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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 802-810

www.thepharmajournal.com
Received: 11-08-2023
Accepted: 17-09-2023

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Preparation of *Aloe vera* pulp powder by using different drying methods with studying changes in the physical quality parameters during drying and storage

Harshada M Pawar, Dr. Gargi D Shirke, Vishal B Yadav and Dr. Jitendra H Kadam

Abstract
The present research work was carried at the department of PHM of MAPSF of PGI PHM Killa, Roha, Dist. Raigad, (Dr. B. S. K. K. V., Dapoli, Dist. Ratnagiri =) Maharashtra. India, during the year 2020-21. The main objective of the research was Preparation of *Aloe vera* pulp powder by using various drying methods with studying changes in the physical quality parameters during drying and storage. The data collected on the physical quality parameters of *Aloe vera* pulp during drying and storage were statistically analyzed by using Completely Randomized Design (CRD) and Factorial Completely Randomized Design (FCRD) respectively.
Analysis of *Aloe vera* pulp for different quality parameters during drying such as initial moisture, final moisture, drying time, rate of drying and analysis of storage parameters of *Aloe vera* powder such as colour and particle size were conducted at 0, 30, 60 and 90 days. During the storage L* value and b* value of colour, decreased with increased in storage period. And a* value of colour was increased with increase in storage period. All the parameters were significantly influenced packaging material and storage time. Particle size 37 micron. Colour value for L*, a* and b* was 39.18, 4.78 and 32.48 respectively.
From overall observation it was concluded that convective tray drying was the best and suitable method for preparation of *Aloe vera* pulp powder followed by microwave drying, Polytunnel drying and Sun drying. In convective tray drying method 50 °C was suitable temperature for preparing *Aloe vera* pulp powder and it was stored for 90 days at room temperature without affecting its quality and also found suitable for human consumption.

Keywords: *Aloe vera* leaves, fresh *Aloe vera* pulp, *Aloe vera* powder, drying, convective drying, storage of *Aloe vera* powder etc.

1. Introduction
Aloe vera is a short-stemmed juicy plant with green pointed and fleshy leaves make with a clear viscous gel. It can achieve a stature of 10-20 m with a stem girth up to 3 m. The flowers of *Aloe vera* which produced annually are orange in colour with the spikes reaching up to 90 cm tall. The plant has triangular, fleshy leaves with serrated edges, yellow tubular flowers and fruits that contain numerous seeds. Each leaf is made up of three layers:

1. An inner clear gel that contains 99% water and remaining is made of glucomannan, amino acids, lipids, sterols and vitamins.
2. The middle layer of latex which is the bitter yellow sap and contains anthraquinones and glycosides.
3. The outer thick layer of 15–20 cells called as rind which has protective function and synthesizes carbohydrates and proteins. Inside the rind are vascular bundles responsible for transportation of substances such as water (xylem) and starch (phloem). (Joseph and Raj, 2010) [13].

Aloe products are susceptible to spoilage due to the high moisture content. Unfortunately, due to lack of proper processing techniques, many of these products spoil before reaching the consumers causing a huge loss to the cultivator and processor. The *Aloe* leaves possessing wide spectrum of biological activities and having extensive use, has become very vital to develop a better method of preservation for enhancing the shelf life while maintaining the quality.

Drying is one of the best methods for preserving the various food materials as compared to other methods. It increases the shelf life by decreasing the water activity in the product which inhibits the growth of microorganisms while decreasing spoilage reactions. Another important benefits of dried product is the reduction in the cost of packaging, storage and transportation due to their comparatively smaller volume and mass. The challenge of *Aloe vera* drying is to maximize the retention of nutrients while minimizing the moisture content of product to a level where microbiological growth should not occur. There is requirement of faster method of dehydration that yields higher quality products. It is generally known that freeze-drying produces highest quality dehydrated products, but this technique is very expensive and requires skilled operators. Hence, a method of convective drying could be a good solution. However some problems like considerable shrinkage due to cell collapse following the loss of water, poor re-hydration characteristics of dried products and unfavourable changes in colour, texture, flavour and nutritive value may occur. This can be solved by controlled drying which helps in overall improvement in the quality of the final product (Ahmed and Singh, 2013) [1].

In the present scenario, *Aloe vera* is referred to as green oil in the industry. Due to main ingredient in many products, *Aloe vera* is considered to be one of the most important constituents in many products in the food, medical, pharmaceutical, cosmetic, chemical, medical, and other industries. The global *Aloe vera* product is estimated at $ 125 million and the value of its finished products is over $ 110 billion. According to industry experts, the global *Aloe vera* gel market was worth US$465 Million in 2016, at CAGR of around 11% during 2009-2016. The global *Aloe vera* market is expected to grow at a CAGR of around 7% during 2021 - 2026. The market has been growing steadily over the last decade driven by varied and increasing usage of *Aloe vera* in the food, health care and cosmetic industries. The healthcare and cosmetics sectors are currently the two biggest drivers of *Aloe vera* consumption. Region-wise, Thailand is the biggest producer of *Aloe vera* accounting for around a third of the total global production. Other leading producers include Mexico, Dominican Republic, United States and Costa Rica. The demand of *Aloe vera* is strong throughout the globe, growth rates in emerging markets such as India, China, Middle East, etc. are expected to be extremely high.

The present research entitled, “Preparation of *Aloe vera* pulp powder by using different drying methods with studying changes in the physical quality parameters during drying and storage.” was conducted at the Department of Post-Harvest Management of Medicinal, Aromatic, Plantation, Spices and Forest Crops, Post Graduate Institute of Post-Harvest Management, Killa -Roha, Dist. Raigad, Maharashtra India, north konkan (18°42’5947” N, 73°17'9361" E) during the year 2020-2021.

2. Materials and Methods

2.1 Experimental materials

2.1.1 *Aloe vera* leaves

The fresh *Aloe vera* leaves of species *Aloe barbadenesis* were obtained from the farmer’s field.

2.1.2 Chemicals

Food grade and analytical grade chemicals obtained from department of Medicinal, aromatic, plantation, spices and forest crops were used for carrying out analysis of the samples.

2.1.3 Packaging Materials

The high -density polyethylene (HDPE) pouch/bag packaging materials were obtained from the local market.

2.1.4 Equipments

The equipment used in this investigation was grinder, peeler, cutting knife, weighing balance, autoclave, different types of dryers, hot air oven, sieve shaker, muffle furnace, soxhlet extraction apparatus, kjeldahal distillation unit etc.

Experimental details
Drying of *Aloe vera* powder
Treatments: 4
Treatment combination: 20
Replications: 5
Statistical design: CRD

Storage of *Aloe vera* powder
Product: *Aloe vera* powder.
Main treatments: 4 (Sun drying, Polytunnel drying, Microwave drying, Convection drying).
Sub Treatments: 4 (Storage period: 0, 30, 60 and 90 days).
Treatment combinations: 16
Replications: 3
Statistical design: FCRD

Treatment details
T_1: Sun Drying
T_2: Polytunnel drying
T_3: Microwave drying
T_4: Convection drying

Sub treatments
Sub treatments: Storage period (Days)
1. S_1: 0
2. S_2: 30
3. S_3: 60
4. S_4: 90

2.1.5 Preparation of *Aloe vera* pulp powder and storage study

Fresh, healthy and matured *Aloe vera* leaves were selected for conducting the experiments. The leaves were brought from *Aloe vera* farm Nashik. The leaves were cut in the early morning for experimentation to avoid moisture loss and spoilage. Each leaf was cut manually with a stainless steel knife and pulled carefully from the mother plant to avoid breaking of rind. The leaves were transported from farm to the working place in a covered polyethylene bag to avoid oxidation or contamination and were kept in upright position in order to drain out the ‘Aloin’ (yellow sap) present in it. After that the *Aloe vera* leaves were washed under tap water to remove sticking materials and dirt. The spikes, placed along the margins, were removed before slicing the leaves. The thick dark green outer skin was peeled out manually from the thick gel fillet using a stainless steel knife. The fillets were cut into 5 × 3 × 1 cm cuboids with the help of stainless steel cutter and stored in an air tight container till the experiment was started. The fresh *Aloe vera* cubes fillet were transferred into a tray for different drying studies such as sun drying,

Polytunnel drying, Convective drying and Microwave drying. The temperature of convective dryer was kept 50 °C and Microwave dryer was 60 °C. The sample was dried still constant weight is observed. After complete drying of sample, sample was transferred into a grinder and used sieve to obtained the fine powder. The powder was packed in small polyethylene bag with the help of packaging machine.

To find out suitable drying method and storage study, 60-80 gm sample was filled in polyethylene bag. The storage was for 90 days and sample were analysed for different quality parameters at 30 days interval. The experiments were done with three replication. The preparation of *Aloe vera* powder was given in flow chart.

Fresh Aloe vera leaves
↓
Washing
↓
Removal of spikes
↓
Slicing the leaves
↓
Separation of mucilage /pulp fillets
↓
Cutting of fillets
↓
Drying
↓
Grinding
↓
Powder packaging
↓
Storage

Flow chart 1: Process flowchart for preparation of *Aloe vera* pulp powder

3. Results and Discussion

The present investigation entitled, "To study the changes in physical quality parameters of *Aloe vera* pulp powder prepared by different drying methods during storage and drying" was undertaken in the Department of Post-Harvest Management of Medicinal, aromatic, plantation, spices and forest crops, Post Graduate Institute of Post-Harvest Management, Killa-Roha, during the year 2020-2021.

The fresh *Aloe vera* leaves were selected for the present investigation which was undertaken to study the changes in physical quality parameters and to study storage behaviour of *Aloe vera* pulp powder. The experiment consisted of four treatments and four sub treatments. The experimental data was analysed statistically using Completely Randomized Design (CRD) and Factorial Completely Randomized Design (FCRD). The observations on the changes in physical parameters of *Aloe vera* pulp powder during storage were recorded at 0, 30, 60 and 90 days of room temperature storage. The results obtained from the investigation are presented and discussed in this chapter.

3.1 Changes in the physical quality parameters of the *Aloe vera* pulp during drying

3.1.1 Initial moisture %

The data for initial moisture percent of *Aloe vera* pulp before drying are presented in table (4.1) and graphically mentioned in fig (4.1).

The treatment T_4 (98.7) recorded the highest initial moisture percent mean value which was at par with treatment T_3 (98.6) and T_2 (98.5) and treatment T_1 (98.2) recorded the lowest initial moisture percent.

These findings are supported by Muaz and Fatma, (2012) [27]. They were found 97% moisture in the *Aloe vera* leaves.

3.1.2 Final moisture %

The data for final moisture percent of *Aloe vera* pulp after drying are presented in table (4.1) and graphically mentioned in fig (4.2).

The treatment T_4 (3.70) recorded highest final moisture percent mean value which was at par with treatment T_3 (3.60) whereas treatment T_1 (2.10) recorded the significantly lowest final moisture percent mean value which was followed by treatment T_2 (2.60).

The similar work was noted by Hendravati, (2015) [12]. The final moisture percent of *Aloe vera* pulp was found 2.88%, 4.04% and 4.89% at temperature 140, 130 and 120 °C. Pattali and Yenge, (2015) [35] found 8.66% final moisture in open yard sun drying, 8.61% in hot air drying and 8.57% in dehumidified air drying of *Aloe vera* leaves. Also Preetinder, Amrit and Kumar, (2017) [36] was found 3.59% moisture in spray dried *Aloe vera* powder.

3.1.3 Drying time (hr)

The data for drying time of *Aloe vera* pulp are presented in table (4.1) and graphically mentioned in fig (4.3).

The treatment T_1 (21.40) recorded significantly highest drying time which was followed by treatment T_2 (20.40). The treatment T_3 (0.095) recorded the lowest drying time which was followed by treatment T_4 (17.40).

The total time required for drying of *Aloe vera* pulp fillets was recorded by Pattali and Yenge, (2015) [35] in experiments, They found that open yard sun drying of *Aloe vera* leaves required 21 hours, hot air drying required 16 hours and dehumidified air drying required 11 hours. Also Das Chandan, Das Arjit and Kumar gold was found that 5.78 min required in microwave drying of *Aloe vera* pulp.

3.1.4 Rate of drying (% moisture/hr)

The data for rate of drying (% moisture/hr) of *Aloe vera* pulp are presented in table (4.1) and graphically mentioned in fig (4.4).

These results indicates that treatment T_3 (158722) recorded the significantly highest rate of drying which was followed by treatment T_4 (5.445). Treatment T_1 (4.479) recorded the lowest rate of drying which was at par with treatment T_2 (4.689).

These findings are in confirmative with of *Aloe vera* pulp fillets recorded by Sabat, Patel and Kalne, (2018) [39]. They found that the drying rate increased with an increase in drying air temperature, resulting in a substantial decrease in the drying time; which is a well-established fact for drying of biological materials. Also Pattali and Yenge, (2015) [35] found that drying process mainly consisted of three drying periods i.e., heating up, constant rate and falling rate period. While in hot air drying at temperature of 50 °C showed only the falling rate period which was due to moderate temperature of drying. In hot air drying, the drying rate period from 47.04 to 0.04% at 50 °C.

Table 1: Changes in the physical quality parameters of *Aloe vera* pulp during drying

Treatments	Initial Moisture (%)	Final Moisture (%)	Drying time (Hour)	Rate of drying (% moisture/hour)
T_1	98.2	2.10	21.40	4.479
T_2	98.5	2.60	20.40	4.689
T_3	98.6	3.10	0.095	158722
T_4	98.7	3.70	17.40	5.445
S.Em±	0.072	0.136	0.061	0.359
C. D at 5%	0.217	0.411	0.185	1.084

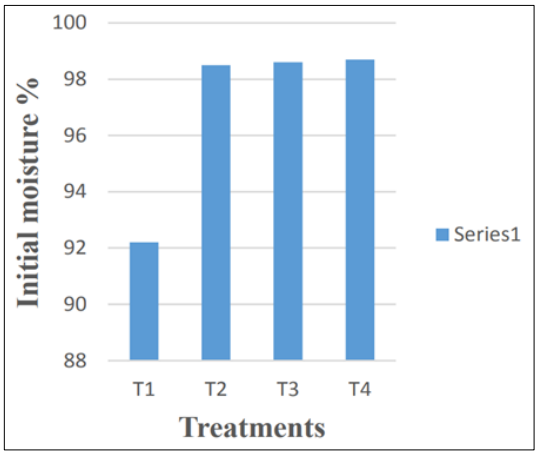

Fig 1: Initial moisture percent in different treatments of *Aloe vera* pulp before drying

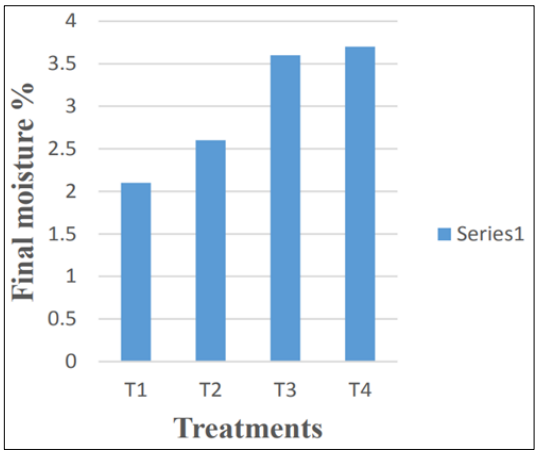

Fig 2: Final moisture percent in different treatments of *Aloe vera* pulp after drying

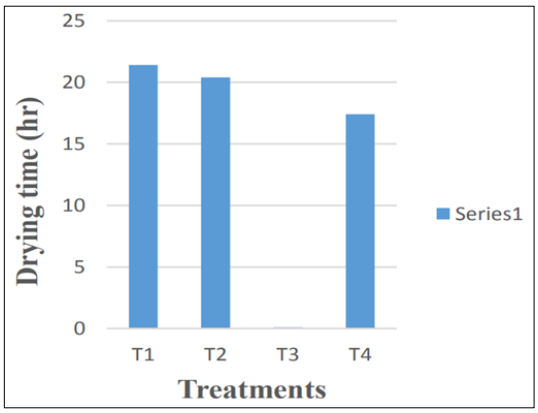

Fig 3: Drying time of *Aloe vera* pulp in different treatments

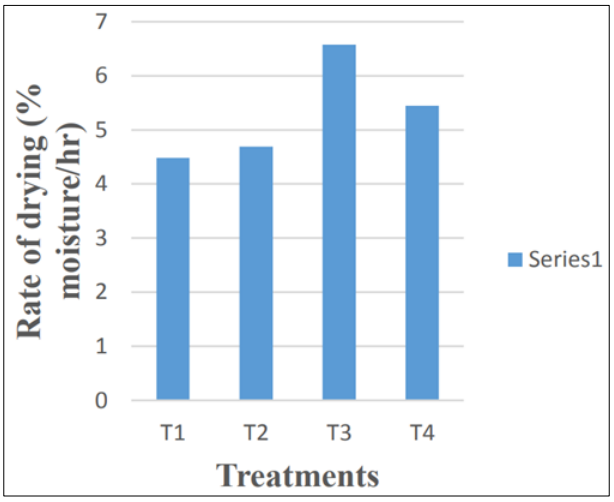

Fig 4: Rate of drying in different treatments of *Aloe vera* pulp

3.2 Changes in the physical quality parameters of the *Aloe vera* pulp powder during storage

3.2.1 Colour

3.2.1.1 L* value for colour

The data for L* value for colour of *Aloe vera* pulp powder during storage period are presented in table (4.2) and graphically mentioned in fig (4.5). L* colour value was recorded to determine lightness of *Aloe vera* pulp powder which decreased with corresponding increase in storage period. The decrease in L* value of colour due to increasing in browning of *Aloe vera* pulp powder during storage of 90 days.

The treatment T_4 (39.18) recorded the significantly highest mean L* value for colour followed by T_1 (31.21) and treatment T_2 (26.84) recorded the lowest mean L* value of colour which was at par with T_3 (26.95). Lightness of the colour in *Aloe vera* pulp powder decreased significantly with increase in storage periods from 33.09 to 27.43 during 90 days storage. Thus, it can be concluded that Lightness of the colour in *Aloe vera* pulp powder decreased with increase in storage period. Interaction effect between storage period and different treatments was found to be statistically non-significant.

The decrease in the L* value of dehumidified air dried *Aloe vera* gel powder was recorded by Ramachandra and Srinivasa Rao, (2011) [37]. They observed the changes in the L* colour value of *Aloe vera* powder due to storage period and different packaging material. They observed decreased in L* value of colour from 0 to 49 days of storage period in three different packaging materials AF, PP and BOPP.

Table 2: Effect of different drying methods and storage periods on the L* colour value of *Aloe vera* pulp powder

Treatments	L* colour value				Mean
	Storage period (days)				
	0	30	60	90	
T_1	34.63	33.30	32.30	24.60	31.21
T_2	28.23	27.17	26.40	25.57	26.84
T_3	28.67	27.33	26.33	25.47	26.95
T_4	40.83	41.53	40.23	34.10	39.18
Mean	33.09	32.33	31.32	27.43	31.04
	Treatment		Storage		Interactions (Txs)
S.Em±	0.90		0.90		0.43
CD at 5%	2.56		2.56		Non-significant

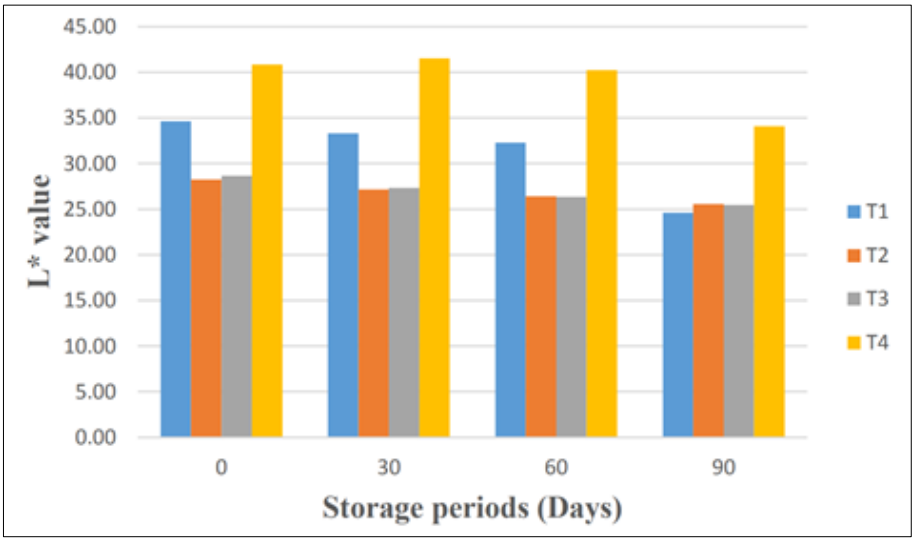

Fig 5: Effect of different drying methods and storage periods on the L* colour value of *Aloe vera* pulp powder

3.2.1.2 a* value for colour

The data for a* value for colour of *Aloe vera* pulp powder during storage period are presented in table (4.3) and graphically mentioned in fig (4.6). a* value was recorded to determine redness of *Aloe vera* pulp powder which increases with corresponding increase in storage period.

The treatment T_3 (12.18) recorded the significantly highest mean a* value for colour which was followed by T_1 (10.86) and treatment T_4 (4.78) recorded the lowest mean a* value of colour which was followed by T_2 (10.11). The a* value of colour during storage of 0 to 90 days also increased significantly.

Redness of the colour in *Aloe vera* pulp powder increased with increase in storage period from 7.83 to 10.93 upto 90 days of storage. Interaction effect between storage period and different treatments was found to be statistically non-significant.

The increase in the a*value of dehumidified air dried *Aloe vera* gel powder was recorded by Ramachandra and Srinivasa Rao, (2011) [37]. They observed the changes in a* colour value of *Aloe vera* powder due to storage period and different packaging material. They was observed increased in a* value of colour from 0 to 49 days of storage period in three different packaging materials AF, PP and BOPP.

Table 3: Effect of different drying methods and storage periods on the a* colour value of *Aloe vera* pulp powder

Treatments	a* colour value				Mean
	Storage period (days)				
	0	30	60	90	
T_1	8.93	10.50	11.50	12.50	10.86
T_2	7.40	9.90	10.90	12.25	10.11
T_3	11.10	11.83	12.33	13.47	12.18
T_4	3.87	4.70	5.07	5.50	4.78
Mean	7.83	9.23	9.95	10.93	9.48
	Treatment		Storage		Interactions (Txs)
S.Em±	0.21		0.21		0.41
CD at 5%	0.59		0.59		Non-significant

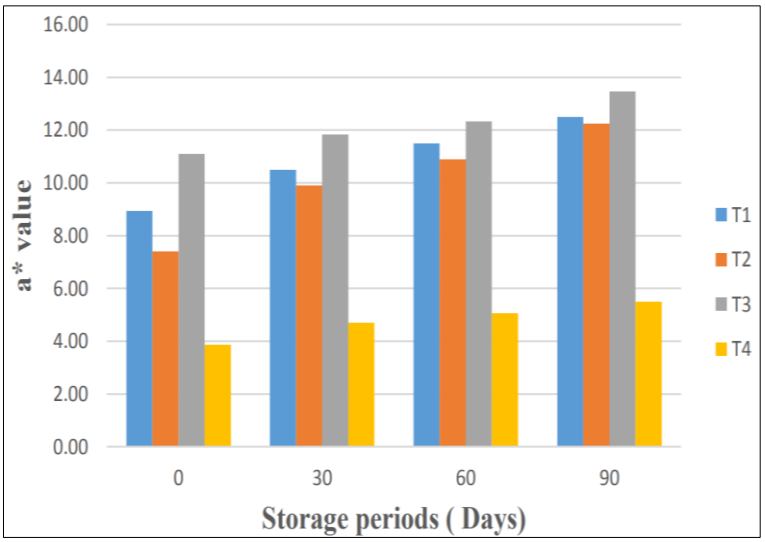

Fig 6: Effect of different drying methods and storage periods on the a* colour value of *Aloe vera* pulp powder

3.2.1.3 b* value for colour

The data for b* value for colour of *Aloe vera* pulp powder during storage period are presented in table (4.4) and graphically mentioned in fig (4.7). b* value was recorded to determine yellowness of *Aloe vera* pulp powder which decreases with corresponding increase in storage period.

The treatment T_3 (38.43) recorded the highest mean b* value for colour which was at par with treatment T_2 (38.39). The treatment T_4 (32.48) significantly recorded the lowest mean b* value of colour which was followed by treatment T_1 (35.89). The b* value of colour during storage of 0 to 90 days also decreased significantly.

Yellowness of the colour in *Aloe vera* pulp powder decreased with increase in storage period from 39.98 to 32.48 upto 90 days storage. Interaction effect between storage period and different treatments was found to be statistically non-significant.

The decrease in the b* value of dehumidified air dried *Aloe vera* gel powder was recorded by Ramachandra and Srinivasa Rao, (2011) [37]. They observed changes in b* colour value of *Aloe vera* powder due to storage period and different packaging material. They observed decrease in b* value of colour from 0 to 49 days of storage period in three different packaging materials AF, PP and BOPP.

Table 4: Effect of different drying methods and storage periods on the b* colour value of *Aloe vera* pulp powder

Treatments	b* colour value				Mean
	Storage period (days)				
	0	30	60	90	
T_1	36.90	36.13	35.90	34.63	35.89
T_2	41.83	39.33	37.67	34.73	38.39
T_3	44.50	41	39	29.20	38.43
T_4	36.70	35	34	31.33	32.48
Mean	39.98	37.87	36.64	32.48	32.48
	Treatment		Storage		Interactions (Txs)
S.Em±	0.64		0.64		1.27
CD at 5%	1.82		1.82		Non-significant

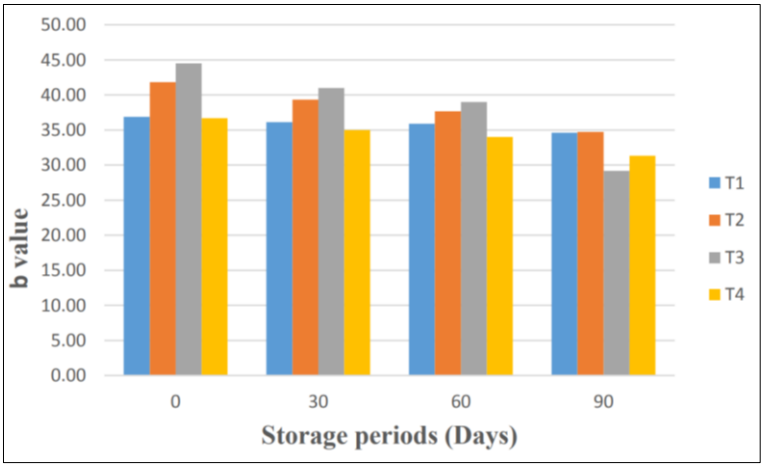

Fig 7: Effect of different drying methods and storage periods on the b* colour value of *Aloe vera* pulp powder

3.2.2 Particle size (micron)

The data for particle size of *Aloe vera* pulp powder during storage period are presented in table (4.5) and graphically mentioned in fig (4.8).

The treatment T_1 (63.46) recorded the highest mean particle size which was at par with treatment T_2 (53.33) and treatment T_4 (37.15) recorded the lowest mean particle size which was at par with treatment T_3 (44.25). The particle size during storage of 0 to 90 days slightly increased.

Particle size in *Aloe vera* pulp powder slightly increased with increase in storage period from 49.35 to 49.72 upto 90 days storage. Interaction effect between storage period and different treatments was found to be statistically non-significant.

These results are in confirmative with work done by Gautam and Awasthi, (2007) [7] reported maximum water retention of the *Aloe vera* powder on 40 mesh size. Stoklosa and Lipasek, (2012) [44] observed the sticking and agglomeration resulting from exposure to relative humidity reduces flow ability and may be influenced by powder composition, particle size and shape.

Table 5: Effect of different drying methods and storage periods on the particle size of *Aloe vera* pulp powder

Treatments	Particle size (micron)				Mean
	Storage period (days)				
	0	**30**	**60**	**90**	
T_1	63.20	63.40	63.57	63.67	63.46
T_2	53.10	53.30	53.40	53.50	53.33
T_3	44.10	44.20	44.30	44.40	44.25
T_4	37.00	37.10	37.20	37.30	37.15
Mean	49.35	49.50	49.62	49.72	49.55
	Treatment		Storage		Interactions (Txs)
S.Em±	3.87		3.87		7.75
CD at 5%	11.07		11.07		Non-significant

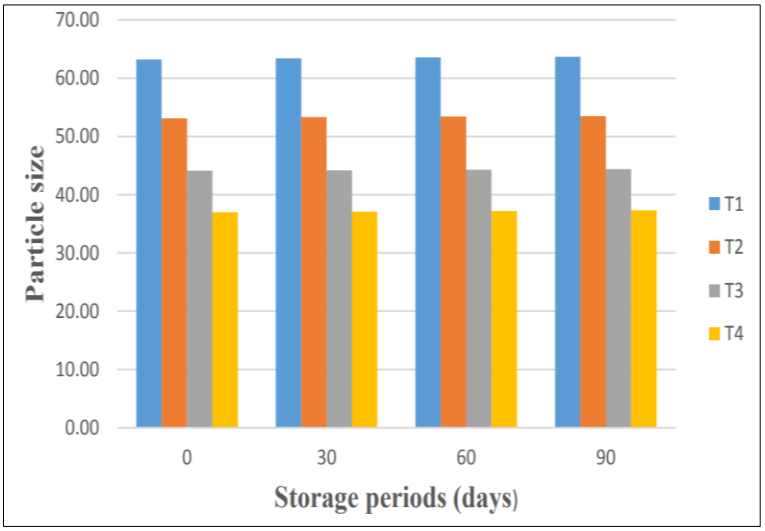

Fig 8: Effect of different drying methods and storage periods on the particle size of *Aloe vera* pulp powder

Plate 1: Sun drying of fresh *Aloe vera* pulp fillets

Plate 2: Sun dried sample of fresh *Aloe vera* pulp fillets

Plate 3: Poly tunnel drying of fresh *Aloe vera* pulp fillets

Plate 4: Polytunnel dried sample of fresh *Aloe vera* pulp fillets

Plate 5: Microwave drying of fresh *Aloe vera* pulp fillets

Plate 6: Microwave dried sample of fresh *Aloe vera* pulp fillets

Plate 7: Convective drying of fresh *Aloe vera* pulp fillets

Plate 8: Convective dried sample of fresh *Aloe vera* pulp filletes

Fig 9: Effect of different drying methods and storage periods on particle size of *Aloe vera* pulp powder

4. Conclusion

1. From overall recorded observation it was concluded that Convective tray drying was the suitable method for preparation of *Aloe vera* pulp powder. Followed by microwave drying, Polytunnel drying and Sun drying.
2. Convective tray drying at 50 °C was suitable temperature for preparation of *Aloe vera* pulp powder.
3. *Aloe vera* pulp powder was stored for 90 days at room temperature without affecting its quality and also found suitable for human consumption.

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