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RESEARCH PAPER

Influence of packaging materials on storage of shatavari (*Asparagus racemosus* Willd.) root powder

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Abstract: The experiment was conducted at the Department of Post Harvest Technology, KRC College of Horticulture, Arabhavi, Belagavi district, Karnataka, India during 2020-21 to find out the suitable packaging material for storage of shatavari root powder in Factorial Completely Randomized Design with two factors (types of roots and packaging materials). Different packaging materials *viz*., aluminium pouch, polyethylene lined aluminium pouch and polypropylene pouch were used for packing of shatavari root powder. Magnesium silicate, an anticaking agent was used at 1.00 and 1.50 per cent concentration to avoid the caking of powder and vacuum packaging were also tried for these different packaging materials for storage of shatavari root powder without anticaking agent. The minimum moisture content (7.64%), water activity (0.550), *L* value (63.76) was noticed in yellow roots after three months of storage whereas maximum moisture content (8.10%), water activity (0.561) and *L* value (67.68) was observed in white root after three months of storage. Shatavari powder packed in polyethylene lined aluminium (laminated) pouch with vacuum recorded lower moisture content (6.25%), water activity (0.416), *a** value (2.72), maximum *L* value (72.33) and *b** value (19.82) followed by polyethylene lined aluminium pouch with 1.5 per cent magnesium silicate. The polyethylene lined aluminium pouch with vacuum condition or 1.5 per cent magnesium silicate proved better for storage of shatavari root powder.

Key words: Laminated pouch, *L* value, Packaging, Shatavari, Water activity

Introduction

Shatavari (*Asparagus racemosus* Willd.) is an important medicinal plant belonging to the family Asparagaceae. The name shatavari means "curer of a hundred diseases" (Alok *et al*., 2013). In Sanskrit, Shatavari means "the plant with hundred roots" owing to the roots of this natural herb that are enriched with medicinal properties and are regularly used in the preparation of various ayurvedic formulations.

Shatavari is commonly grown in low forest areas throughout India. It is a climber which grows to 1-2 m in height having a woody stem (Joshi, 2016). It produces needle-like leaves reduced to minute chaffy scales. Flowers are white, fragrant and in simple or branched racemes on the bare nodes of the main shoot or in the axils of the thorns (Kirtikar and Basu, 2003; Sharma and Sharma, 2013). The fruits are small, red and spherical (Sharma and Sharma, 2013), lobed pulpy berries with 1-2 seeds, purple-black in colour when ripe. Seeds have a harsh and bitter taste. The plant produces tuberous roots which are 13-20 cm long and 10-15 mm in diameter. Shatavari is classified into two broad groups based on the colour of its roots *viz*., Indian shatavari (also called white or Safed Shatavari) and Nepali shatavari (Yellow shatavari or Pili shatavari).

In Ayurveda, the roots of Asparagus are known for their properties like fertility promotion, phyto-estrogenic and hormone modulation in both females and males (Singh and Geetanjali, 2016). It has been utilized as a galactagogue that stimulates secretion of breast milk (Kirtikar and Basu, 2003; Wani *et al*., 2011; Zhang *et al*., 2019), anodyne, antispasmodic, diuretic, aphrodisiac and nervine tonic. It is considered as the women's tonic and used as a natural regulator (Zhang *et al*., 2019). The dried root in the form of powder is mainly used as an ingredient in a majority of the formulations. The tuberous roots of *Asparagus racemosus* are very much hygroscopic. Both roots and root powder readily absorb moisture causing caking of powder and degradation of saponin occurs when exposed to air. Magnesium silicate is the most commonly used anticaking agent and it is approved under GRAS. Therefore, a suitable packaging material and concentration of magnesium silicate needs to be standardised for storage of root powder for a longer time. Hence, the experiment was planned to develop a suitable packaging material and concentration of magnesium silicate for storage of shatavari root powder.

Material and methods

The experiment was laid out in Factorial Completely Randomised Design with two factors and two replications. The factor I being the type of roots (C_1- white root type, C_2- yellow root type) and factor II being three different packaging materials (aluminium pouch, polyethylene lined aluminium pouch, polypropylene pouch) and magnesium silicate (1.00% and 1.50%) as anticaking agent (P_1: Magnesium silicate @ 1.0% + packing in Aluminium pouch, P_2: Magnesium silicate @ 1.5% + packing in Aluminium pouch, P_3: Packing in Aluminium pouch + vacuum packaging, P_4: Magnesium silicate @ 1.0% + packing in polyethylene lined aluminium (laminated) pouch, P_5: Magnesium silicate @ 1.5% + packing in polyethylene lined aluminium (laminated) pouch, P_6: Packing in polyethylene lined

aluminium (laminated) pouch + vacuum packaging, P_7: Magnesium silicate @ 1.0% + packing in polypropylene bag, P_8: Magnesium silicate @ 1.5% + packing in polypropylene bag, P_9: Packing in polypropylene bag + vacuum packaging).

The shatavari root powder was prepared by steam blanching the roots for five minutes, peeled and dried in electric cabinet drier at 60°C for 6 hours. The dried roots were powdered using a mixer grinder and the powder was sieved using 60 mm sieve, stored in different packaging materials, kept under ambient conditions and different observations were recorded during storage at monthly intervals.

Observations like moisture content of the dried roots was measured using a moisture analyser and the values were expressed in percentage. The water activity of dried roots was measured using a digital water activity meter. The colour of the shatavari powder was measured using a Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK). The instrument was calibrated using the black and white tiles provided. Colour was expressed in Lovibond units *L* (lightness/darkness), *a* (redness/greenness) and *b* (yellowness/blueness).

Results and discussion

The observation on the moisture content of dried shatavari root powder as influenced by different types of roots, packaging materials and their interactions showed significant differences (Table 1). Initial moisture content of white and yellow shatavari root powder was 5.90 and 5.75 per cent, respectively and moisture content of shatavari root powder showed an increasing trend as the storage period advanced. Among the types of roots, minimum moisture content of shatavari root powder (6.64 and 7.64%) was recorded in yellow root powder (C_2) compared to white roots (6.69 and 7.82%) at 2 MAS and 3 MAS, respectively. Among the different packaging materials, P_6 (laminated pouch + vacuum packaging) recorded the lowest moisture content (6.25, 6.33 and 6.73%) which was on par with P_5 (6.27, 6.40 and 6.79%) at 1 MAS, 2 MAS and 3 MAS, respectively. Whereas, the highest moisture content was recorded in P_8 and P_9 (6.33% each) at 1 MAS, in P_7 (7.07%) at 2 MAS and in P_3 (8.49%) at 3 MAS. Polyethylene lined aluminium (laminated) pouch had better barrier properties to water vapour compared to aluminium and polypropylene pouch that prevented the absorption of moisture during storage.

Interaction effects between the type of roots and packaging materials differed significantly. Minimum moisture content was recorded in C_1P_6 (6.24 and 6.33%) which was on par with C_2P_6 (6.26 and 6.33%) at 1 MAS and 2 MAS, respectively. But, at 3 MAS minimum moisture content was recorded in C_2P_6 (6.59%) which was on par with C_1P_6 (6.87%).

The data on the interpretation of water activity of shatavari root powder showed significant differences (Table 2). At the initial period water activity of white and yellow shatavari root powder was around 0.428 and 0.422, respectively. The water activity of shatavari root powder showed an increasing trend as the storage period advanced. Among different types of shatavari roots, minimum water activity was recorded in yellow root (0.442, 0.487 and 0.550) whereas, maximum (0.469, 0.513 and 0.561) was recorded in C_1 (white type) at 1 MAS, 2 MAS

Table 1. Moisture content (%) of shatavari root powder as influenced by packaging materials during storage

Packaging materials	1 MAS			2 MAS			3 MAS		
	Types of roots		Mean P	Types of roots		Mean P	Types of roots		Mean P
	C_1	C_2		C_1	C_2		C_1	C_2	
P_1	6.37	6.26	6.31	6.63	6.61	6.62	8.31	8.26	8.28
P_2	6.30	6.31	6.30	6.53	6.54	6.53	8.21	8.20	8.20
P_3	6.31	6.34	6.32	6.52	6.82	6.67	8.67	8.31	8.49
P_4	6.30	6.31	6.30	6.37	6.39	6.38	7.06	6.86	6.96
P_5	6.28	6.27	6.27	6.36	6.44	6.40	6.90	6.69	6.79
P_6	6.24	6.26	6.25	6.33	6.33	6.33	6.87	6.59	6.73
P_7	6.27	6.33	6.30	7.21	6.94	7.07	8.16	7.83	7.99
P_8	6.31	6.36	6.33	7.14	6.92	7.03	8.18	7.87	8.02
P_9	6.29	6.38	6.33	7.11	6.82	6.97	8.00	8.16	8.08
Mean C	6.29	6.31		6.69	6.64		7.82	7.64	
	C	P	C X P	C	P	C X P	C	P	C X P
S. Em±	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.04	0.06
C.D.@1%NS	0.04	0.06	0.03	0.07	0.10	0.08	0.18	0.25	

*MAS- Months After Storage

P_1- Magnesium silicate @ 1.0%+packing in aluminium pouch
P_2- Magnesium silicate @ 1.5% +packing in aluminium pouch
P_3- Packing in aluminium pouch + Vaccum packing
P_4- Magnesium silicate @ 1.01% + packing in polythene lined aluminium pouch
P_5- Magnesium silicate @ 1.5% +packing in polythene lined aluminium pouch
P_6- Packing in polythene lined aluminium pouch + vaccum packing
P_7- Magnesium silicate @ 1.5% + packing in polythene bag
P_8- Magnesium silicate @ 1.5% + packing in polythene bag
P_9- Packing in aluminium pouch + Vaccum packing

C_1- White roof type
C_2- Yellow roof type

Table 2. Water activity of shatavari root powder as influenced by packaging materials during storage

Packaging materials	1 MAS			2 MAS			3 MAS		
	Types of roots		Mean P	Types of roots		Mean P	Types of roots		Mean P
	C_1	C_2		C_1	C_2		C_1	C_2	
P_1	0.468	0.431	0.449	0.494	0.481	0.487	0.567	0.561	0.564
P_2	0.467	0.418	0.442	0.492	0.471	0.481	0.566	0.553	0.559
P_3	0.486	0.426	0.456	0.514	0.479	0.496	0.588	0.578	0.583
P_4	0.440	0.424	0.432	0.479	0.460	0.469	0.516	0.502	0.509
P_5	0.438	0.417	0.427	0.474	0.439	0.456	0.507	0.472	0.489
P_6	0.424	0.408	0.416	0.459	0.435	0.447	0.486	0.495	0.490
P_7	0.497	0.487	0.492	0.566	0.539	0.552	0.599	0.599	0.599
P_8	0.501	0.484	0.492	0.562	0.532	0.547	0.604	0.587	0.595
P_9	0.504	0.485	0.494	0.577	0.553	0.565	0.619	0.606	0.612
Mean C	0.469	0.442		0.513	0.487		0.561	0.550	
	C	P	C X P	C	P	C X P	C	P	C X P
S Em±	0.002	0.004	0.006	0.001	0.003	0.004	0.002	0.005	0.006
C.D. @1%	0.008	0.016	0.023	0.006	0.012	NS	0.009	0.018	NS

*MAS- Months After Storage

and 3 MAS, respectively. Wherever moisture content was less, water activity was also less indicating the direct relationship between moisture content and water activity.

Among different packaging materials, P_6 recorded minimum water activity at 1 MAS, 2 MAS and 3 MAS (0.416, 0.447 and 0.490, respectively) and was on par with P_5 (0.427, 0.472 and 0.489, respectively) whereas, maximum water activity was recorded in P_9(0.494, 0.565 and 0.612, respectively). Polyethylene lined aluminium (laminated) pouch had better barrier properties to water vapour compared to aluminium and polypropylene pouch that prevented the absorption of moisture during storage. Hence, the moisture content and water activity of shatavari root powder were less in laminated pouch.

Interactions between the type of roots and packaging materials indicated that, minimum water activity was recorded in C_2P_6 (0.408 and 0.435) and was on par with C_2P_5 (0.417 and 0.439) at 1 MAS and 2 MAS, respectively. At 3 MAS, minimum water activity was recorded in C_2P_5 (0.472) and was on par with C_2P_6 (0.495). The lower moisture content and water activity in the laminated pouch might be due to the barrier properties of the pouch to water and gas transmission. Similar results of low moisture content and water activity in the laminated pouch were reported by Yian and Phing (2020) in mango powder, Khodifad *et al*. (2018) in custard apple powder and Singh and Hathan (2017) in beetroot powder. Chang *et al*. (2019) concluded that anticaking agents prevented moisture adsorption in soursop powder. Pui *et al*. (2020) also demonstrated that calcium phosphate reduced the moisture content and water activity in *Artocarpus integer*.

The data on *L* value of dried shatavari root powder during three months of storage showed a significant difference (Table 3). Initial *L* value of white and yellow shatavari root powder was 72.35 and 70.28, respectively. The *L* value decreased during the three months of storage. Among the type of roots, C_1 (white type) showed maximum *L* value of 71.81, 70.17 and 67.68 whereas, minimum was recorded in yellow type *i.e*., C_2 (69.60, 67.61 and 63.76) at 1 MAS, 2 MAS and 3 MAS, respectively. Maximum lightness in white root might be a genetic character.

Table 3. Lightness (*L* value) of shatavari root powder as influenced by packaging materials during storage

Packaging materials	1 MAS			2 MAS			3 MAS		
	Types of roots		Mean P	Types of roots		Mean P	Types of roots		Mean P
	C_1	C_2		C_1	C_2		C_1	C_2	
P_1	71.01	69.30	70.15	68.95	67.78	68.36	66.69	63.68	65.19
P_2	71.98	69.98	70.98	70.19	68.51	69.35	67.21	64.02	65.61
P_3	71.40	69.40	70.40	69.87	68.05	68.96	66.66	63.65	65.15
P_4	73.39	70.21	71.80	71.76	68.21	69.98	68.72	64.11	66.42
P_5	73.73	70.48	72.10	72.78	68.41	70.59	70.01	65.93	67.97
P_6	74.04	70.62	72.33	73.07	68.89	70.98	71.92	66.44	69.18
P_7	69.68	68.97	69.32	68.18	66.88	67.53	65.70	62.65	64.18
P_8	70.83	69.17	70.00	68.48	67.17	67.82	65.85	63.00	64.42
P_9	70.23	68.29	69.26	68.31	64.62	66.46	66.34	60.35	63.34
Mean C	71.81	69.60		70.17	67.61		67.68	63.76	
	C	P	C X P	C	P	C X P	C	P	C X P
S Em±	0.09	0.20	0.28	0.12	0.26	0.37	0.15	0.32	0.46
C.D.@1%	0.38	0.81	1.15	0.50	1.06	1.49	0.62	1.32	NS

*MAS- Months After Storage

Table 4. Redness (*a** value) of shatavari root powder as influenced by packaging materials during storage

Packaging materials	1 MAS			2 MAS			3 MAS		
	Types of roots		Mean P	Types of roots		Mean P	Types of roots		Mean P
	C_1	C_2		C_1	C_2		C_1	C_2	
P_1	2.27	3.81	3.04	2.91	4.03	3.47	3.23	4.42	3.82
P_2	2.20	3.77	2.98	2.78	3.99	3.38	3.17	4.26	3.71
P_3	2.20	3.88	3.04	2.86	4.09	3.48	3.27	4.18	3.72
P_4	1.99	3.83	2.91	2.40	4.07	3.23	2.76	4.27	3.51
P_5	1.94	3.79	2.86	2.29	4.03	3.16	2.69	4.25	3.47
P_6	1.88	3.57	2.72	2.20	3.79	2.99	2.52	4.11	3.31
P_7	2.40	4.17	3.28	3.07	4.59	3.83	3.39	4.88	4.13
P_8	2.31	4.15	3.23	2.99	4.39	3.69	3.27	4.82	4.04
P_9	2.39	4.19	3.29	3.14	4.46	3.80	3.28	4.93	4.10
Mean C	2.17	3.91		2.74	4.16		3.06	4.45	
	C	P	C X P	C	P	C X P	C	P	C X P
S Em±	0.01	0.03	0.04	0.03	0.05	0.08	0.02	0.03	0.05
C.D. @1%	0.06	0.13	NS	0.11	0.22	0.32	0.07	0.14	0.20

*MAS- Months After Storage

Table 5. Yellowness (*b** value) of shatavari root powder as influenced by packaging materials during storage

Packaging materials	1 MAS			2 MAS			3 MAS		
	Types of roots		Mean P	Types of roots		Mean P	Types of roots		Mean P
	C_1	C_2		C_1	C_2		C_1	C_2	
P_1	16.83	21.80	19.31	16.29	20.70	18.49	15.62	18.69	17.15
P_2	17.06	21.90	19.48	16.79	20.69	18.74	16.04	18.94	17.49
P_3	16.89	21.80	19.34	16.22	20.63	18.42	15.59	18.78	17.18
P_4	17.10	22.24	19.67	16.80	21.81	19.30	16.51	20.71	18.61
P_5	17.17	22.34	19.75	16.88	21.87	19.37	16.51	21.05	18.78
P_6	17.23	22.40	19.82	16.91	22.04	19.48	16.73	21.79	19.26
P_7	16.45	21.46	18.95	16.00	20.23	18.11	15.36	18.18	16.77
P_8	16.70	21.59	19.15	16.38	20.39	18.38	15.50	18.35	16.92
P_9	16.52	21.39	18.95	16.20	20.19	18.19	15.52	17.90	16.71
Mean C	16.88	21.88		16.49	20.95		15.93	19.38	
	C	P	C X P	C	P	C X P	C	P	C X P
S .Em±	0.02	0.04	0.06	0.02	0.05	0.07	0.03	0.07	0.10
C.D. @1%	0.08	0.16	NS	0.09	0.20	0.28	0.14	0.29	0.42

*MAS- Months After Storage

With respect to packaging materials, P_6 showed the highest *L* value (72.33, 70.98 and 69.18) followed by P_5 (72.10, 70.59 and 67.97) and P_2 (70.98, 69.35 and 65.61) at 1 MAS, 2 MAS and 3 MAS, respectively. Whereas, significantly minimum *L* value (69.26, 66.46 and 63.34, respectively) was recorded in P_9. Gas transmission rate of laminated pouch was very less followed by aluminium pouch. This property had prevented the exchange of gas and light which in turn helped to maintain the colour for longer time.

Maximum L value of shatavari root powder (74.04 and 73.07) was recorded in C_1P_6 followed by C_1P_5 (73.73 and 72.78) and C_1P_4 (73.39 and 72.11) at 1 MAS and 2 MAS, respectively whereas, C_2P_9 recorded minimum *L* value (68.29 and 64.62, respectively). At three months of storage non-significant difference was observed.

The results of *a** value showed that, there were significant differences among all the treatments (Table 4). Initial a* value of white and yellow shatavari root was 1.83 and 3.42, respectively. White type recorded the least *a** value (2.17, 2.74 and 3.06) while, yellow type recorded the highest *a** value (3.91, 4.16 and 4.45) at 1 MAS, 2 MAS and 3 MAS, respectively.

With respect to different packaging materials, P_6 recorded the lowest *a** value (2.72, 2.99 and 3.31) followed by P_5 (2.86, 3.16 and 3.47) at 1 MAS, 2 MAS and 3 MAS, respectively while, maximum was recorded by P_9(3.29, 3.80 and 4.10, respectively). Interaction effect of type of roots and packaging materials indicated that, *a** value did not differ significantly at 1 MAS. While significantly lower *a** value was recorded at 3 MAS by C_1P_6 (2.52) followed by C_1P_5 (2.69) whereas, higher *a** value was recorded by C_2P_9 (4.93) at 3 MAS.

The influence of type of roots, packaging materials and their interactions on *b** value of shatavari root powder showed significant variation (Table 5). The initial *b** value of white and yellow shatavari root powder was 17.74 and 22.45, respectively. Among different type of roots, C_2 recorded maximum *b** value (21.88, 20.95 and 19.38) and the minimum was recorded in C1 (16.88, 16.49 and 15.93) at 1 MAS, 2 MAS and 3 MAS, respectively. P_6 recorded maximum *b** value (19.82, 19.48 and

19.26) followed by P_5 (19.75, 19.37 and 18.78), whereas, minimum *b** value was recorded in P_9 (18.95, 18.19 and 16.71) at 1 MAS, 2 MAS and 3 MAS, respectively.

Among the interactions, the highest *b** value was recorded by C_2P_6 (22.40, 22.04 and 21.79) followed by C_2P_5 (22.34, 21.87 and 21.05) whereas, the lowest *b** value was recorded by C_1P_7 (16.45, 16.00 and 15.36) followed by C_1P_9 (16.52, 16.20 and 15.52) at 1 MAS, 2 MAS and 3 MAS, respectively.

The maximum *b** value in the yellow root and the *L* value in the white root might be due to genetic character of both yellow and white root, respectively. Root powder packed in a laminated pouch had shown minimum colour change during storage. This might be due to better barrier properties of the pouch to light, gas and water vapour and even vacuum condition also helped to maintain the colour. Anticaking agent magnesium silicate might have also prevented moisture absorption by shatavari root powder, preventing all chemical reactions and helping to keep the colour during storage. These results are in accordance with Apriyati *et al*. (2022) in ginger and galangal powder, Pui *et al*. (2020) in *Artocarpus integer*, Khodifad *et al*. (2018) in custard apple powder, Singh and Hathan (2017) in beetroot powder. They also observed minimum colour change in laminated packaging material than other types of packaging materials.

Conclusion

For the long period storage of shatavari root powder, a polyethylene lined aluminium (laminated) pouch with vacuum or 1.5 per cent magnesium silicate followed by aluminium pouch with 1.5 per cent magnesium silicate was considered better. These packaging materials helped to maintain lower moisture content and minimum colour change during storage at ambient condition.

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