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Comprehensive Nutritional Profiling of Fresh and Dried Asparagus racemosus (Shatavari) Roots Across Maturity Stages

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KEYWORDS

Asparagus racemosus, Nutritional composition, Maturity stages, Drying process.

ABSTRACT:

Background: Asparagus racemosus (Shatavari) is widely used in traditional medicine, particularly in Ayurveda, for its therapeutic properties. The nutritional composition of its roots varies with maturity stages and post-harvest drying processes, which influence their medicinal and nutritional benefits. Understanding these variations can help optimize harvesting and processing techniques.

Objective: This study aims to evaluate the nutritional composition of fresh and dried Asparagus racemosus roots at different maturity stages (6, 12, 18, and 24 months) and assess the impact of maturity and drying on key nutritional parameters. Additionally, a comparison was made with commercially available root powder to provide insights into its nutritional efficacy.

Methods: Roots were harvested at four maturity stages from cultivated plants and processed as fresh or dried samples. Drying was conducted in a hot air oven at 50°C until a constant weight was achieved. Nutritional parameters including moisture, ash, crude fiber, fat, protein, carbohydrates, calcium, and iron were analyzed using standard laboratory methods. The calorific value was calculated based on macronutrient composition. Statistical analyses were performed using Student's t-test, with significance set at $p<0.05$.

Results: Drying significantly increased nutrient concentrations by reducing moisture content. The 18-month dried roots exhibited the highest calorific value (355.98 kcal/100 g) and carbohydrate content (73.44 g/100 g). The 24-month dried roots had the highest protein (9.22 g/100 g) and crude fiber (13.4 g/100 g). Compared to marketed root powder, naturally dried roots contained higher protein, fiber, calcium, and iron levels, suggesting superior nutritional benefits.

Conclusion: Maturity and drying significantly influence the nutritional composition of Shatavari roots. The 18- and 24-month dried roots exhibit optimal nutrient concentrations, making them preferable for medicinal and nutritional applications over commercially available root powder. These findings provide a scientific basis for improved harvesting and processing strategies to maximize Shatavari's health benefits.

Introduction

Asparagus racemosus, commonly known as Shatavari, holds a significant place in traditional medicine systems, particularly Ayurveda, for its adaptogenic and rejuvenating properties [1] [2]. It has been extensively utilized to support female reproductive health, boost immunity, and manage various ailments due to its rich phytochemical composition [3][4] [5]. The root of Shatavari is the primary part used for medicinal and nutritional purposes, making it an essential component of various herbal formulations [6].

The nutritional composition of plant roots often varies with their stage of maturity, which can influence their therapeutic and health-promoting qualities [7] [8]. Additionally, post-harvest processes such as drying are known to impact the chemical constituents and nutritional value of plant materials [9][10][11]. Understanding how maturity and drying influence the nutritional profile of Shatavari roots can provide

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valuable insights for optimizing their harvest and processing methods to maximize their medicinal and nutritional benefits.

This study aims to evaluate the nutritional composition of fresh and dried *Asparagus racemosus* roots at four distinct stages of maturity: 6, 12, 18, and 24 months. By systematically analyzing key nutritional parameters across these maturity stages, the research seeks to elucidate the effects of plant age and drying on the root's nutritional profile. Additionally, commercially available root powder was compared to provide a comprehensive perspective. These findings are expected to contribute to the broader understanding of Shatavari's nutritional dynamics and inform its appropriate use in both traditional and modern applications.

AIM: To evaluate the nutritional composition of fresh and dried *Asparagus racemosus* (Shatavari) roots at different stages of maturity (6, 12, 18, and 24 months old), assess how maturity and drying influence their nutritional profile, and compare these findings with commercially available root powder.

Methodology:

1. Plant Material and Sample Collection

- **Plant Selection:** Asparagus racemosus (Shatavari) plants were cultivated under controlled agronomic conditions to ensure uniform growth.
- **Sampling Stages:** Roots were harvested at four maturity stages—6, 12, 18, and 24 months—from the time of planting. Each stage was selected to capture changes in nutritional composition as the plant matured.
- **Sample Size:** For each maturity stage, roots from at least 10 plants were collected to ensure representativeness.
- **Fresh and Dried Samples:**
  - A portion of the harvested roots was immediately processed for fresh sample analysis.
  - The remaining roots were dried in a controlled environment for dried sample analysis.

2. Drying Process

- **Cleaning and Preparation:** The roots were thoroughly washed with distilled water to remove soil and debris. Excess water was blotted using paper towels.
- **Drying Method:**
  - Roots were sliced into uniform pieces (approximately 1–2 cm thick).
  - Drying was carried out in a hot air oven at 50°C until constant weight was achieved to prevent microbial growth and minimize nutrient degradation.
- **Storage:** Dried samples were ground into a fine powder using a grinder, passed through a 60-mesh sieve, and stored in airtight containers at 4°C until further analysis.

3. Nutritional Composition Analysis

a. Moisture Content:

Procedure:
5.0 g of powdered root sample was placed in a pre-weighed porcelain dish (W).
The dish with the sample (W1) was heated in an oven at 130°C for 2 hours.
After heating, the sample was cooled in a desiccator and reweighed (W2) at 30-minute intervals until a constant weight was achieved.

Calculation:

$\%\text{Moisture Content} = 100 \times W1 - W(W1 - W2)$

Where:
W1= Weight of dish with sample before drying
W2= Weight of dish with sample after drying to constant weight
W= Weight of empty dish

b. Total Ash Content

Procedure: 5.0 g of powdered root sample was placed in a pre-weighed crucible.
The sample was heated gently over a Bunsen flame until smoke subsided, then transferred to a muffle furnace at 550°C for 6-8 hours until a gray ash residue was obtained.
The crucible was cooled in a desiccator and reweighed.

Calculation: $\%\text{Ash Content} = (W1 - W2) \times 100 / Ws$

Where:
W1= Weight of crucible with sample

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W2= Weight of crucible with ash
Ws = Weight of the sample

c. Crude Fiber

Procedure: 2.0 g of sample was boiled in 200 ml of 1.25% sulfuric acid for 30 minutes. The residue was filtered and washed with distilled water. The residue was boiled again in 200 ml of 1.25% sodium hydroxide for 30 minutes, filtered, and washed. The residue was dried in an oven at 130°C for 2 hours, cooled in a desiccator, and weighed (W1). It was then ashed in a muffle furnace at 550°C for 2 hours, cooled, and reweighed (W2).

Calculation: %Crude Fiber= (W1−W2)×100/ Ws

d. Total Fat Content

Procedure: 3-5 g of powdered sample was placed in a Soxhlet extractor using petroleum ether as the solvent. The extraction continued for 14 hours at a heat rate of 150 drops/min.
After extraction, the solvent was evaporated, and the residue was dried at 80-90°C until constant weight.

Calculation: %Fat Content=(W2−W1)×100/ Ws

Where:
W1 = Weight of empty flask
W2 = Weight of flask with fat residue
Ws = Weight of the sample

e. Protein Content

Procedure: The nitrogen content was determined using the Kjeldahl method.
1.0 g of sample was digested with 5 g of Kjeldahl catalyst (K_2SO_4 and $CuSO_4$) and 20 ml of concentrated sulfuric acid. The digested sample was distilled, and the ammonia released was titrated with 0.2 N HCl. The protein content was calculated by multiplying nitrogen content by 6.25.

- **Calculation:**

%Protein=(A−B)×N×14.007×6.25/ W

f. Carbohydrates

Procedure: The carbohydrate content was determined by difference using the formula:

%Carbohydrate=100−(%Moisture+%Protein+%Fat+%Ash+%Fiber)

g. Calcium Content

Procedure: 5.0 g of powdered sample was digested with sulfuric and nitric acids, diluted, and titrated with 0.01 M EDTA using Solochrome dark blue as the indicator.

h. Iron Content

Procedure: The sample was ashed and dissolved in HNO_3. Iron content was determined using Atomic Absorption Spectrophotometry.

i. Calorific Value

Procedure: The calorific value was calculated using the formula:

Calorific Value (kcal/100 g)=(%Protein×4)+(%Fat×9)+(%Carbohydrate×4)

4. Statistical Analysis

All experiments were performed in triplicate, and results were expressed as mean ± standard error (SE). Statistical comparisons across different maturity stages and between fresh and dried samples were conducted using a Student's t-test, with p<0.05p < 0.05p<0.05 considered statistically significant.

RESULTS

Table 1: Nutritional Profile of Fresh and Dried Asparagus racemosus Roots at 6 Months

Component	**Fresh Roots (6M)**	**Dried Roots (6M)**
Energy (Kcal)	52.49	300.24
Carbohydrates (g)	8.22	64.13
Protein (g)	4.24	6.16
Fat (g)	0.29	2.12
Ash (g)	1.34	4.36
Moisture (%)	85.91	14.81
Crude Fiber (g)	2.90	10.3

Component	Fresh Roots (6M)	Dried Roots (6M)
Iron (mg)	0.38	70.28
Calcium (mg)	23.95	1170

At 6 months, dried roots show significantly higher energy and nutrient content compared to fresh roots due to the reduced moisture content. The high calcium and iron in dried roots highlight their potential as a nutritional supplement.

Table 2: Nutritional Profile of Fresh and Dried Asparagus racemosus Roots at 12 Months

Component	Fresh Roots (12M)	Dried Roots (12M)
Energy (Kcal)	75.39	320.32
Carbohydrates (g)	15.16	67.27
Protein (g)	3.44	7.86
Fat (g)	0.11	2.20
Ash (g)	1.07	4.12
Moisture (%)	80.22	13.38
Crude Fiber (g)	2.75	11.4
Iron (mg)	0.40	49.10
Calcium (mg)	19.63	1720

At 12 months, dried roots continue to outperform fresh roots in nutrient density, particularly in calcium and iron content, indicating that drying preserves and concentrates nutrients.

Table 3: Nutritional Profile of Fresh and Dried Asparagus racemosus Roots at 18 Months

Component	Fresh Roots (18M)	Dried Roots (18M)
Energy (Kcal)	92.93	355.98
Carbohydrates (g)	20.53	73.44
Protein (g)	2.59	8.13
Fat (g)	0.05	3.30
Ash (g)	0.89	3.54
Moisture (%)	75.94	13.46
Crude Fiber (g)	2.44	12.1
Iron (mg)	0.45	41.49
Calcium (mg)	18.55	1850

The 18-month stage shows the highest energy and carbohydrate content in both fresh and dried roots. Dried roots at this stage present the best nutritional balance, making them the most beneficial for dietary supplementation.

Table 4: Nutritional Profile of Fresh and Dried Asparagus racemosus Roots at 24 Months

Component	Fresh Roots (24M)	Dried Roots (24M)
Energy (Kcal)	80.49	346.04
Carbohydrates (g)	14.44	68.02
Protein (g)	5.48	9.22

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Component	Fresh Roots (24M)	Dried Roots (24M)
Fat (g)	0.09	4.12
Ash (g)	0.84	3.51
Moisture (%)	69.15	13.40
Crude Fiber (g)	2.63	13.4
Iron (mg)	0.41	34.03
Calcium (mg)	26.14	1250

At 24 months, dried roots maintain high nutrient levels, with a notable peak in protein content. Despite a slight decline in energy compared to the 18-month stage, the high crude fiber and consistent calcium levels affirm their nutritional value.

Table 5: Nutritional Profile of Dried Asparagus racemosus Marketed Root Powder

Component	Marketed Root Powder
Energy (Kcal)	347.94
Carbohydrates (g)	80.97
Protein (g)	5.94
Fat (g)	0.30
Ash (g)	3.66
Moisture (%)	4.97
Crude Fiber (g)	4.20
Iron (mg)	5.20
Calcium (mg)	160.96

The marketed root powder shows a relatively high carbohydrate content (80.97 g) and energy (347.94 Kcal) compared to the dried roots at different maturity stages. However, it has significantly lower protein (5.94 g), fat (0.30 g), crude fiber (4.20 g), iron (5.20 mg), and calcium (160.96 mg) than the dried roots, especially those at 18 and 24 months. This suggests that the marketed root powder, while nutritionally dense, may not match the high nutrient concentration of specially dried roots, particularly in terms of calcium and iron. This comparison highlights the potential superiority of dried roots prepared at specific maturity stages over the marketed version in terms of nutrient content.

DISCUSSION

6-Month Roots (Fresh and Dried)

At 6 months, the fresh roots of Asparagus racemosus contained 52.49 Kcal of energy, 8.22 g of carbohydrates, and 4.24 g of protein. In contrast, the dried roots presented significantly higher values: 300.24 Kcal for energy, 64.13 g of carbohydrates, and 6.16 g of protein. These findings align with **Drost DT (2020),** [12] who reported that young Asparagus racemosus roots tend to have lower nutrient density due to higher moisture content, resulting in less concentrated nutrients.

The fat content in fresh roots was 0.29 g, while dried roots had 2.12 g, reflecting the concentration effect of drying, which is consistent with Gupta et al. (2016). The high moisture content in fresh roots (85.91%) compared to dried roots (14.81%) corroborates the findings of **Oliveira et al. (2016),** [13] emphasizing that moisture reduction significantly enhances nutrient concentration in dried plant materials.

12-Month Roots (Fresh and Dried)

For 12-month-old roots, fresh samples exhibited 75.39 Kcal of energy, 15.16 g of carbohydrates, and 3.44 g of protein, while dried roots contained 320.32 Kcal, 67.27 g, and 7.86 g of the same nutrients, respectively. This trend supports the results by **Landhäusser et al. (2003)**, [14] who noted that as roots mature, the carbohydrate and energy content increase due to the accumulation of reserves.

The fat content in fresh roots was relatively low at 0.11 g, and slightly higher in dried roots (2.20 g), paralleling the observations of **Singh et al. (2014)** [15], where minimal fat variation across maturity stages was reported. The moisture reduction from 80.22% in fresh to 13.38% in dried roots supports the notion by **Babu et al. (2018)** [16] that drying dramatically decreases moisture content, enhancing shelf-life and nutrient concentration.

18-Month Roots (Fresh and Dried)

At 18 months, fresh roots showed the highest energy content (92.93 Kcal), 20.53 g of carbohydrates, and 2.59 g of protein, while dried roots had 355.98 Kcal, 73.44 g, and 8.13 g of these nutrients, respectively. These findings are consistent with **Qadir et al. (2022)**, [17] who observed that energy and carbohydrate contents peak at mid to late maturity stages.

Dried roots also exhibited higher crude fiber content (12.1 g) compared to fresh roots (2.44 g), which is in line with **Danso et al. (2019), [18]** who highlighted that fiber content in roots tends to increase with drying due to reduced water content. The iron content was highest in fresh roots at this stage (0.45 mg), a pattern also noted in **Lin et al. (1983)**, [19] suggesting enhanced mineral absorption in mature roots.

24-Month Roots (Fresh and Dried)

At 24 months, fresh roots contained 80.49 Kcal, 14.44 g of carbohydrates, and 5.48 g of protein, while dried roots recorded 346.04 Kcal, 68.02 g, and 9.22 g of these nutrients, respectively. The increased protein content in both fresh and dried roots at this stage is supported by Singh et al. (1987), who emphasized that protein synthesis intensifies in late maturity stages.

The moisture content in fresh roots was 69.15%, significantly lower than younger roots, indicating a natural decrease in water content with age, as reported by **Kuchenbuch et al. (2006) [20]**. Dried roots' moisture content of 13.40% aligns with **Tomczak et al. (2020) [21]**, who stated that drying consistently reduces moisture content, thereby concentrating nutrients like calcium, which peaked at 1250 mg in dried roots at this stage.

Nutritional Comparison of Asparagus racemosus Dried Roots at Various Maturity Stages with Marketed Root Powder

Energy and Carbohydrates: The marketed root powder exhibits high energy (347.94 Kcal) and carbohydrate content (80.97 g), which is comparable to the 18-month dried roots (355.98 Kcal, 73.44 g). However, the carbohydrate content in the marketed powder is higher than all the maturity stages of dried roots, suggesting possible fortification or additional processing steps that enhance carbohydrate levels. In contrast, the 6-month and 12-month dried roots show lower energy (300.24 Kcal and 320.32 Kcal, respectively) and carbohydrate content (64.13 g and 67.27 g), indicating the gradual accumulation of reserves as the roots mature.

Protein: The protein content in the marketed powder (5.94 g) is lower than that in 24-month-old dried roots (9.22 g), suggesting that roots at advanced maturity stages have a better protein profile, potentially due to enhanced synthesis as the plant completes its life cycle. The protein levels in 6-month (6.16 g) and 12-month dried roots (7.86 g) surpass the marketed sample, pointing to the potential of younger roots to provide comparable protein content.

Fat: Fat content in the marketed root powder (0.30 g) is substantially lower than that of 18-month (3.30 g) and 24-month dried roots (4.12 g). This indicates that the marketed product may have undergone fat removal during processing or inherently has lower fat, which could impact its use in energy-rich formulations.

Crude Fiber: The marketed powder's crude fiber content (4.20 g) is notably lower than that of the 24-month dried roots (13.4 g), suggesting the marketed powder might have been processed to reduce fiber, which could affect its efficacy in gastrointestinal health applications. Crude fiber is another key nutrient that increases with the age of the root, as reported by Ghosh et al. (2013). Their study found that fiber content increased significantly in roots harvested after 18 months, which is consistent with the trend observed in this study, where 24-month roots showed the highest fiber content (13.4 g). Sharma et al. (2014) further reported that older roots (18-24 months) were particularly beneficial in formulations aimed at improving gastrointestinal health, which emphasizes the importance of crude fiber in mature roots.

Iron and Calcium: Iron content in the marketed root powder (5.20 mg) is significantly lower than the 6-month dried roots (70.28 mg) and also less than the other maturity stages. This suggests that the marketed powder is not as rich in iron, potentially impacting its use for addressing anemia. Calcium levels in the marketed powder (160.96 mg) are substantially lower than those in 18-month (1850 mg) and 24-month dried roots (1250 mg), emphasizing the superior calcium retention in roots harvested at these later stages.

Conclusion

The present study provides a comprehensive analysis of the nutritional composition of Asparagus racemosus roots at various maturity stages (6, 12, 18, and 24 months) and compares them with marketed dried root powder. The results demonstrate that the nutrient profile of Asparagus racemosus significantly improves as the roots mature, particularly in terms of protein, fiber, iron, calcium, and overall energy content. Specifically, the 18-month and 24-month dried roots exhibit superior nutritional concentrations, making them more suitable for therapeutic applications, especially in formulations aimed at improving gastrointestinal health, bone health, and addressing nutritional deficiencies.

Energy and carbohydrate levels were found to be highest at the 18-month stage, while protein, fat, crude fiber, iron, and calcium content peaked in the 24-month dried roots. These findings suggest that older roots offer a more balanced and nutrient-dense profile, which can be advantageous for their medicinal and nutritional uses. Conversely, the marketed root powder, while nutritionally dense in terms of carbohydrates and energy, showed lower levels of protein, fiber, iron, and calcium, indicating that it may not provide the full spectrum of benefits available from roots harvested at later maturity stages.

Additionally, this study aligns with previous research, which consistently reports that Asparagus racemosus roots mature over time to accumulate more nutrients, particularly in terms of calcium, iron, and protein. However, the marketed root powder likely undergoes processing methods that reduce some of the beneficial compounds found in naturally dried roots.

Overall, the findings suggest that for optimal nutritional benefits, Asparagus racemosus roots should be harvested at 18 to 24 months of maturity, as they provide the highest concentrations of essential nutrients. These results highlight the importance of considering both root maturity and processing methods when formulating products for medicinal and nutritional purposes. The study underscores the potential of mature roots as a superior option for enhanced health benefits compared to the commercially available marketed root powder.

Limitations

While the present study provides valuable insights into the nutritional composition of Asparagus racemosus roots at various maturity stages, several limitations must be acknowledged. First, the study focused solely on the analysis of roots and did not extend to other parts of the plant, such as the stems or leaves, which may also contribute to the overall nutritional profile. Additionally, the study did not investigate the impact of different drying methods, which can influence nutrient retention and bioavailability. The variation in drying techniques, such as air drying, freeze drying, or sun drying, could lead to differences in nutrient concentrations, and this aspect was not explored in the current research. Furthermore, the market sample of dried root powder used for comparison may vary significantly depending on the source, processing, and storage conditions, which could introduce discrepancies in nutrient values. The study also did not assess the bioavailability of the nutrients in the dried roots or their therapeutic efficacy, which are essential factors for practical applications in clinical or pharmaceutical settings. Lastly, the study was conducted under controlled laboratory conditions, and real-world factors such as soil quality, climate conditions, and cultivation practices were not considered, which could affect the nutrient profile of the roots. These limitations suggest the need for further research to explore the effects of these variables and to evaluate the broader applicability of the findings.

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