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Optimization of process of sprouting for moth beans (*Vigna acontifolia* L.)

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Abstract
An affordable source of protein meal must be identified in order to prevent protein deficiency in emerging nations. The moth bean (*Vigna aconitifolia* L.), one of the key members of the Fabaceae family, ensures an outstanding nutritional content. Moth bean seeds are a rich source of protein in addition to carbohydrates, fatty acids, minerals and vitamins. For millennia, people have utilized sprouting, a traditional processing technique, to increase the nutritious content of cereals and legumes. Five levels of soaking time (2 h, 4 h, 6 h, 8 h and 10 h) and number of rinsings at interval of 6 hours, were used in the experiment to optimize both. At room temperature (28 °C), the desired sprouting was attained, with optimal responses such as 99.5% sprouting, 13.11 mm sprout length and 83.9% wb moisture content, when samples were soaked for 6 h followed by 4 gentle rinsings in water, each at 6 h of interval.

Keywords: Moth beans, sprouts, rinsing

Introduction

Moth beans (*Vigna aconitifolia)*, are a type of pulse crop that can withstand dryness and are cultivated in arid and semi-arid regions of India. Due to their high protein content, boiled or sprouted green pods and grains constitute a largely consumable portion of the plant (Sedani *et al*., 2021) [20]. Other names for this extremely durable legume are mat bean, matki, Turkish gram and dew bean.

Rajasthan is the leading moth bean-growing state in India, accounting for over 86% of the total land area (NAS 1979). India is the biggest producer and customer of moth beans and pulses worldwide. About 22-25% of the world's pulse production comes from it. Moth beans are easy to grow. Rajasthan produces 0.22 million tons of moth beans, or around 85% of all moth bean farming. The expected range for the average seed output is 70-270 kg/ ha. However, it can produce up to 2600 kg/ ha. (Bhadkaria *et al*., 2022) [2].

India is a major producer of legumes, accounting for 19% of global production and 29% of the world's land area. Because of their high protein content, dietary fiber, low fat content and numerous micronutrients, legumes are considered to be nutritionally significant (Panicker *et al*., 2023) [14].

The moth bean is a drought-resistant legume that grows in hot, arid to semiarid climates. Although the plant can handle daytime temperatures of 45 °C and cannot withstand water logging, it needs a temperature between 24 °C and 32 °C for optimal production. A broad pH range (3, 5-10) and a certain amount of salinity are accepted.

Moth bean seeds are roughly composed of proteins, carbohydrates, lipids, fats, ash and moisture (Bhadkaria *et al*., 2022) [2]. The moth bean is an underutilized legume that is mostly grown in dryland agriculture in the tropics and subtropics. Its chemical makeup is similar to that of frequently grown legumes. This legume lacks tryptophan and methionine, just like other legumes (Pawar *et al*., 1988) [18]. Grain legumes' nutritional value is mostly determined by their nutrients and whether or not they include harmful or antinutrient elements (Ramakrishna *et al*., 2006) [19]. Soaking, germination and heating are a few easy and affordable processing methods that are very effective at lowering antinutritional factors and enhancing the organoleptic quality of the product (Abusing *et al*., 2009) [1].

Table 1: Nutritional composition raw and germinated moth bean

Nutrient content	Mean value		
	Raw Moth bean	**Soaked Moth bean**	**Germinated Moth bean**
Moisture (%)	8.4±2.0	10.02±2.0	10.6±1.2
Fat (%)	1.13±0.5	1.21±0.5	1.09±0.03
Carbohydrate (%)	60.23±0.5	58.76±0.5	56.05±0.20
Protein (%)	21.3±1.43	21.09±1.3	23.82±0.45
Ash (%)	3.4±1	3.2±1	3.2±0.15
Vit C (mg/100g)	3.7±0.2	7.4±0.2	12.3±1.2

(Source: Deshmukh *et al*., 2020) [5]

Cereal germination has been used for centuries to soften kernel structure, enhance nutrient content and availability, reduce antinutritive chemical content and add novel flavours, all without understanding the biochemistry behind these processes. (Norja *et al*., 2004) [13].
Germination, a complicated process in which grains undergo physical, chemical and structural changes, has been found as a low-cost and effective solution for increasing cereal quality. Germination is defined by the growth of the grain embryo, as revealed by rootlet growth and increased alteration of endosperm contents (Deshmukh *et al*., 2020) [5].
Germination is a sustainable method that may be effectively implemented at the household level to improve the nutritional value of beans. Legumes can be germinated before consumption as a nutritional intervention to increase the amount, digestibility and body availability of protein. According to the current study, extending the germination durations is advised for improved germination process results. To tackle malnutrition, it is necessary to raise awareness of household germination and encourage the use of highly nutritious legumes at cost-effective prices. (Devi *et al*., 2015) [6].
Soaking, draining, and then rinsing seeds at regular intervals until they germinate, or sprout, is known as sprouting (Pardeshi and Tayde, 2013) [16]. Because many enzyme inhibitors are efficiently neutralized during the germination and sprouting of grains and seeds, sprouting of grains addresses the anti-nutritional factors and also eliminates the need of additives and chemicals to produce better nutrient content (Ledaskar *et al*., 2018) [9].
Therefore, before being consumed, the pulse seeds need to be further processed to improve their dietary components and decrease their anti-nutritional components, such as phytic acid and trypsin inhibitor. According to studies, sprouting is a powerful method for removing of anti-nutrient factors and for catalyzing secondary metabolites such a-galactosides and phytates. (Medhe *et al*., 2019) [11].
The moth bean plant's seeds and sprouts are an advantageous supplement to diets based on cereals because they are high in protein and other nutrients. However, little is known about how sprouting alters biochemical profiles and antioxidant qualities. (Kestwal *et al*., 2012) [8].
During the soaking process, water imbibition is crucial for sprouting. There are three main steps to the water uptake process. Studying the hydration rate is essential to understanding the effective moth bean sprouting process since the first phase involves the imbibition of water during soaking, followed by the activation of enzymes and the development phase. A short soaking period will prevent enough water imbibition, which may either delay the sprouting process or fail to activate the hydrolytic enzymes needed for additional sprout growth. In view of this, the soaking period must be optimized for the highest possible rate of sprouting (Dattatray *et al*., 2019) [4].
Present study aimed to study the effect of three different (2 h, 4 h, 6 h, 8 h and 10 h) soaking time on the hydration rate and sprouting rate of moth bean.

Materials and Methods Selection of Materials
Collection of raw material
The selected moth bean variety is a local variety from Maharashtra's Raigad district. It is the most common moth bean cultivar. The local variety of moth bean, known as the '*Sudhagad* variety', is found and grown in *Pali, Sudhagad, Nandgaon* and other villages in Raigad districts to optimize sprouting technology.

Fig 1: Moth bean (*Sudhagad* variety)

Preparation of sprouted Moth beans
To optimize soaking times and number of rinses, the experiment was conducted using 5 levels of soaking time (2 h, 4 h, 6 h, 8 h and 10 h) and four rinsing intervals (6 h, 12 h, 18 h and 24 h) for each sample until desired sprouting was reached. Rinsing refers to the process of cleaning sprouted grains with running water or spraying (Tayde and Pardeshi, 2013) [16]. The observations were recorded based on responses such as sprouting percentage (%), sprout length (mm) and moisture content (% wb).

Soaking and Germination of Grains

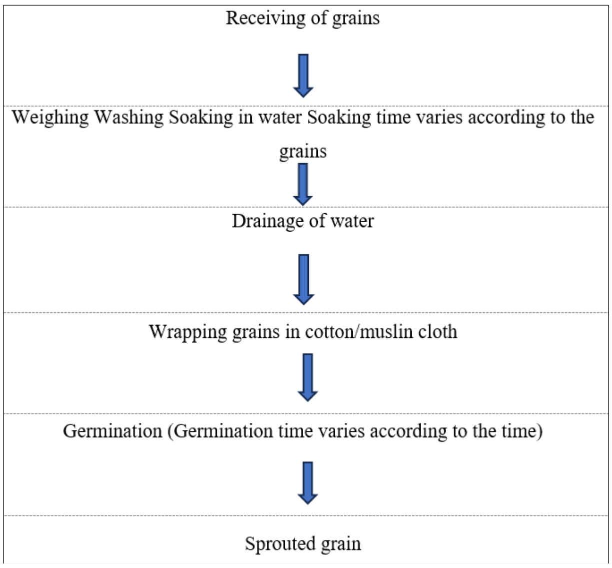

Fig 2: Preparation of Sprouts

Results and Discussion

Development of sprouted moth bean grains

In order to study process for sprouting of moth bean grains, the experimentation on effect of process variables like soaking period and number of rinsings of moth bean grains was conducted as discussed in Materials and methods.

Effect of soaking time (h) and number of rinsings on moth bean sprouts: The experiment was carried out to determine the effect of process parameters such as soaking time and number of rinsings on the preparation of sprouted moth beans. The responses analysed included sprouting percentage (%), sprout length (mm) and moisture content (% wb). The observations were statistically examined using Analysis of Variance (ANOVA), as shown in Tables 2 to 4.

Table 2: ANOVA for effect of soaking time (h) and number of rinsings on percent sprouting of moth beans

Soaking, h (A)	Sprouting Percentage (%)				
	1st Rinsing	2nd Rinsing	3rd Rinsing	4th Rinsing	Mean A (Sprouting percent,%)
2 h	10.000	41.000	50.333	55.167	39.125[a*]
4 h	40.667	80.000	85.500	91.833	74.500[b]
6 h	60.167	94.833	97.000	99.333	87.833[c]
8 h	64.833	90.833	96.917	99.033	87.904[c]
10 h	70.167	88.033	97.500	99.000	88.675[d]
Mean (B) (Soaking time, h)	49.167[a**]	78.940[b]	85.450[c]	88.873[d]	
		S.Em±		CD at 5%	
Soaking, h (A)		0.163		0.468	
Sprouting% (B)		0.146		0.418	
Interaction A×B		0.326		0.935	

* The column wise values superscripted by similar letters are statistically at par
** The row wise values superscripted by similar letters are statistically at par

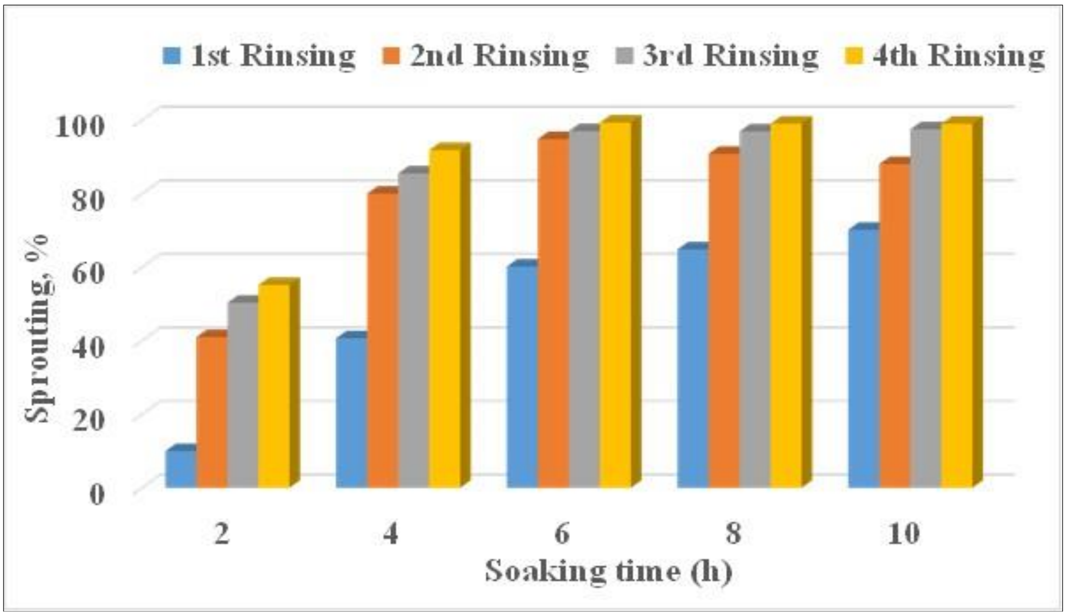

Fig 2: Effect of soaking time and number of rinsings on percent sprouting of moth beans

Table 2 and Fig. 2 demonstrate how the length of soaking time and the number of rinses affect moth bean sprouts. The mean B value in Table 2 denotes soaking time (h) and the mean A value denotes sprouting percentage (%). Five soaking times (2 h, 4 h, 6 h, 8 h and 10 h) and four rinses spaced six hours apart were recorded for observation.

The higher the percentage of sprouting, the longer the soaking time. The mean values of 39.195% and 74.500%, respectively, indicate a significant variation, suggesting that the soaking times of 2 h and 4 h may not be adequate. However, there is not a significant distinction between the 6 h and 8 h soaking times, with averages of 87.833 and 87.904 at-par, respectively. Both values are therefore taken into account; however, the sample undergoes anaerobic fermentation if it is soaked for more than eight hours. As a result, outcomes are much improved by soaking moth bean grains for six hours and then rinsing them four times at six-hour intervals.

Table 3: ANOVA for effect of soaking time (h) and number of rinsings on sprout length, mm of moth beans

Soaking time, h (A)	Sprout Length (mm)				
	1st Rinsing	2nd Rinsing	3rd Rinsing	4th Rinsing	Mean A (Sprout Length, mm)
2 h	0.640	2.307	3.103	3.450	2.375a*
4 h	1.910	4.900	6.320	10.750	5.970b
6 h	2.650	8.500	9.260	13.110	8.380c
8 h	2.660	8.520	10.350	14.004	8.883c
10 h	3.480	9.080	11.030	15.830	9.855d
Mean (B) (Soaking time, h)	2.268a**	6.661b	8.013c	11.429d	
	S.Em±	CD at 5%			
Soaking, h (A)	0.009	0.026			
Sprout Length (B)	0.008	0.023			
Interaction A×B	0.018	0.052			

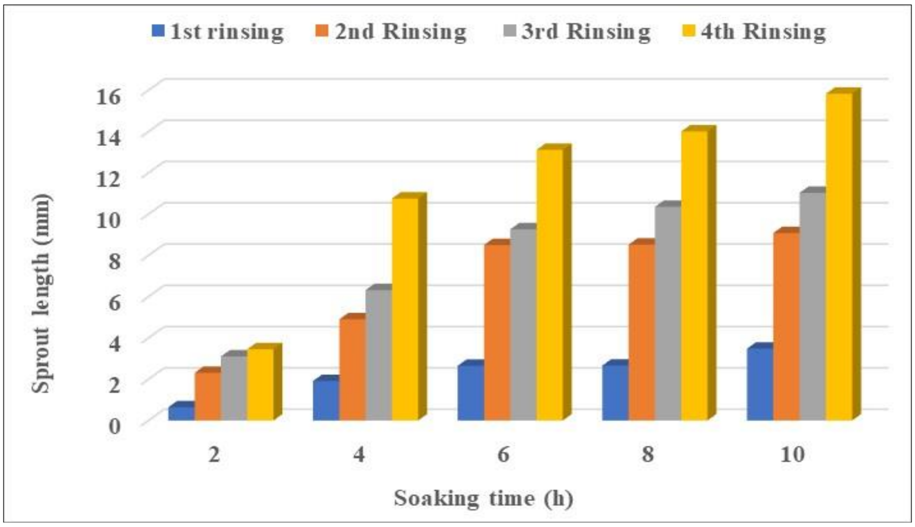

Fig 3: Effect of soaking time and number of rinsings on sprout length, mm of moth beans

Table 3 and Fig. 3 demonstrate how the length of moth bean sprouts is affected by the length of soaking time and the number of rinses. The sprout length (mm) and soaking duration (h) are represented by the mean A and B values, respectively, in Table 3. Five soaking times and four rinsing intervals six hours each were taken down for observation.

The more prolonged the soaking time, the higher percentage of sprouting. The soaking times of two and four hours may not be sufficient to enhance the sprout length of moth bean grains, as shown by the mean values of 2.375 mm and 5.970 mm for two and four hours, respectively.

Their mean values of 8.380 mm and 8.883 mm, respectively, indicate that there is no significant difference between the average soaking times of 6 h and 8 h with four rinses over 24 h. Therefore, both values are taken into account; however, if the sample remains soaked for more than eight hours, anaerobic fermentation occurs. Therefore, it has been considered to be ideal to soak moth bean grains for six hours and then rinse them four times for twenty-four hours.

Table 4: ANOVA for effect of soaking time (h) and number of rinsings on Moisture Content,% db of moth beans

Soaking, h (A)	Moisture content (%)				
	1st Rinsing	2nd Rinsing	3rd Rinsing	4th Rinsing	Mean (A) (Moisture content,%)
2 h	35.430	44.360	59.670	63.150	50.653a*
4 h	51.250	62.380	68.970	70.710	63.328b
6 h	62.140	69.600	75.000	83.900	72.660c
8 h	63.550	71.300	78.670	88.250	75.443c
10 h	72.600	79.730	83.500	91.150	81.745d
Mean (B) (Soaking time, h)	56.994a**	65.474b	73.162c	79.432d	
	S.Em±	CD at 5%			
Soaking, h (A)	0.512	1.520			
Moisture content (B)	0.458	1.359			
Interaction (A×B)	1.023	3.040			

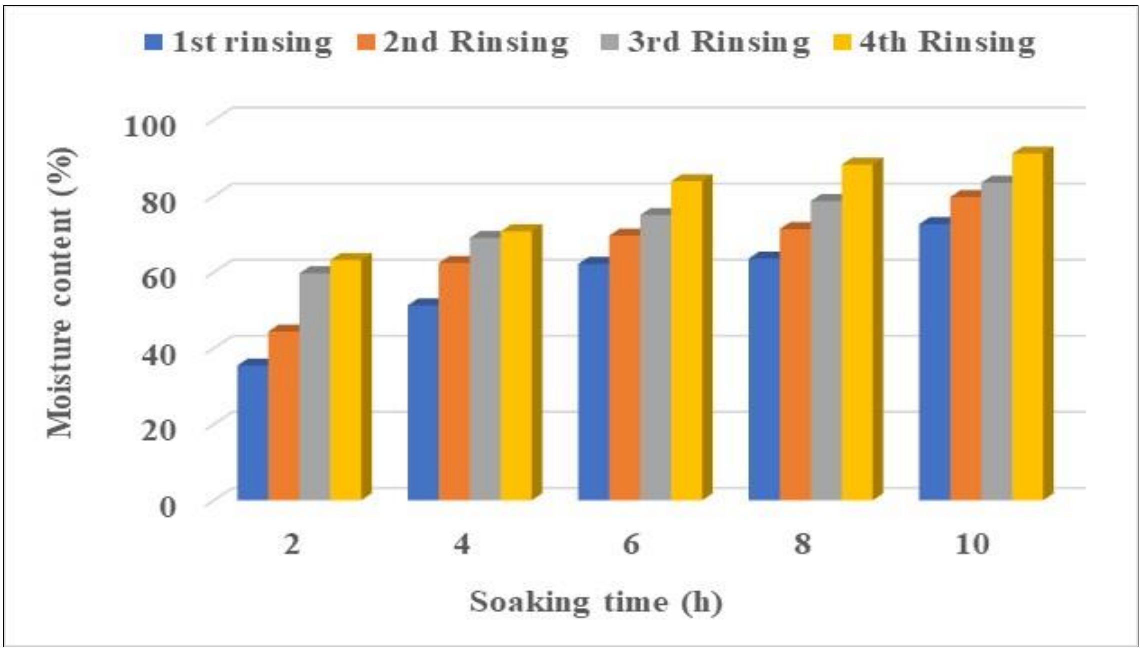

Fig 4: Effect of soaking time and number of rinsings on Moisture content,% db of moth beans

Table 4 and Fig. 4 show the impact of soaking time and number of rinses on the moisture content (% db) of moth bean grains. The moisture content (% db) and soaking duration (h) are represented by the mean A and B values, respectively, in Table 4. Five soaking times (2 h, 4 h, 6 h, 8 h and 10 h) as well as four rinsing intervals six hours apart were recorded for observation.

As soaking and sprouting times increase, also increases the percentage of moisture content. The 2 h and 4 h soaking intervals may not be enough to increase the moisture content of moth bean grains, as indicated by the significantly different mean values of 50.653% wb and 63.328% wb, respectively.

The mean results of 72.660% wb and 75.443% wb, which are equal, indicate that there is not a significant difference between the average soaking times of 6 h and 8 h with four rinses intervals 6 h each. After soaking for eight hours, the material begins to ferment, according to the observations. Therefore, the ideal condition is to soak the moth bean grains for six hours and then rinse them four times at six-hour intervals.

Optimization of Soaking period and rinsing time for sprouting of moth beans

Table 2 to 4 and Fig. 2 to 4 shows that the highest sprouting percentage (%), maximum sprout length (mm) and maximum moisture content (% db) were determined for a sample that was soaked for 6 h and then rinsed four times at 6 h intervals. The greater soaking period results the sprouts to develop in the water, emitting an unpleasant odour. The soaking time was thereby limited to 6 h. Furthermore, until the fourth rinse, the most sprouting was accomplished.

Furthermore, samples that were soaked for 6 h and subsequently rinsed four times at 6 h intervals exhibited the highest sprouting percentage (%), sprout length (mm) and maximum moisture content (% wb). To obtain the best potential sprouting of moth beans in terms of variables such as sprouting percentage (%), sprouting length (mm) and moisture content (% wb) 6 h soaking time and four rinses were selected.

Fig 5: Optimally obtained sprouted moth bean grains

Conclusion

The present study clearly reveals that optimizing soaking and rinsing conditions is essential for enhancing the sprouting efficiency and nutritional quality of moth beans. The most effective treatment among the analyzed condition was soaking for 6 hours followed by four rinses at 6 h intervals, which resulted in the highest sprouting percentage (99%), sprout length (13.11 mm) and moisture content (83.9% wb). Shorter soaking intervals (2 h and 4 h) were insufficient for appropriate hydration and enzymatic activation, whereas longer soaking more than 8 h resulted in anaerobic fermentation and unfavourable change. Thus, a 6 h soak time results in an equilibrium between effective imbibition, enzyme activity and sprout growth.

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