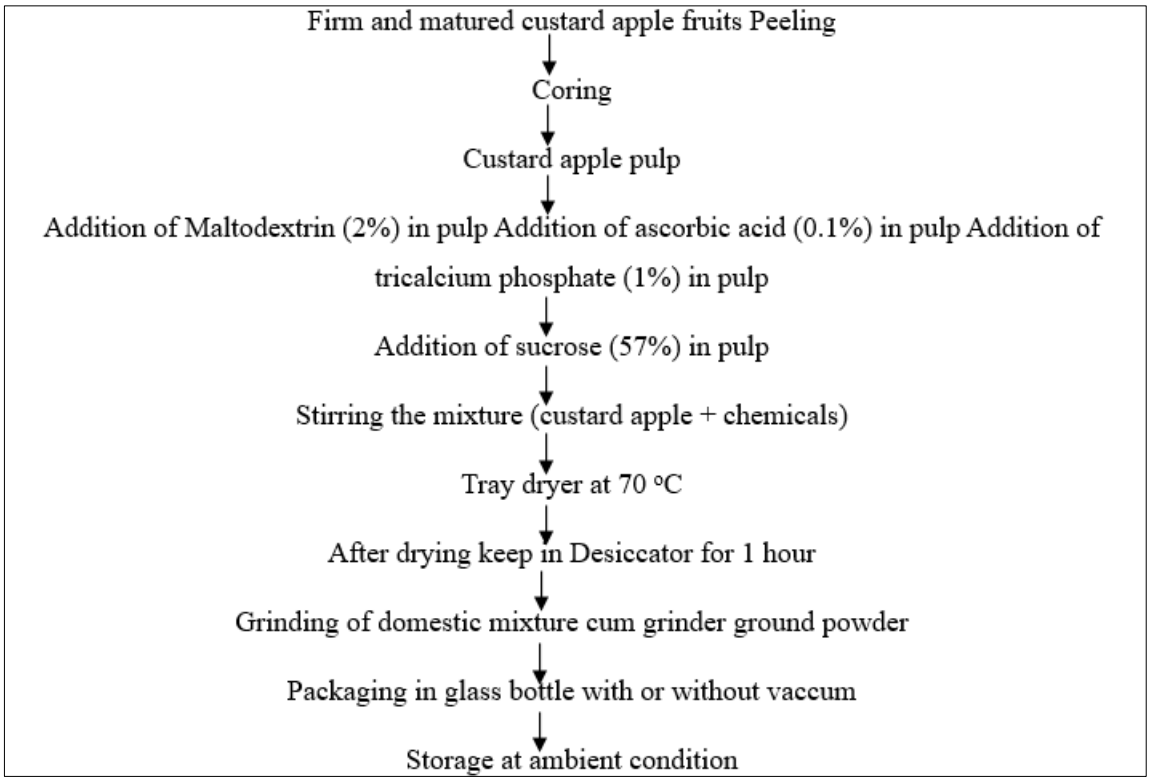

Fig 4: Preparation of custard apple powder by using Tray drier

Determination of physical and mechanical properties of custard apple fruit

Dimensions of custard apple pulp: A digital Vernier Caliper was used to measure the dimensions of length (L), width (W), and thickness (T) of the custard apple samples. The width and thickness were measured at the center of the fruits.

Weight: Weight (g) of custard apple fruit was measured using an electronic balance with an accuracy of 0.01g.

Volume of fruit (V): The volume was calculated by considering the geometry of the object similar to the oblate spheroid shape. The volume was calculated by using the formula,

Volume (cm^3) = L × B × T

Weight of displacement of water (g)/weight density of water (g/cm3)

Where,
V = volume of Fruit (cm^3) L = length of fruit (cm)
B = width of fruit (cm)
T = Thickness of fruit (cm)

True density

True density was determined using the platform scale method (Mohsenin 1986). A digital balance (Shimadzu corporation Japan) with measurement precision of ---- was used for weighing the sample.
The true density of fruit was calculated using the following equation (Mohsenin, 1986)

$$\text{True density } (g/cm^3) = \frac{mass\ of\ fruit\ (g)}{volume\ of\ fruit\ (cm3)}$$

Mean diameter, sphericity and surface area

The athematic mean diameter (D_a), geometric mean diameter (Du), sphericity, and surface area (As) were calculated by using the following relationships.

Geometric mean diameter (D_g)

Geometric mean diameter measured with the help of Vernier-caliper having a least count of 0.02 mm. The size of the fruit and the seed was calculated by using the following formula.

$$D_g = \frac{L \times B \times T}{3}$$

where,
L= Major axial dimension (mm)
B= Intermediate axial dimension (mm)
T= Minor axial dimension (mm)

Arithmetic mean diameter (Da)

The arithmetic mean diameter (Da) for each custard apple fruit was calculated by using the following equation

$$D_a = \frac{L \times B\ T}{3}$$

Where,
D_a = Arithmetic mean diameter (mm) L = length of fruit (mm)
B = width of fruit (mm) T= thickness of fruit (mm)

Sphericity (Φ): The sphericity of fruits and seeds was calculated by using the following formula (Mohsenin [3]).

$\Phi = (LBT)^{1/}/L$

Where,
Φ=Sphericity
L= Major axial dimension (mm)

B= Intermediate axial dimension (mm)
T= Minor axial dimension (mm)

Surface Area (S): The surface area of custard apple fruit was calculated by using below given formula π x Dg
$S = \pi \times D_g$

Where,
S = Surface area (mm2)
D_g = geometric mean diameter (mm)

Pulp content of fruit: The pulp of custard apple fruit was separated from the peel and seeds. The Pulp content was calculated by using the following formula (Kolekar and Tagged).

$$\text{Pulp content, \%} = \frac{C}{I} \times 100$$

Where,
C= Weight of pulp (g)
I= Weight of fruit (g)

Seeded pulp content of fruit: The Seeded pulp content of fruit was calculated by using the following formula

$$\text{Seeded pulp content, \%} = \frac{A}{I} \times 100$$

Where,
A= Seeded pulp weight (g)
I= Weight of fruit (g)

Seed content of fruit: Seed content of fruit was calculated by using the following formula K/I*100

$$\text{Seed content, \%} = \frac{K}{I} \times 100$$

Where,
K= Weight of seeds (g)
I = Weight of fruit (g)

Peel content of fruit: Peel content of fruit was calculated by using the following formula; B/I*100

$$\text{Peel content, \%} = \frac{B}{I} \times 100$$

Where,
B= Peel weight, (g)
I= Weight of fruit, (g)

Pulp recovery rate: Pulp recovery of the sample was determined using the following expression.

$$\text{Pulp recovery (\%)} = \frac{Mass\ of\ pulp}{Total\ mass\ of\ fruit} \times 100$$

$$\text{Pulp recovery from the pulp (\%)} = \frac{mass\ of\ powder}{mass\ of\ pulp} \times 100$$

$$\text{Powder recovery (\%)} = \frac{\text{mass of powder}}{\text{total mass of fruit}} \times 100$$

Determination of Hardness
The physical characteristics of custard apple can be measured by Texture Analyser (MAKE: BROOKFIELD, MODEL: CT3 50K).

Procedure
1. Attach firmness testing probe to the TPA instrument.
2. Switch on the instrument.
3. Select a test mode normal.
4. Press start, then attach probe. Again, press start to continue. Auto zeroing.
5. Press start, then reading such as peak load, Deformation load.

Determination of Bio-Chemical Properties of Custard Apple
Moisture content: The sample was kept in an oven at 100 ℃ in uncover pre-weighed Petri dishes (Ranganna). After drying, Petri dishes were covered with a lid and cooled in desiccators containing silica gel for 1 h before weighing.

$$\text{M.C., \% w. b.} = \frac{initial\ weight\ of\ sample - final\ weight\ of\ sample}{initial\ weight\ of\ sample}$$

$$\text{M.C., \% d. b.} = \frac{initial\ weight\ of\ sample - final\ weight\ of\ sample}{dry\ weight\ of\ sample}$$

PH
The PH of the products is determined by using a digital PH meter.

Total soluble solids
Small samples of the fruit pulp were filtered through muslin cloth and a drop of the filtrate was taken to determine the total soluble solids (TSS) using a handheld refractometer (Erma Tokyo A) and TSS was expressed as Brix' (Ranganna)

Acidity
The acidity of the custard apple pulp was determined by diluting an aliquot of the sample with distilled water and titrating with 0.1N NaOH using phenolphthalein as an indicator. The calculated acidity was expressed as percent anhydrous citric acid.

Results and Discussion
Determination of Physical Properties of Custard Apple Fruit

Table 1: Dimensions of unripined custard apple fruit

Samples No.	Length (mm)	Width (mm)	Thickness (mm)
1	74mm	72.18	59.75
2	60.63	59.28	51.29
3	69.88	62.22	55.94
4	78.06	66.96	58.17
5	61.98	59.59	46.78

Table 2: Physical properties of custard apple fruit

No	Physical properties	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	Weight of the sample (gm)	155	112.101	140.258	130.26	200.634
2	Geometric Mean Diameter (mm)	67.13	56.92	62.224	66.96	55.597
3	Arithmetic Mean Diameter (mm)	67.4	57.08	62.68	67.71	56.096
4	Sphericity (mm	0.907	0.93	0.89	0.85	0.89
5	Surface are	14157.38	10178.40	14085.77	14085.77	9710.71
6	Volume of fruit	158468.046	96579.62	126147.2	157234.80	89985.33
7	Pulp content (%)	43.85	35	44	43.46	41
8	Seed pulp content of fruit (%)	54.3	41.79	52.85	39.60	42.5
9	Seed content of fruit (%)	10.46	9.1	7.76	7.76	11
10	Peel content of fruit (%)	43.67	55	43.76	43.76	42.5

Table 3: Dimensions of ripened custard apple fruit

Samples No.	Length (mm)	Width (mm)	Thickness (mm)
1	55.65	48.4	46.36
2	64.35	61.38	61.23
3	66.5	62.5	59.5
4	70.5	63.6	61.5
5	65.7	60.1	59.4

Determination Chemical Properties of Custard Apple Pulp

Table 4: Chemical properties of custard apple pulp

No	Chemical properties	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	Moisture content (%) wb	7.58	7.92	7.62	7.75	7.86
2	TSS (%)	24.9	26.7	19.3	23.5	26
3	PH	5.75	5.46	5.96	5.67	5.72

Determination of Hardness: Hardness was determined by using Texture Analyser. The hardness of custard apple was determined by using replication method. In this method 5 samples were used and each sample replicated 3 times.

Evaluation of hardness for sample 1 in three replications

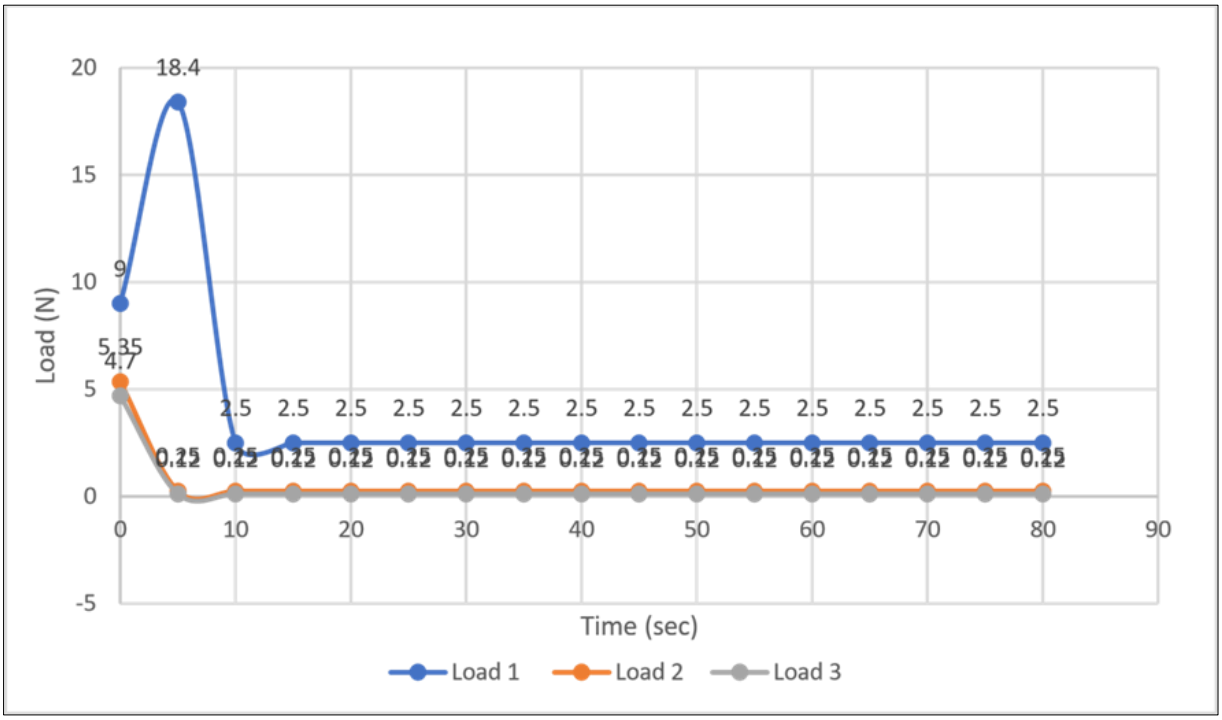

Fig 5: Variation of hardness with respect to load and time sample 1

It was observed from the chart (fig 5) that, hardness of custard apple sample 1 was decreased while load increasing with respect to time and it attains constant at zero load with time intervals at 10sec and it remains constant throughout the period.

Evaluation of hardness for sample 2 in three replications

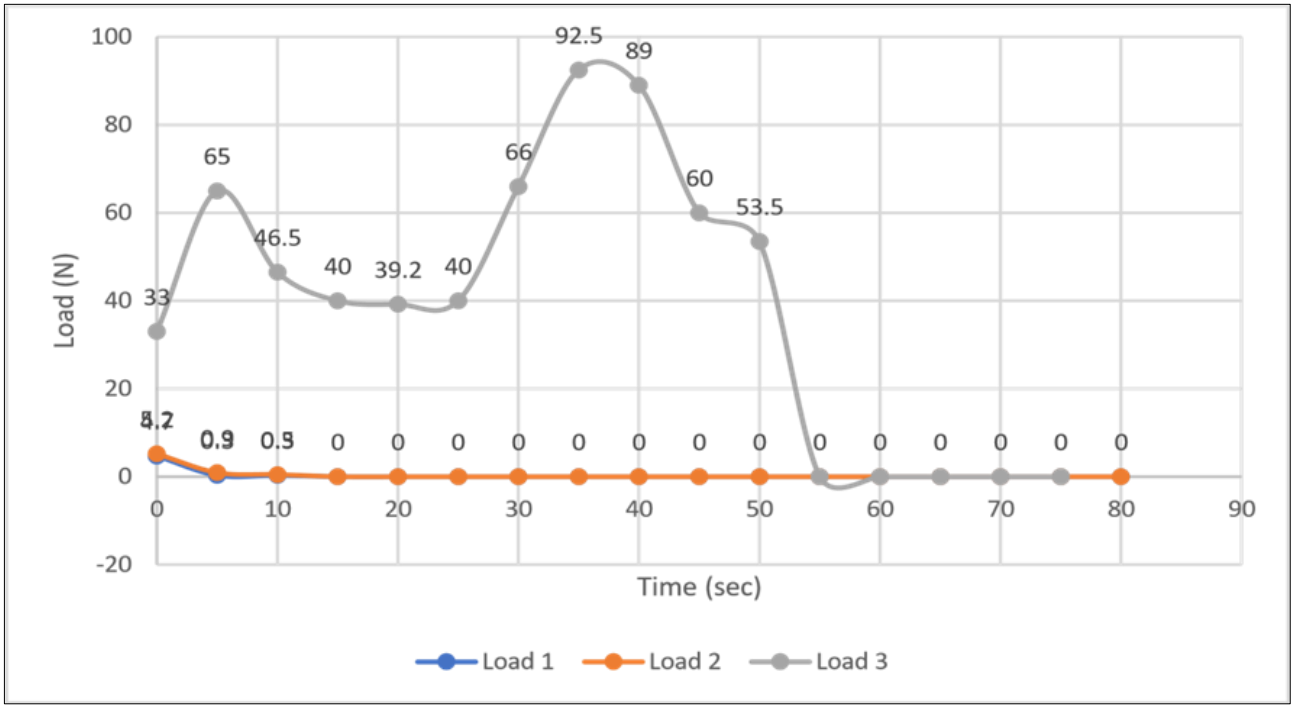

Fig 6: Variation of hardness with respect to load and time sample 2

It was observed from the chart (fig 6) that, hardness of custard apple sample 2 was increased and decreased at some time intervals, it increases at 5sec and 35sec and then it decreases at 50sec and it constant at zero load.

Evaluation of hardness for sample 3 in three replications

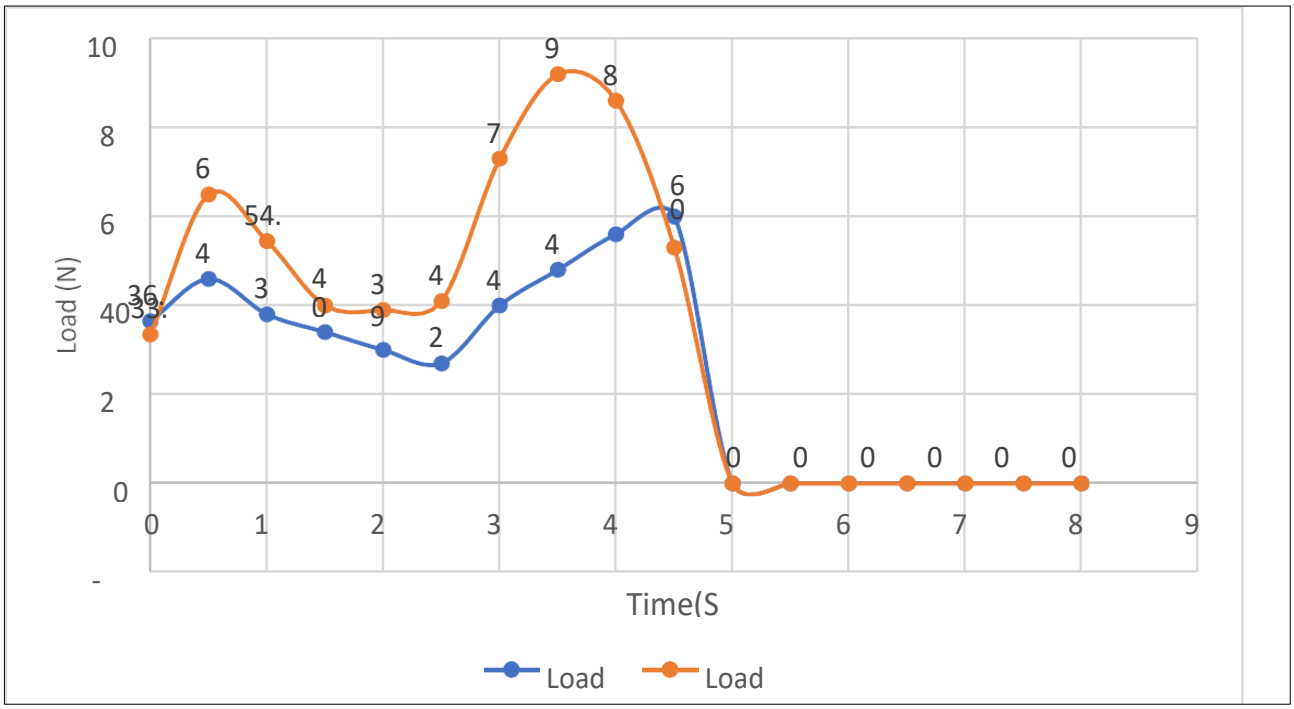

Fig 7: Variation of hardness with respect to load and time sample 3

From the above chart (fig7) hardness of custard apple sample 3 slightly increases and decreases at different time intervals and it remains constant at zero load with a time interval of 55sec.

Evaluation of hardness for sample 4 in three replications

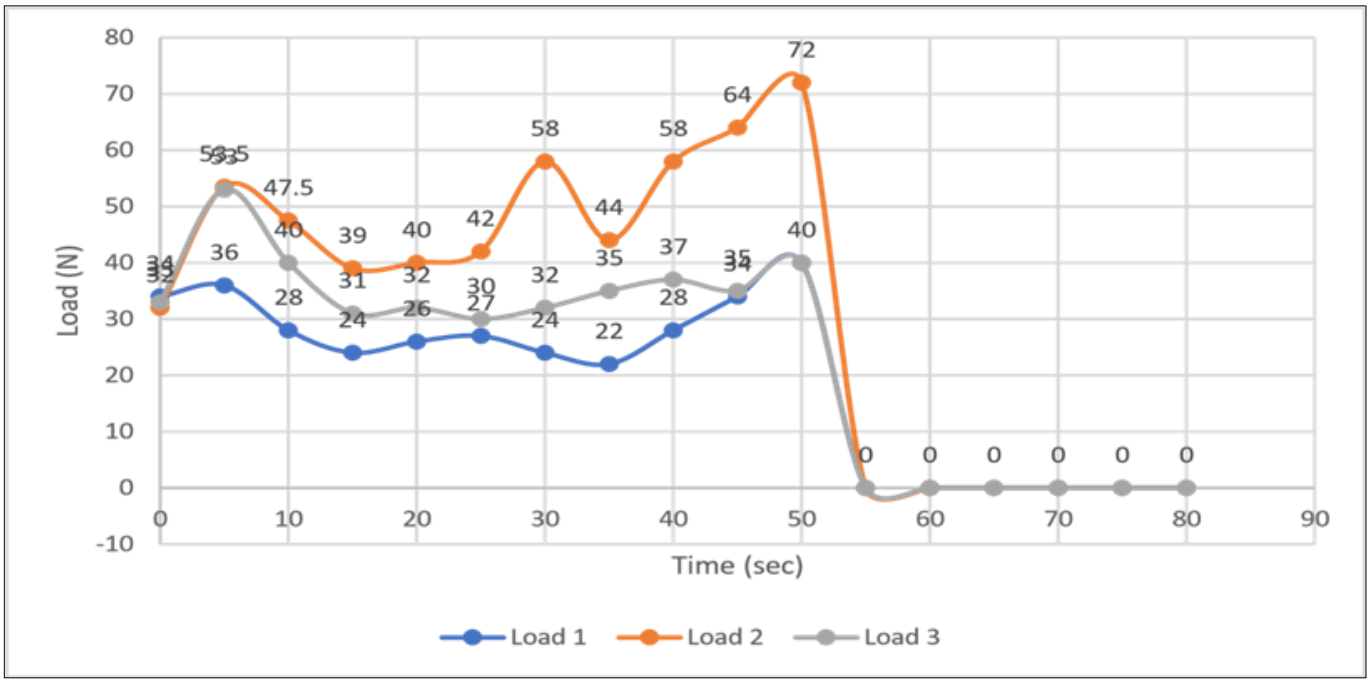

Fig 8: Variation of hardness with respect to load and time sample 4

From the chart (fig8) that, hardness of custard apple sample 4 was decreases and increases in different time intervals, here maximum hardness attains at 50sec. And maximum hardness attains at load of 72N at time intervals of 50sec and it remains constant at zero load from time intervals of 55sec.

Evaluation of hardness for sample 5 in three replications

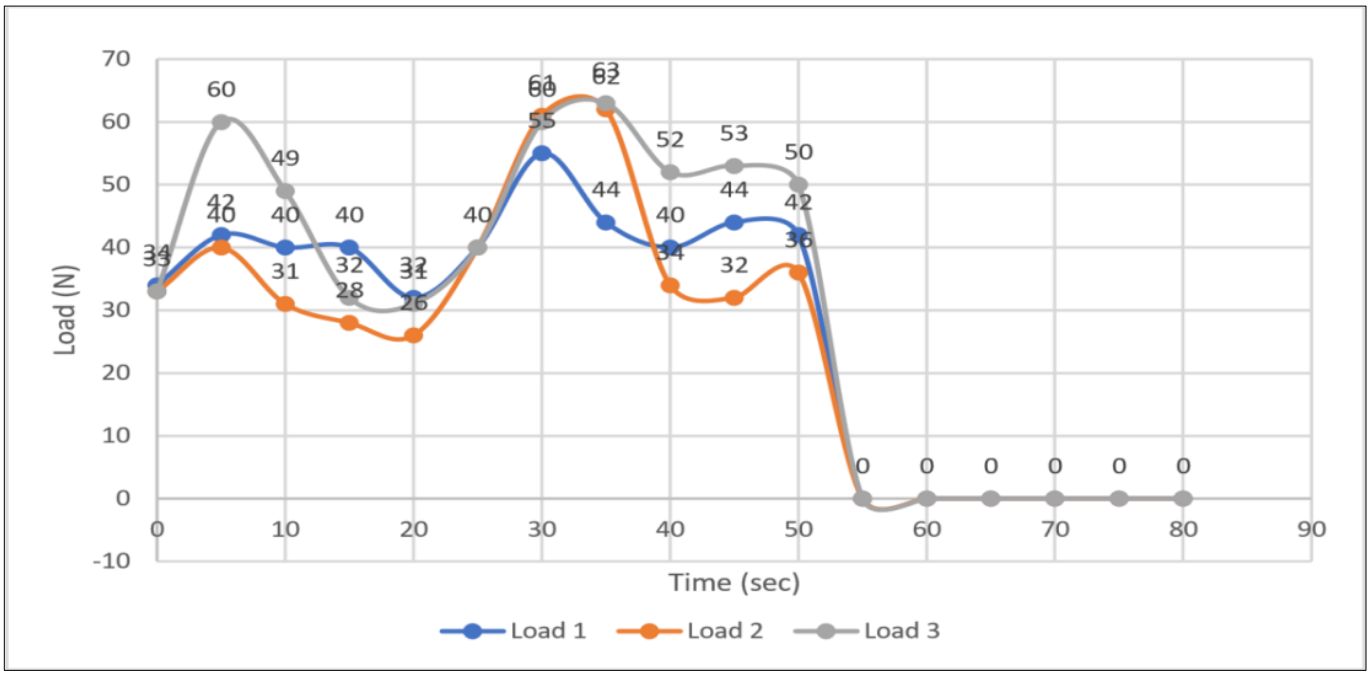

Fig 9: Variation of hardness with respect to load and time sample 5

From the chart (fig9) hardness of custard apple is maximum at load of 62N with a time interval of 35sec and the hardness of custard apple is minimum at load of 28N with a time intervals of 20sec and it remains constant at load 0N with a time intervals of 60sec.

Drying characteristics of custard apple pulp

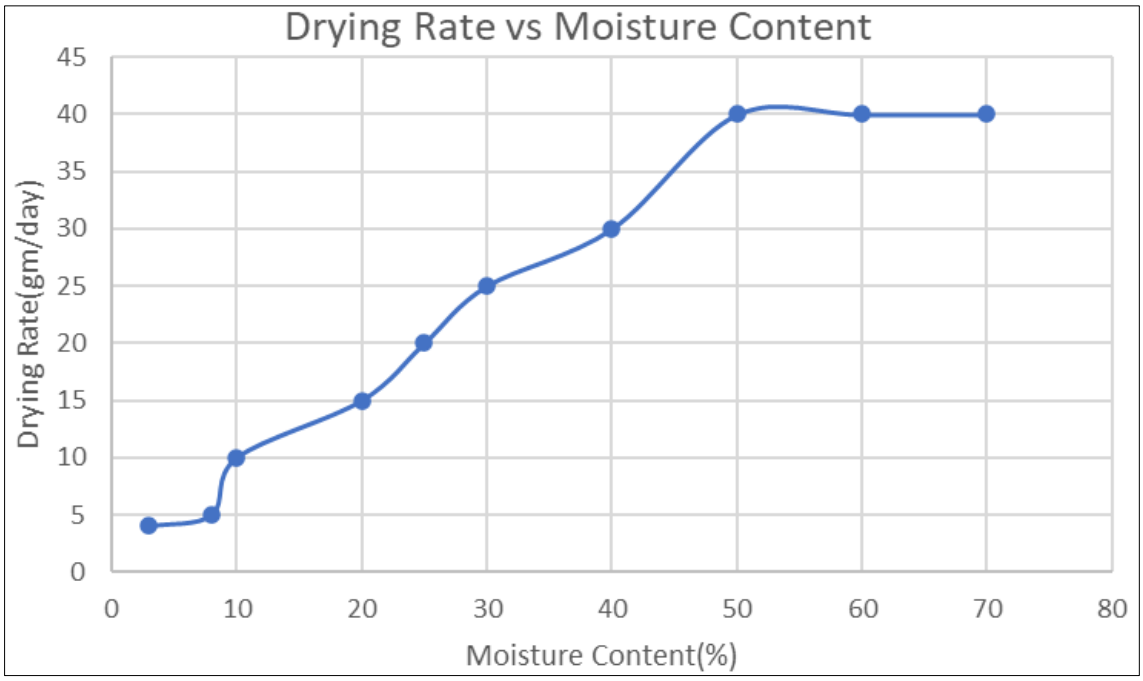

Fig 10: Moisture content vs drying rate by tray dryer

From the fig(10) drying rate of custard apple pulp was increases while decreasing in moisture content. In tray dryer from the above results the weight of custard apple pulp is gradually decreases while decreasing in moisture content.

Drying of custard apple pulp by solar cabinet dryer

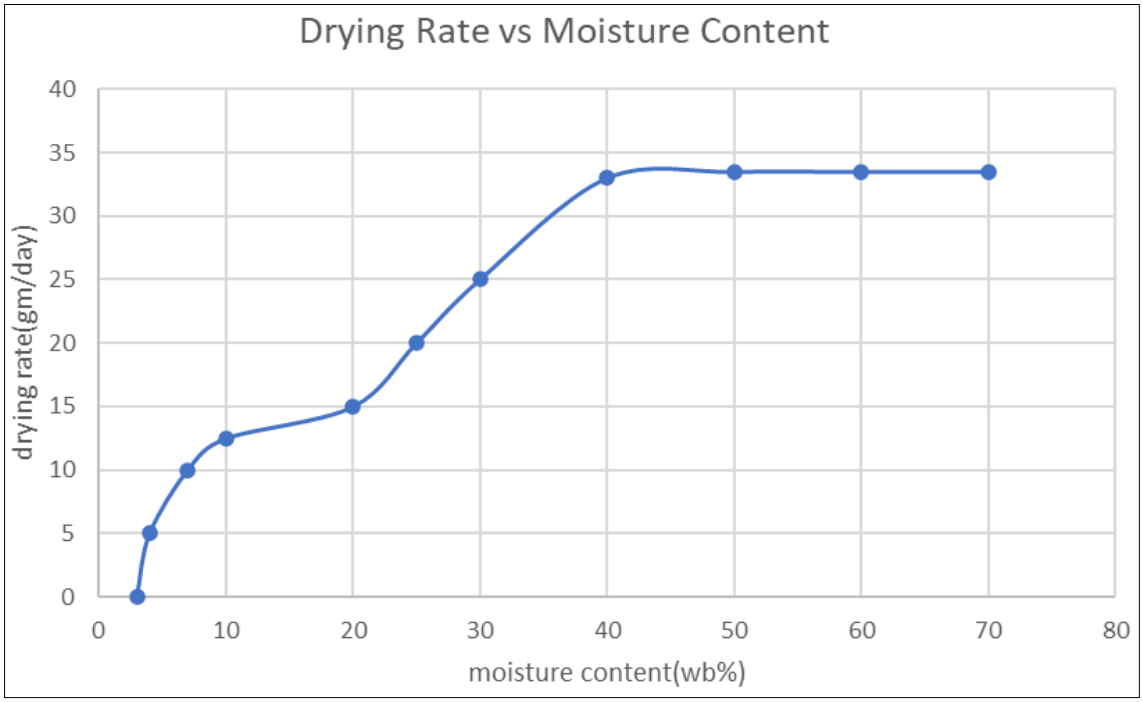

Fig 11: Moisture content vs drying rate by solar cabinet

From the chart (11) drying rate of custard apple pulp was increases and decreases by solar cabinet dryer.

Drying of custard apple pulp by sun drying

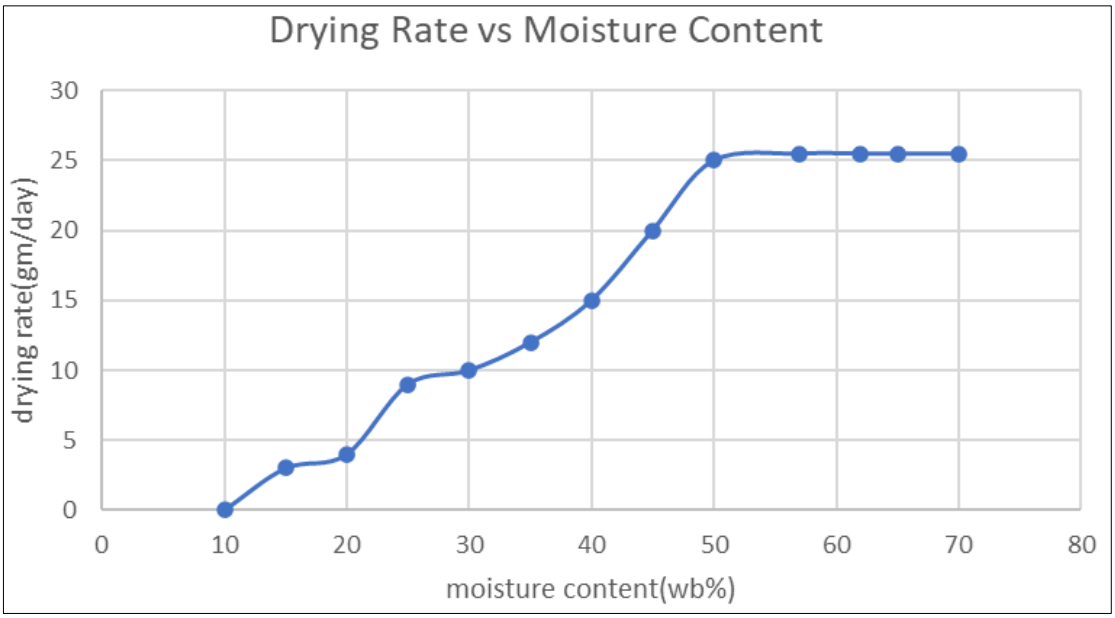

Fig 12: Moisture content vs drying rate

Conclusion

As this research undergo three types of drying processes i.e tray drying, solar cabinet drying, sun drying, following conclusions were observed.

1. Tray dryer takes 59 hours for complete drying of custard apple pulp at 70 ^{o}C temperature.
2. After drying we observed that the colour of custard powder is normal brown due to constant temperature.
3. In solar cabinet dryer it takes 360hours for complete drying of custard apple pulp at atmospheric temperature.
4. After drying we observed that the colour of custard powder is brown because of temperature variations
5. In sun drying it takes 450hours for complete drying of custard apple pulp.
6. Based on these observations we conclude that Tray dryer is the best and most effectivemethod for drying as compared to Solar cabinet dryer and Sun drying. This process requires no agitation and allows control over temperature and other properties.

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