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PHARMACEUTICAL AND PHYTOCHEMICAL EVALUATION OF SPRAY-DRIED SHATAVARI KSHEERAPAKA GRANULES: AN AYURVEDIC AND MODERN PHARMACEUTICAL APPROACH

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ABSTRACT

Introduction: *Ksheerapaka* is a classical *ayurvedic* formulation prepared using milk as a medium to enhance the therapeutic efficacy and palatability of medicinal drugs. However, its short shelf life and inconvenience in repeated fresh preparation limit its practical utility. Spray-drying technology offers a modern pharmaceutical approach for converting liquid *Ksheerapaka* into a stable, patient-friendly dosage form. The present study aimed to prepare *Shatavari Ksheerapaka* (SK) and develop spray-dried *Shatavari Ksheerapaka* Granules (SKG), followed by their pharmaceutical and phytochemical evaluation. **Materials And Methods:** This study was conducted by preparing *Shatavari Ksheerapaka* according to the reference of *Ksheerapaka* preparation of *Acharya Saranghadhar* and spray dried granules by using spray-drier at Drug Formulation Development Laboratory, NIA, Jaipur. A comparative qualitative phytochemical analysis of Shatavari Ksheerapaka and extract of its spray dried granules was conducted at Drug Testing Laboratory, NIA, Jaipur. **Results:** The prepared SK showed a light yellow colour and a pH of 6.1, whereas SKG exhibited a 6.61% yield, a slight yellowish colour, water solubility, and a pH of 5.65. Phytochemical screening confirmed the presence of cardiac glycosides and steroids in both formulations, with saponins observed prominently in SKG. HPTLC analysis showed comparable chromatographic profiles for SK and SKG at 254 nm and 366 nm,

indicating preservation of major phytoconstituents after spray drying. Quality control parameters revealed low moisture content, satisfactory flow properties, high extractive values, and minimal contamination in the granules. **Conclusion** Spray-dried *Shatavari Ksheerapaka* Granules were successfully developed using modern pharmaceutical technology while preserving the essential phytochemical profile of the classical formulation. The developed granules demonstrated satisfactory physicochemical quality, stability, and patient convenience, suggesting that spray drying is an effective approach for the modernisation of *ayurvedic ksheerapaka* formulations.

KEYWORDS: *Ksheerapaka*, Phyto-constituents, *Shatavari.*

INTRODUCTION

Ayurveda emphasises the preparation of formulations to enhance therapeutic efficacy while minimising unwanted properties of medicinal substances.[1] *Ksheerapaka* is a classical pharmaceutical preparation in which milk is the medium of administration, usually *kashaya rasa pradhan* (astringent) and *tikshna* drugs are selected to bring down *tikshnata* and to mask the *kashayatva* of the drug, with the help of *madhura rasa and madhura vipaak* of milk[2] Inconvenience of preparing the dosage form freshly every time due to the short shelf life.[3] and palatability issues arises the need for a new modified dosage form.[4] *Ksheerapaka* formulations that aid the extraction of both water- and lipid-soluble phytoconstituents,[5] thereby enhancing the bioavailability and nourishing properties of the medicinal drug. Different methods of preparing Ksheerapaka are described in the classics.

Spray drying technology offers a modern solution for converting liquid *ksheerapaka* into a stable, convenient granular or powdered form[6] The spray drying process is considered a conventional method to convert liquids to powders with some but at an acceptable level of degradation and oxidation of volatile compounds. Spray drying is based on the preparation, homogenization, atomization, dispersion and subsequent dehydration of the solution.[7] It works by atomizing the liquid into a fine mist and rapidly evaporating the moisture using a stream of hot gas. The purpose of convenient dosing, shelf-life enhancement and bio-active preservation can be achieved by converting liquid *ksheerapaka* into spray-dried granules.[7] *Shatavari (Asparagus racemosus)* is well-known for its indications in *stanya vardhanartha* (galactogogue), *swarabheda (hoarseness of voice) and rasayana (*rejuvenation)[8]. It is rich in bioactive compounds such as shatavarin, sarsapogenin, beta-sitosterol and asparagamine.[9]

The medicinal values of *Shatavari* can be obtained from *Ksheerapaka* preparation, as indicated for *Mutrakrichhra* in the text of *Sahasrayogam.*[10]

MATERIALS AND METHODS

Drug procurement

The pharmaceutical preparation of *Shatavari Ksheerapaka (SK)* was done in the Formulation Development Laboratory(FDL) of the Department of *Rasashastra and Bhaishajyakalpana*, NIA, Jaipur. *Shatavari mula* was acquired from the *Nagarjuna* Pharmacy of NIA, Jaipur. Whole milk was acquired *fssai* certified company from the local market and water purified with reverse osmosis method was acquired from the FDL.

Preparation of *Shatavari Ksheerapaka (SK)*

The preparation of SK was done as per the *Acharya Sarangadhar*, where drug, milk and water are considered in the ratio of 1:8:32.[11] Initially, 850 g of dried roots were converted into coarse powder. The coarse powder was transferred into a 40-L SS-303 stainless steel vessel, followed by the addition of milk and water. The mixture was heated at a maintained temperature of 80–90°C for 8.5 hours until the preparation of SK was completed. The pharmaceutical preparation of *Shatavari Ksheerapaka* is illustrated in Figure 1, and the illustrative process is shown in Figure 2.

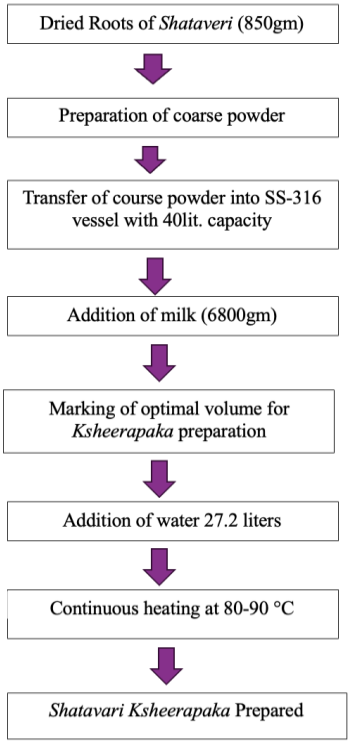


Figure 1: Pharmaceutical preparation of *Shatavari Ksheerapaka.*

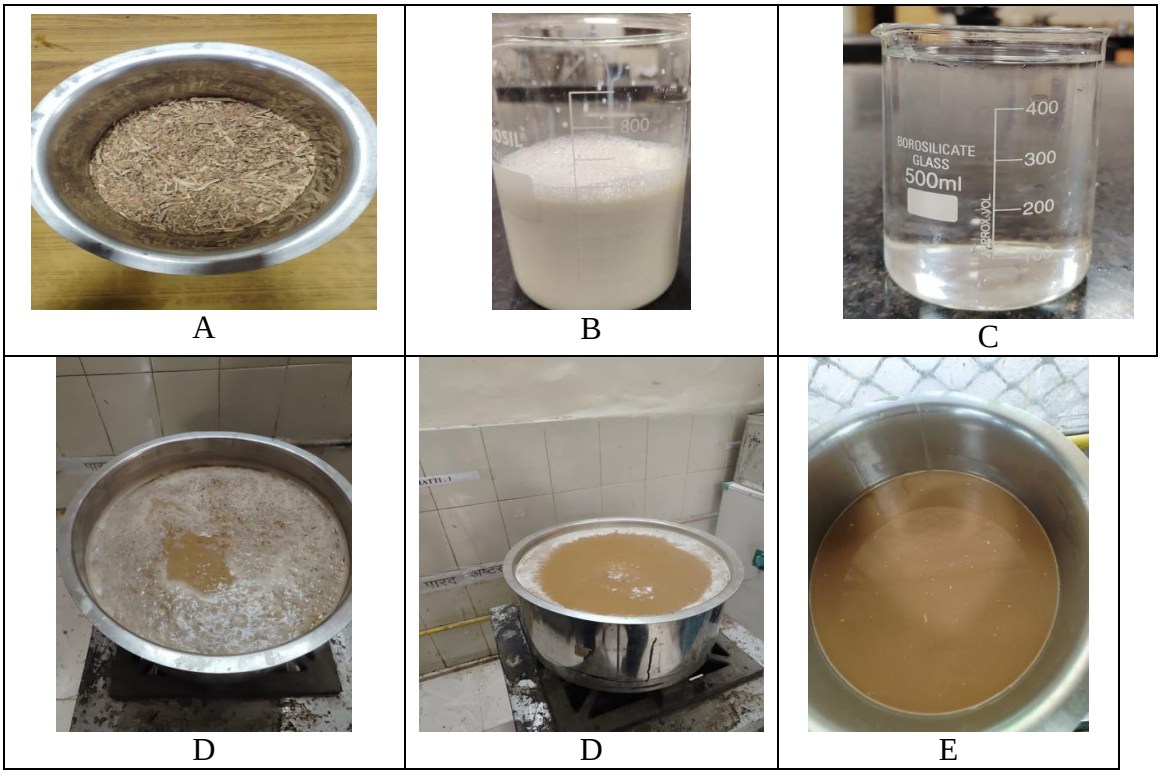


Figure 2: A- *Shatavari* Roots. B- Milk. C- water.

D- Initial stage of boiling. E- After starting of boiling. F- Formation of Ksheerapaka.

Preparation of Spray Dried-*Shatavari Ksheerapaka Granules (SKG)*

The pharmaceutical preparation of Spray-Dried *Shatavari Ksheerapaka* Granules was performed in the Spray Drier Machine, PSP3-D-19/20-24 made by Techno Search Process and System present in DDDL of NIA, Jaipur. 6.5 litres of *SK* were transformed to the granular dosage form by maintaining the controlled unit with input temperature of 215° °C, condenser pressure of 0.5 mm of water, feed rate 47.5 ml per minute, blower speed of 35.05 meter per second and outlet temperature of 100 °C. After four and a half hours, spray-dried *Shatavari* Granules were prepared and stored in an air-tight container. The final product is shown in Figure 3.

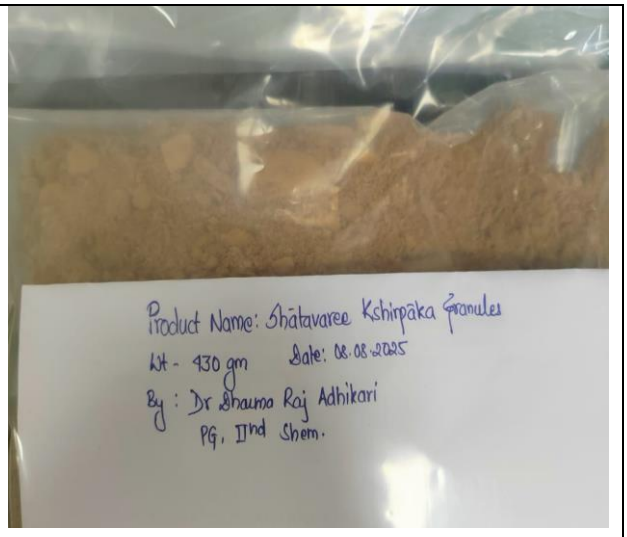


Figure 3: A: Spray-dried machine. **Figure 3: B: Final product.**

Qualitative Phytochemical Analysis of *SK* and its spray-dried SKG

Both the *SK* and its spray-dried SKG were analysed for phytochemicals in the Drug Testing Laboratory, Department of *Rasashastra* and *Bhaishajya Kalpana*, NIA, Jaipur. SK was used directly, whereas the water-soluble extract for SKG was prepared by mixing 5 g of granules with 100 mL of distilled water, followed by frequent shaking for 6 hours and allowing the mixture to stand undisturbed for 18 hours. Fehling's test, Biuret test, Ninhydrin test, Salkowski tests, Keller-Killiani test, Foam tests were conducted to identify the presence of carbohydrate, protein, amino-acids, steroids and saponin respectively. Dragendroff's test and Mayers test were done for test of alkaloids. The treatment with lead acetate solution followed by zinc and concentrated Hcl followed by heating was done for flavonoids. The treatment with lead acetate solution followed by acetic acid was performed for the detection of tannins.

High-Performance Thin Layer Chromatography (HPTLC)

HPTLC analysis was performed to evaluate and compare the phytochemical profile of SK and SKG. The analysis was carried out using a CAMAG HPTLC system equipped with TLC Scanner 4 and visionCATS software in the Department of *Rasashastra and Bhaishajya Kalpana*, NIA Jaipur.

The chromatographic separation was achieved using a mobile phase consisting of formic acid: ethyl acetate: toluene in the ratio of 1:3:6 (v/v/v). The chamber was saturated for 20 minutes before development. The solvent front was allowed to migrate up to 70 mm and the plate was dried at room temperature after development.

The developed plates were scanned densitometrically at 254 nm and 366 nm. Scanning at 254 nm was performed in absorbance mode using Deuterium and Tungsten lamps while fluorescence mode with Mercury lamp was used for scanning at 366 nm.

Quality test of Spray- dried *SKG*:

Loss on drying, bulk density, tap density, Hausrer ratio, extractive values and ash value were studied in DTL to identify the quality of final product.

OBSERVATIONS AND RESULTS

SK

6.5 litres of *SK* was obtained with the light-yellow colour and characteristic odour of milk with the pH of 6.1.

Spray-dried SKG

6.61% of SK was obtained as the final yield of granules, with a slight yellowish colour, a milky odour, a slightly bitter taste, a sticky consistency, water solubility, and a pH of 5.6.

Phytochemical Analysis of SK and its Spray-dried SKG

A brick-red precipitate was observed after heating the mixture of Fehling's A and Fehling's B reagents with the sample in a water bath for about 10 minutes, indicating the presence of carbohydrates in SK.[12]

In the Salkowski test, the chloroform layer turned red while the acid layer showed yellow fluorescence after the addition of concentrated H_2SO_4, confirming the presence of steroids in both samples.[12,13] For cardiac glycosides, the formation of a reddish-brown ring at the junction of the two liquid layers along with a bluish-green upper layer confirmed their presence in the sample extracts.[12]

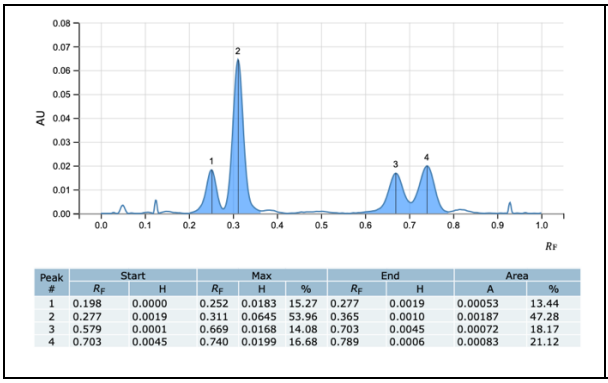
In the saponin test, vigorous shaking of the sample with water produced stable foam in the SKG extract, which persisted for more than 15 minutes, indicating the presence of saponins.[13] Analysis showed the presence of cardiac glycosides and steroids in both products. Reducing sugar was detected in *SK,* and a saponin compound was observed only in Spray-dried SKG. On the other hand, proteins, amino acids, flavonoids and tannin were absent in both products, as shown in Table 1.

Table 1: Qualitative phytochemical analysis of SK and SKG.

Phytochemical	Detection test	Observation and Result	
		SK	SKG
Carbohydrate	Fehling's test	Brick Red Precipitate (+ve)	No change in color (-ve)
Protein	Biuret Test	No change in color (-ve)	No change in color (-ve)
Amino Acid	Ninhydrin test	No change in color (-ve)	No change in color (-ve)
Steroid	Salkowski test	Chloroform layer appear red and acid layer shows yellow florescence. (+ve)	Chloroform layer appear red and acid layer shows yellow florescence (+ve)
Cardiac-Glycosides	Keller- Killiani test	Reddish Brown color appears at the junction of two liquid layers and upper layer appears bluish-green (+ve)	Reddish Brown color appears at the junction of two liquid layers and upper layer appears bluish-green. (+ve)
Saponin	Foam Test	No any changes. (-ve)	Foam formation, persistent more than 15 minutes. (+ve)
Alkaloid	Dragendorff's test	Light yellow color remains persistent (-ve)	Brown color remain persistent (-ve)
	Mayers test	Light yellow color remains persistent (-ve)	Brown color remain persistent (-ve)
Flavonoids	Treated with Lead Acetate Solution and Treated with Zinc and Conc. Hcl followed by heating	No change in color. (-ve)	No change in color. (-ve)
Tannin	Treated with Lead Acetate Solution and Treated with Acetic acid.	No change in color. (-ve)	No change in color. (-ve)

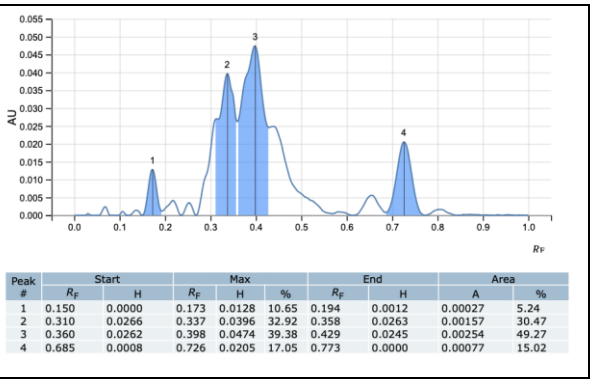
HPTLC analysis

The HPTLC fingerprint profile of SK and SKG revealed the presence of multiple phytochemical constituents at both 254 nm and 366 nm. At 254 nm, SK exhibited two major peaks at Rf 0.319 and 0.400, whereas SKG showed four peaks at Rf 0.158, 0.271, 0.324, and 0.398. Similarly, at 366 nm, SK demonstrated four fluorescent peaks at Rf 0.252, 0.311, 0.669, and 0.740, while SKG exhibited peaks at Rf 0.173, 0.337, 0.398, and 0.726 as shown in Figure 5. The band formation is shown in Figure 6.



Peak #	Start R_F	Start H	Max R_F	Max H	Max %	End R_F	End H	Area A	Area %
1	0.198	0.0000	0.252	0.0183	15.27	0.277	0.0019	0.00053	13.44
2	0.277	0.0019	0.311	0.0645	53.96	0.365	0.0010	0.00187	47.28
3	0.579	0.0001	0.669	0.0168	14.08	0.703	0.0045	0.00072	18.17
4	0.703	0.0045	0.740	0.0199	16.68	0.789	0.0006	0.00083	21.12

Figure 5: A: Peaks and Rf values of SK.



Peak #	Start R_F	Start H	Max R_F	Max H	Max %	End R_F	End H	Area A	Area %
1	0.150	0.0000	0.173	0.0128	10.65	0.194	0.0012	0.00027	5.24
2	0.310	0.0266	0.337	0.0396	32.92	0.358	0.0263	0.00157	30.47
3	0.360	0.0262	0.398	0.0474	39.38	0.429	0.0245	0.00254	49.27
4	0.685	0.0008	0.726	0.0205	17.05	0.773	0.0000	0.00077	15.02

Figure 5: B: Peaks and Rf values of SKG.

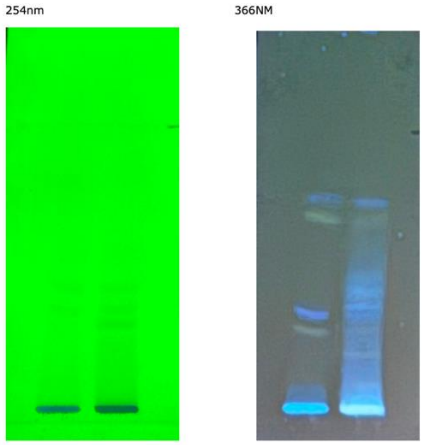


Figure 6: Band formation of SK and SKG.

Quality controlled test of Spray- dried SKG

The result of quality-controlled parameters of granules is shown in Table 2.

Table 2: Quality-controlled parameters of final product.

S/N	Parameters	Result
1	Loss on Drying	2.94%
2	Bulk density	0.45
3	Tap density	0.56
4	Hausrer ratio	1.24
5	Alcohol soluble extractive value	65.52%
6	Water soluble extractive value	89.12%
7.	Total ash value	5.47%
8.	Acid insoluble ash	0.006%
9.	pH	5.65

DISCUSSION

In the present study, *SK* was prepared according to classical principles and further converted into spray-dried granules using modern pharmaceutical technology. In day-to-day

pharmaceutical practice, *Shatavari* granules were prepared as *Khandakalpa* by using a sugar compound which alters the nutritive and therapeutic significance of Shatavari. In order to overcome this, the spray-dried granule was considered to be prepared through the method of *ksheerapaka.*

The preparation of *SK* using the classical ratio of drug, milk and water (1:8:32) facilitated efficient extraction of both water-soluble and lipid-soluble phytoconstituents. Milk acts not only as a nourishing medium but also as a bioavailability enhancer due to its lipid content. Continuous heating at controlled temperature (80–90°C) for 8.5 hours ensured proper *paka* formation without charring or degradation of active constituents. The final *SK* obtained showed a light yellow colour and a characteristic milky odour, which indicates proper extraction and homogenization of herbal and milk components.

The pH of *SK* was found to be 6.1, indicating a near-neutral and mildly acidic nature. Such pH may contribute to better gastrointestinal compatibility and stability of the formulation. Spray drying technology was successfully employed to convert the liquid *Ksheerapaka* into a granular dosage form. The obtained yield of 6.61% indicates effective moisture removal and concentration of solid constituents. The slight bitterness may be attributed to the concentration of phytoconstituents after dehydration. Sticky consistency observed in granules may be due to the presence of natural sugars and milk solids. The pH of spray-dried granules was observed to be 5.65, slightly lower than the original *SK*. This variation may be due to the concentration of acidic phytoconstituents and changes occurring during thermal drying. However, the pH remained within an acceptable range for oral administration.[14]

Phytochemical screening revealed the presence of cardiac glycosides, steroids in both formulations, suggesting that the pharmaceutical processing and spray-drying procedure did not significantly affect important phytoconstituents. Interestingly, saponins were more prominently detected in spray-dried granules. *Shatavari* is known to contain steroidal saponins such as shatavarins, which are considered major bioactive compounds responsible for its *rasayana* and *stanyajanana* properties. The concentration of these compounds after drying may explain their enhanced detection in the granules. The absence of proteins, amino acids and tannins in both formulations may be due to their lower concentration or possible degradation during prolonged heating. Reducing sugars detected in SK may have originated from milk components and herbal constituents.

The similarity in HPTLC fingerprint patterns confirms that the pharmaceutical processing involved in granule preparation did not significantly alter the chemical identity of the formulation. Densitometric scanning at 254 nm revealed a high degree of structural preservation of UV-absorbing constituents during the transition from liquid to granular structure. In the SK, two major prominent peaks were resolved at R_F 0.319 and 0.400. A matching chemical profile was consistently observed in the SKG with major peaks eluting at nearly identical retention factors (R_F 0.324 and 0.398). This strong spatial correlation indicates that the core bioactive matrix of *Shatavari* remains robustly intact despite the physical processing, drying and granulation phases. Interestingly, scanning at 254 nm also resolved an additional distinct peak at R_F 0.271 in the SKG which was not integrated as an independent peak in the liquid counterpart.

Under fluorescent scanning at 366 nm, a corresponding shift in dominant peak area was observed; the major fluorescent marker shifted from R_F 0.311 in the ksheerapaka to R_F 0.398 in the SKG., These minor variations and changes in peak area percentages are highly likely to reflect matrix modification which may be due to thermal processing, concentration of bioactive constituents and changes occurring during dehydration.

Spray drying effectively transformed the liquid formulation into stable granules with good water solubility and convenient handling properties. The low loss on drying value suggested minimal moisture content, which may enhance the stability and shelf-life of the formulation.

Bulk density and tap density suggested satisfactory packing and flow properties of the granules. The Hausner ratio indicated satisfactory flow properties of the granules[15], while high water and alcohol soluble extractive values revealed the presence of a considerable amount of active phytoconstituents soluble in both polar and semi-polar media. A very low acid-insoluble ash value suggested minimal contamination and good purity of the final product.

CONCLUSION

The present study successfully demonstrated the preparation of SK according to classical *Ayurvedic* principles and its conversion into spray-dried granules using modern pharmaceutical technology. Controlled heating, optimal duration and organoleptic monitoring are the key process parameters in *Ksheerapaka* preparation. The prepared Ksheerapaka

showed acceptable organoleptic characteristics and a suitable pH, indicating proper pharmaceutical processing.

Spray drying effectively transformed the liquid formulation into a stable and convenient granular dosage form with satisfactory physicochemical parameters, including low moisture content, good flow properties and high extractive values, suggesting better stability and quality of the final product.

Phytochemical evaluation confirmed the presence of important bioactive constituents in both formulations, while HPTLC fingerprinting revealed comparable chromatographic profiles of SK and its spray-dried SKG. This indicates that the spray-drying process did not significantly alter the formulation's major phytoconstituents, thereby successfully validating the modernization of *Shatavari Ksheerapaka* into a consumer-friendly granule.

Consequently, spray drying can be considered an effective pharmaceutical approach for developing a stable, manageable, and patient-friendly dosage form of *Shatavari Ksheerapaka*. This modernized format improves convenience, handling, and potential shelf-life while completely preserving the phytochemical integrity and therapeutic value of the traditional preparation.

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