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RESEARCH ARTICLE

Underutilized pulses: Quality evaluation and value addition

E Tamilselvi[1*], G Sashidevi[1], S Arokiamary[1], K P Sivakumar[1], R Senthilkumar[2] & R Haritha[1]

[1]Community Science College and Research Institute (CSC&RI), Tamil Nadu Agricultural University, Madurai 625 104, India
[2]Department of Processing and Engineering, Kelappaji College of Agricultural Engineering & Food Technology, Tavanur 679 573, Malappuram, Kerala, India

*Correspondence email - tamilselvi.e@tnau.ac.in

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Abstract

Underutilized pulses have significant potential for enhancing food and nutritional security while contributing to agricultural development. Quality assessment and value addition are important to promote underutilized pulses in an effective way. This study evaluated the physical, cooking, nutritional and phytochemical profiles of moth bean and rice bean. The bulk density of moth bean and rice beans were found to be 892 kg/m^3 and 846 kg/m^3, respectively. The cooking time for unroasted moth bean was 60 min and for roasted moth bean it was nearly half the time reduced (≈35 min). Roasting of pulses had significant reduction of cooking time. Both moth bean and rice bean exhibited a favorable nutritional profile, with protein contents of 20.63 g/100g and 19.28 g/100g respectively. The fat content was less than 1 g in both pulses while fiber content was at 5.6 % for moth bean and 4.32 % for the rice bean. The phytochemicals such as phytic acid, tannins and saponins were present in both pulses. Moth bean and rice bean are highly suitable for the preparation of regular pulse based recipes and products with commercial value as well. Nutrimix prepared using underutilized pulses were highly acceptable by semi-trained panel of sensory evaluation with a shelf life of two months and is suitable for commercial production.

Keywords: moth bean; quality analysis; rice bean; underutilized pulses; value addition

Introduction

Pulses are excellent and major source of protein for vegetarian population, but they are less expensive when compared to animal protein. It contains about 20-25 % protein by weight. India is the world's largest producer and consumer of pulses. Major pulses grown in India are chickpeas, pigeon pea, mung beans, urd beans, masur and peas. Pulses have a huge demand–supply mismatch in India due to per capita availability of 47 g, which is less than the recommended intake as per Indian National Institute of Nutrition (NIN) which recommends a daily pulse intake of 80 g per person. The decline in per capita availability of pulses leads to poor nutritional status especially in protein deficiency among the population, posing a major challenge for low income and economic development. Protein deficiency can lead to malnutrition, which can manifest as life-threatening conditions such as kwashiorkor and marasmus. This issue can be addressed through increasing the production and consumption of underutilised pulses such as moth bean and rice bean, facilitating the availability of food and nutritional security.

The underutilized pulses are not very popular though they may have potential to use as regular food. They are significant for food and nutritional security because they provide high nutritional value that are resilient to harsh conditions and can improve the soil health, making them a sustainable and adaptable food source, especially in regions with food scarcity. Also, they are a rich source of protein, fiber, other essential nutrients and secondary metabolites that aid in the rectification of nutritional inadequacies. It helps to increase dietary variety and food security, emerges as a critical component of their importance. They are an effective means for crop diversification which contribute to the agricultural sustainability and overall improvement of a nation's economy.

Moth bean and rice bean are underutilized pulses, not common among people but reported to have high protein, high fiber and low-fat content. Moth bean (*Vigna aconitifolia*) is an underutilized legume, primarily cultivated in India. It is an important dry-land crop, requires less water and less external input for its cultivation. It is also grown in Sri Lanka, Myanmar, China, Pakistan, Malaysia, Africa and south-western states of the USA (1-3). Rajasthan, the driest state in India, contributes the most,both in terms of production as well as area. at national level (4, 5). It grows in arid and semi-arid regions. It is an extremely hardy, drought -tolerant legume crop belonging to the Fabaceae family (6). Despite its significance, moth bean cultivation receives minimal attention from farmers. A total of 9.26 lakh hectares and 2.77 lakh tones of moth bean production were recorded in the country during the 12th plan (2012-15) period (7). Rice bean (*Vigna umbellata)* is a native of South and Southeast

Asia primarily used for food, fodder and green manure, noted for its high protein content. In India, it is cultivated in 20000 ha with an average green fodder productivity of 15-30 t/ha (8).

With good nutritional profile like high protein, high fiber and low-fat content, underutilized pulses can be promoted for consumption by all age groups to meet the food and nutritional needs. It is also good for patients with non-communicable diseases like diabetes, cardiovascular diseases etc. Recently, a study has reported that moth bean the unexploited plant which is enriched with its plethora of minerals, vitamins and nutrients, plays a crucial role in ensuring food security, serving as an essential and leading protein source for the deprived communities of economically underdeveloped countries (9).

Hence, the study was undertaken to analyze the physical, cooking and nutritional qualities of underutilized pulses like moth bean and rice bean to develop value added products. Quality analysis is highly essential which determines the quality of grain production, machinery design for processing like milling, grain storage, transportation etc. and facilitates for utilization and regular consumption of pulses. Nutritional quality is important for picking the best quality foods for human consumption, dietary recommendations etc. Value addition of underutilized pulses generates good revenue for the farmers through entrepreneurial activities besides regular consumption.

Material and Methods

The physical, cooking and nutritional qualities of underutilized pulses such as moth bean and rice bean were analyzed at the Community Science College and Research Institute, Madurai.

Physical parameters

The physical properties such as 1000 grain weight, length, breadth, length to breadth ratio, bulk density, kernel density and specific gravity were determined. The 1000 grain weight was measured directly by weighing 1000 grain kernels (10). The length and breadth of randomly selected seeds were measured using a Vernier caliper with an accuracy of 0.01 mm (11). The average of ten measurements was recorded. Length/breadth ratio was calculated by simply dividing calculated length by calculated breadth (12). Bulk density was determined by measuring the weight of a known volume of grain. True density of seeds was determined using the liquid displacement method (13).

Cooking qualities

The cooking qualities such as cooking time (11), temperature, percentage increase in weight, water uptake ratio and gruelling loss (14) were determined for raw and roasted pulses.

Nutritional and phytochemical analysis

Nutritional parameters such as protein (Micro-Kjeldahl method), fat (Soxplus), crude fibre (acid alkali digestion) and ash (dry ashing) content in pulses were analyzed by the previously described methods (15). The phytochemicals such as phytic acid and tannins in the pulses were analyzed by the method described (16). Saponin content was studied by another method (17).

Value added products

The underutilized pulses like moth bean (Fig. 1) and rice bean (Fig. 2) were used to prepare value added food products such as nutrimix, fried gram, sundal and pulse masiyal and the same was evaluated for consumer acceptance with experts using 9-1-point sensory score card and the mean sensory scores arrived.

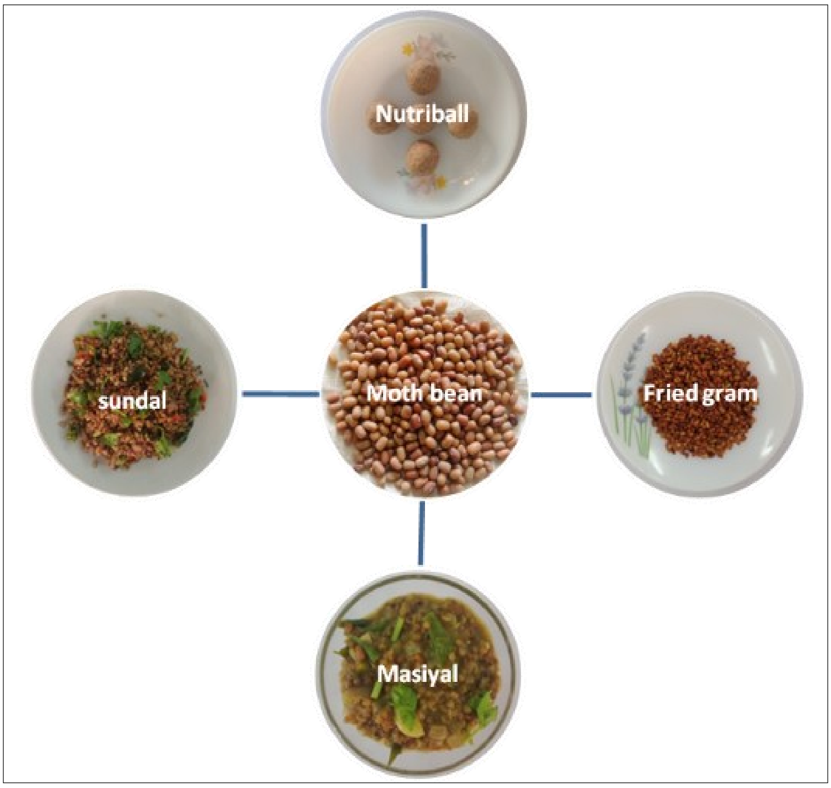

Fig. 1. Moth bean value added products.

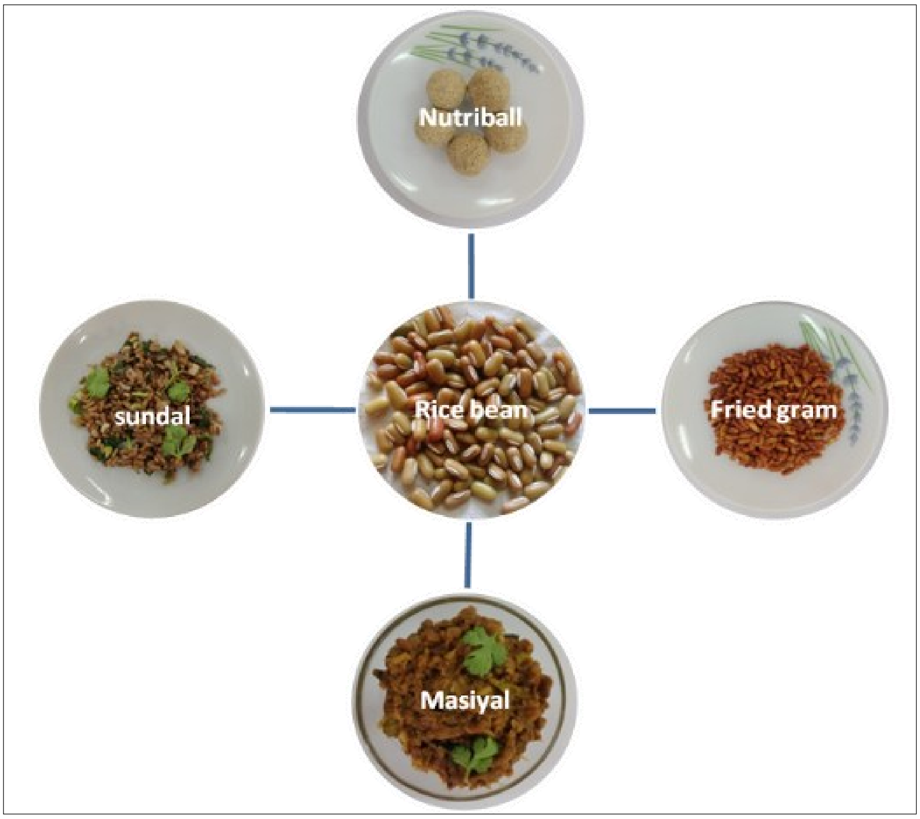

Fig. 2. Rice bean value added products.

Among the four products sundal, masiyal and fried gram can be regularly prepared in the home and thus meet out the regular protein needs of the family. Nutrimix can be prepared in the home kitchen and they have commercial value as well.

Nutrimix

Nutrimix was prepared with 15 g of each pulse for moth bean nutrimix and rice bean nutrimix separately. The other ingredients used were 15 g of roasted bengal gram dhal, 50 g of pearl millet (cumbu) and 20 g of sugar. The pulses (moth bean/ricebean) and cumbu were cleaned and washed separately to remove foreign particles. The water was completely drained off and the grains were roasted until they began to splutter and develop a distinct aroma, then cooled. Bengal gram dhal was slightly roasted; thereafter the grains and dhals were powdered separately. Powdered sugar (20 %) (optional) was then added, mixed thoroughly, packed and stored.

For preparation of nutriball, 15 g of melted ghee was added to the nutrimix and made into balls of desirable size. Addition of ghee facilitates binding and enhances the flavor and taste of the nutriball.

Fried gram

For preparing fried gram, pulses were soaked in water for 3 hrs and then completely drained. 2 % salt was sprinkled over it, mixed thoroughly, surface dried for 10-15 min and deep fried in hot oil. Curry leaves and chopped garlic were also deep fried and garnished the fried grams.

Other value-added products

Sundal and masiyal can be included in our regular diet as affordable protein source. For sundal preparation, pulses were cleaned, washed and cooked with optimum quantity of water and seasoned with mustard, curry leaves, onion and chillies and garnished with grated coconut and coriander leaves. For masiyal preparation, pulses were cleaned, washed and boiled with excess quantity of water Ingredients such as salt, turmeric, coriander seeds, garlic and tomato were added and minced coarsely. The mixture was seasoned with coconut oil, chopped onion, chillies and garnished with coriander leaves.

Storage study

The value-added products developed were both for household preparation and for commercial value as well. Among the food products developed, nutrimix was studied for storage stability due to less moisture and fat content which create a conducive environment for microbial spoilage and rancidity. The consumer acceptability was recorded once in 15 days interval.

Statistical analysis was performed using Agres and SPSS Software employing a Completely Randomised Design (CRD) with one-way ANOVA and two-way ANOVA to determine Standard Error difference and Critical Difference at 5 % and 1 % levels.

Results and Discussion

Physical properties of pulses

Understanding the physical properties of pulses is crucial for designing equipment utilized in harvesting, transportation, cleaning, separation, packaging, storage and processing into various food products (18). The mean values of physical properties such as 1000 grain weight, length, breadth, length/breadth ratio, bulk density, kernel density and specific gravity of moth bean and rice bean are given in Table 1.

Table 1. Physical properties of underutilized pulses

Sl. No.	Physical parameters	Moth bean	Rice bean
1	1000 grain weight (g)	23.9±0.54	42±0.32
2	Length/grain (cm)	0.41±0.01	0.63±0.01
3	Breadth/grain (cm)	0.25±0.01	0.35±0.01
4	Length breadth ratio	1.64±0.01	1.8±0.02
5	Bulk density (kg/m^3)	892±5.46	846±12.6
6	True density/kernel density (kg/m^3)	1363.64±25.9	1296±41.4
7	Specific gravity (kg/m^3)	892±1.8	846±9.78

mean value replicates of 3 ±SD value

The results showed that 1000 grain weight of pulses was 23.9 g for moth bean and 42 g for rice bean respectively. The 1000 grain weight was low for moth bean when compared to rice bean and this might be due the smaller size of the grains. A similar study showed that the 1000 grain weight of green gram was 38.60 g at 10.86 % moisture content (19). The mean value of length and breadth shows lowest values for moth bean *viz.*,0.41cm and 0.25cm/grain) and highest values for the rice bean i.e., 0.63cm and 0.35cm/grain); where the grain size is the determining factor.

The bulk density gives a good idea of the storage space required for a known quantity of grain. Bulk density of grains varies with grain size, shape and moisture content of the grains. In the present study, the bulk density and true density of moth bean was observed as 892 and 1363.6 kg/m3 while in case of rice bean it was measured as 846 and 1296 kg/m3 respectively. The specific gravity (relative density) was recorded as 892 kg/m^3 for moth bean and 846 kg/m^3 for rice bean, compared to the specific density of water (999.974 kg/m^3). The bulk density of moth bean and rice bean are higher when compared to lentils (772 kg m^3) in a literature cited (20) hence advantages in storing and transportation.

Statistical analysis of physical parameters showed that there was highly significant difference between pulses with respect to bulk density, true density and specific gravity at 1 % and 5 % level. Significant difference noted for length and 1000 grain weight at 5 % level.

Cooking qualities of pulses

Cooking quality of pulses is important for consumer acceptance (11). In the present study the cooking qualities of both unroasted and roasted moth bean as well as rice bean were assessed and the results were given in Table 2. Roasting is one of the common cooking methods to improve the cooking quality in pulses. Roasting makes the husk to separate easily, improves flavour and enhances digestibility and nutritional quality by destroying antinutritional factors. Hence, both unroasted and roasted pulses were taken to assess the cooking qualities.

The cooking time gives an indication of cooking quality which is one of the most important factors responsible for consumer's choice for a particular food. The time required to cook a product is an important quality attribute for food processors and consumers; because a) longer cooking times are inconvenient and some pulses will require presoaking [usually overnight to reduce the cooking period which significantly reduced the phytic acid and tannin contents with slight reduction in nutrients such as protein, minerals and total sugars (21)] and b) longer cooking times require more electricity or fuel and, therefore, are more costly to processors or consumers (22). Consumers expect their pulses and pulse products to cook quickly (23).

A comparative analysis of cooking qualities was conducted between moth bean and rice bean in both unroasted and roasted forms. The results showed significant differences in cooking time, increase in weight, water

Table 2. Cooking qualities of underutilized pulses

Sl. No.	Cooking qualities	Moth bean						Rice bean					
		Unroasted	Roasted	SED	CD (0.05)	CD (0.01)	P-Value 5%	Unroasted	Roasted	SED	CD (0.05)	CD (0.01)	P-Value 5%
1	Weight of pulses taken (g)	5	5	-	-	-	-	5	5	-	-	-	-
2	Cooking time (boiling) (min)	60±1.44	35±0.35	0.63	1.93	3.20	0.00 ^{S}	45±0.21	25±0.68	0.53	1.48	2.4	0.000^{S}
3	Increase in weight (g %)	11.2±0.32 (124)*	10.3±0.34 (106)*	0.18	0.50	0.83	0.008^{S}	11.1±0.34 (122)*	10.55±0.35 (111)*	0.25	0.70	1.16	0.09$^{N.S}$
4	Water absorption (ml) (No. of times)	20±0.46 (1:4.0)^	16±0.21 (1:3.2)^	0.27	0.77	1.28	0.00^{S}	11.0±0.30 (1:2.2)^	10.0±0.18 (1:2.0)^	0.26	0.74	1.24	0.02^{S}
5	Gruel loss (g %)	10±0.25	8±0.16	0.17	0.48	0.80	0.00^{S}	10.2±0.09	8.5±0.02	0.20	0.56	0.93	0.001^{S}

* values are in percentage

^ no. of times water absorbed for one part of pulse grain

mean value replicates of 3±SD value

absorption and gruel loss. The cooking time for unroasted moth bean was 60 minutes, which decreased to 35 min after roasting (P-value: 0.00). Similarly, the cooking time for unroasted rice bean was 45 min, which decreased to 25 min after roasting (P-value: 0.000).

The increase in weight of unroasted and roasted moth bean after cooking were 11.2 % and 10.3 % (P-value: 0.008), while for rice bean it was 11.1 % and 10.55 % (P-value: 0.09) respectively. The water absorption capacity of moth bean decreased from 20 mL to 16 mL after roasting (P-value: 0.00), while that of rice bean decreased from 11 mL to 10 mL (P-value: 0.02). The gruel loss for unroasted moth bean was 10 %, which decreased to 8 % after roasting (P-value: significant). Similarly, the gruel loss for unroasted rice bean was 10.2 %, which decreased to 8.5 % after roasting (P-value: 0.001). The minimum weight gain of roasted cooked pulses might be due to Maillard reaction or non-enzymatic browning which might reduce the water holding capacity and solubility of roasted pulses; thus less weight gain when compared to unroasted cooked pulses.

The statistical analysis revealed Standard Error Difference (SED) and Critical Difference (CD) values at the 5 % and 1 % levels. For cooking time, the SED values were 0.63 for moth bean and 0.53 for rice bean, with corresponding CD values at 5 % level being 1.93 and 1.48, and at 1 % level being 3.20 and 2.40 respectively. For weight increase, the SED values were 0.18 for moth bean and 0.25 for rice bean, with corresponding CD values at 5 % level being 0.50 and 0.70 and at the 1 % level of 0.83 and 1.16, respectively. For water absorption, the SED values were 0.27 for moth bean and 0.26 for rice bean, with corresponding CD values at 5 % level being 0.77 and 0.74 and at the 1 % level of 1.28 and 1.24 respectively. For gruel loss, the SED values were 0.17 for moth bean and 0.20 for rice bean, with corresponding CD values at 5 % level being 0.48 and 0.56 and at the 1 % level of 0.80 and 0.93 respectively. These statistical values indicate significant differences in cooking time, increase in weight, water absorption and gruel loss between moth bean and rice bean in both unroasted and roasted forms.

A study revealed that the cooking time for different cultivars of raw kidney beans was ranged between 68 - 86 min. The water uptake ratio of kidney bean cultivars was quoted in study which ranged from 2.15-2.45 (11).

Nutritional quality of pulses

The nutritional quality of underutilized pulses like moth bean and rice bean was analyzed and is presented in Table 3. It was observed that the underutilized pulses like moth bean and rice bean had the protein content of 20.63 g/100 g and 19.28 g/100 g, respectively, while the fat content was less than one gram in both the pulses. The protein content in moth bean quoted in another study as 19.75 g (8) and for rice bean genotypes as 22.56-25.97 % (24) which are comparable to the values in the present study. The difference in values might be due to genetic, climatic and environmental factors. The fat present in selected pulses was an insignificant amount i.e.0.53 g and 0.98 g for moth bean and rice bean respectively which is very less when compared to 1.76 g quoted for moth bean (9). Hence, consumption would not add extra calorie from fat.

The fiber content of pulses was 5.6 % and 4.32 % respectively, for moth bean and rice bean. The higher the fibre content in moth bean might be due to smaller the size of the grain and more seed coat proportion of the grain. The fibre content of pulses is comparable to that of values for pulses such as whole horsegram (5.3 g %), dried peas (4.5 g %) and greengram (4.5 g %) (25). The ash content of moth bean and rice bean were 3.53 g and 3.9 g respectively and similar data was found for moth bean ie.3.47 g (9). It was found that the minerals such as iron, zinc and copper content were highest in rice bean (4.84, 2.9 and 0.84 mg/100 g respectively) when compared to moth bean (3.80, 1.64 and 0.36 mg/100 respectively).

Statistical analysis of data using one way ANOVA revealed a highly significant difference between moth bean and rice bean with respect to protein, crude fibre, fat, minerals like copper, iron and zinc at the 5 % and 1 % level of significance.

Phytochemicals in underutilised pulses

Phytochemicals are non-nutritive substances found in plant foods which contribute a vast role in physiological regulation, health care and disease prevention (26). Legumes contain several phenolic compounds such as flavonoids, phenolic acids and tannins. There is a considerable interesting finding natural phytochemicals and antioxidants from plants due to their role in the treatment and/or prevention of various diseases (27). The phytochemicals such as phytic acid, tannins and saponins in pulses were analysed and given in

Table 3. Nutritional and phytochemical profile of underutilized pulses per 100 g

Sl. No.	Name of the nutrients	Moth bean	Rice bean
1	Moisture (g)	7.11±0.01	7.35±0.16
2	Protein (g)	20.63±0.14	19.28±0.11
3	Crude fibre (g)	5.6±0.03	4.32±0.10
4	Fat (g)	0.53±0.01	0.98±0.01
5	Ash (g)	3.53±0.03	3.9±0.05
6	Copper (mg)	0.36±0.003	0.84±0.01
7	Iron (mg)	3.80±0.05	4.84±0.14
8	Zinc (mg)	1.64±0.03	2.90±0.01
9	Phytic acid (mg)	1837.5±41.25	1668.75±44.28
10	Tannins (mg)	18±0.02	2.8±0.08
11	Saponins (g %)	0.42±0.01	0.45±0.003

mean value replicates of 3 ±SD value

Table 3. It was noted that both moth bean and rice bean contain more amount of phytic acid followed by tannins and saponins. Moth bean had higher phytic acid (1837.5 mg/100 g) and tannins (18 mg) content. Rice bean had significantly a smaller concentration of tannins (2.8 mg) but had a little higher content of saponins (0.45 g %) when compared to moth bean (0.42 g %).

There was highly significant difference between moth bean and rice bean on the factors like tannins and phytic acid at 5 % and 1 % significant level.

Value addition of pulses

Underutilized pulses like moth bean and rice bean were used to prepare value added food products, such as nutrimix, fried gram, sundal and pulse masiyal. These products were evaluated for acceptability by experts using a 9-1 point sensory scorecard. The mean sensory scores of the value-added products are presented in the Table 4.

Among the products, those prepared from moth bean received the highest overall scores, i.e., sundal (7.87/9), masiyal (7.97/9), fried gram (8.07/9) and nutriball (8.22/9). It was observed that the fried gram and nutriball prepared from moth bean were highly acceptable. The fried gram and nutriball prepared from rice bean were moderate to highly acceptable. Likewise, sundal and masiyal prepared from both the pulses were moderate to highly acceptable (7 -8/9).

Shelf life of value-added product

Among the value-added products, nutrimix was assessed for storage stability. Standardized moth bean and rice bean nutrimix were packed in HDPE covers and kept for storage under ambient and refrigeration conditions. The stored products were assessed for the consumer acceptability with 15 days interval upto 60 days of storage.

The sensory parameters of moth bean nutrimix stored at ambient and refrigeration conditions were evaluated, including colour and appearance, flavor, texture, taste and overall acceptability during the storage period (Table 5). The initial scores were 8.22 for color and appearance, 8.07 for flavor, 8.12 for texture, 8.22 for taste and 8.22 for overall acceptability. However, after 60 days, the scores dropped at room temperature to 7.8 for color and appearance, 7.2 for flavor, 8.0 for texture, 7.5 for taste and 7.63 for overall acceptability. In contrast, refrigerated temperature relatively maintain the scores, with values of 8.0 for color and appearance, 7.9 for flavor, 8.0 for texture, 8.1 for taste and 8.0 for overall acceptability.

Statistical analysis revealed SED values of 0.17 for color and appearance, 0.15 for flavor, 0.16 for texture, 0.20 for taste and 0.17 for overall acceptability. CD values were also calculated, with 5 % levels of 0.35 for color and appearance, 0.32 for flavor, 0.33 for texture, 0.42 for taste and 0.36 for overall acceptability. Furthermore, the 1 % levels were 0.48 for color and appearance, 0.43 for flavor, 0.45 for texture, 0.57 for taste and 0.50 for overall acceptability.

The results showed that there were no significant differences in the sensory parameters between the different storage days (0-60 days) and between the two storage temperatures (room temperature and refrigerated temperature). This was confirmed by the p-values at 5 %, which were 0.8 (non-significant) for color and appearance, 0.1 for flavor, 0.9 for texture, 0.3 for taste and 0.6 for overall acceptability. These findings indicated that the storage temperature and duration did not have a significant impact on the sensory properties of moth bean nutri mix hence stored for 60 days with good sensory attributes.

Table 4. Mean sensory scores of value-added products of underutilized pulses

Sensory Properties / VAP	Sundal		Masiyal		Fried gram		CD
	MB	RB	MB	RB	MB	RB	
Colour and appearance	8.22±0.18	8.05±0.05	8.02±0.18	7.83±0.10	8.37±0.17	7.95±0.04	0.245
Flavour	7.97±0.23	8.0±0.07	7.97±0.01	7.48±0.18	8.32±0.21	7.6±0.08	0.243
Texture	8.27±0.11	7.53±0.08	8.07±0.21	7.98±0.17	8.02±0.19	7.75±0.20	0.196
Taste	7.97±0.08	7.75±0.03	8.07±0.03	7.53±0.23	8.27±0.23	7.55±0.02	0.312
Overall acceptability	7.87±0.14	7.75±0.14	7.97±0.10	7.53±0.01	8.07±0.03	7.5±0.01	0.115

VAP - value added products MB - moth bean RB - rice bean

mean value replicates of 3 ±SD value

Table 5. Mean sensory scores of moth bean nutrimix during storage

Sensory parameters	0^{th} day		15 days		30 days		45 days		60 days		P-Value 5%
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	
Colour and appearance	8.22±0.19	8.22±0.06	8.0±0.14	8.22±0.03	8.16±0.06	8.20±0.21	7.95±0.027	8.0±0.03	7.8±0.18	8.0±0.01	$0.8^{N.S}$
Flavour	8.07±0.22	8.07±0.17	8.07±0.05	8.05±0.21	8.0±0.17	8.0±0.11	7.7±0.09	7.9±0.15	7.2±0.15	7.9±0.11	$0.1^{N.S}$
Texture	8.12±0.19	8.12±0.24	8.06±0.19	8.1±0.16	8.0±0.24	8.1±0.25	8.0±0.16	8.0±0.16	8.0±0.11	8.0±0.02	$0.9^{N.S}$
Taste	8.22±0.17	8.22±0.20	8.20±0.15	8.2±0.03	8.0±0.05	8.16±0.15	7.7±0.09	8.1±0.24	7.5±0.20	8.1±0.25	$0.3^{N.S}$
Overall acceptability	8.22±0.08	8.22±0.08	8.08±0.14	8.14±0.13	8.04±0.02	8.11±0.18	7.8±0.05	8.0±0.038	7.63±0.12	8.0±0.26	$0.6^{N.S}$

R1 - room temperature R2 - refrigeration temperature

Mean value replicates of 3 ±SD value

Similarly, the sensory parameters of rice bean nutrimix (Table 6) were evaluated during storage at ambient (R1) and refrigeration temperature (R2) for 60 days, with an interval of 15 days. The results showed that the sensory scores for colour and appearance, flavor, texture, taste and overall acceptability remained stable, with no significant differences between the two storage temperatures. The overall mean sensory scores of rice bean nutrimix was 8.13 ± 0.22 on 0th day of storage and the scores reduced to 7.1 ± 0.06 and 7.6 ± 0.01 on the 60th day of storage at ambient and refrigeration storage respectively. The p-values were non-significant, ranging from 0.07 to 0.445, indicating no significant differences between the two storage temperatures. The SED values (Table 6) obtained were: color and appearance (0.16), flavor (0.20), texture (0.16), taste (0.13) and overall acceptability (0.18), with corresponding CD values at 5 % and 1 % levels i.e. color and appearance (0.35, 0.47), flavor (0.42, 0.58), texture (0.35, 0.47), taste (0.28, 0.39) and overall acceptability (0.37, 0.51). Overall, the results indicated that the sensory parameters of rice bean nutrimix remained stable during storage at both ambient and refrigeration temperature for 60 days.

A study revealed that the technology on moth bean dhal puff developed by a central institute (28) possessed a shelf life of 3 months.

Conclusion

The quality parameters of selected underutilized pulses with respect to physical, cooking and nutritional parameters shown that they are easy to handle, transportable, with better cooking qualities and are nutritionally good. They are highly suitable for household food preparation and regular consumption, with no adverse sensory attributes noted. The study suggests that further value addition technologies can be developed for these pulses to enhance commercialization, including instant food mixes, retort packaging of Ready to Eat (RTE) foods, extrusion technologies and canning. There is significant potential for entrepreneurial ventures, allowing farmers to benefit from value-added pulse products.

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Authors' contributions

ET carried out the quality analysis and value addition of underutilised pulses and drafted the manuscript. SA and KPS carried out the storage studies. TS & RH participated in the design of the study and performed the statistical analysis. GS conceived of the study and participated in its design and coordination. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare

Ethical issues: None

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Table 6. Mean sensory scores of the rice bean nutrimix during storage

Sensory parameters	0th day		15th day		30th day		45th day		60th day		SED	CD (0.05)	CD (0.01)	P-Value 5%
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2				
Colour and appearance	8.2±0.16	8.2±0.13	8.0±0.13	8.2±0.22	8.16±0.18	8.20±0.01	7.95±0.04	8.0±0.14	7.2±0.15	8.0±0.038	0.16	0.35	0.47	$0.10^{N.S}$
Flavour	8.0±0.06	8.0±0.00	7.9±0.03	8.0±0.00	7.3±0.05	7.9±0.08	7.5±0.14	7.5±0.19	7.2±0.02	7.5±0.11	0.20	0.42	0.58	$0.33^{N.S}$
Texture	8.05±0.15	8.05±0.01	8.0±0.12	7.9±0.24	8.0±0.01	8.1±0.24	7.0±0.19	7.8±0.13	7.0±0.21	7.5±0.20	0.16	0.35	0.47	$0.07^{N.S}$
Taste	8.25±0.15	8.25±0.07	7.6±0.09	8.2±0.15	7.6±0.18	7.9±0.06	7.3±0.07	7.7±0.04	7.0±0.06	7.2±0.24	0.13	0.28	0.39	$0.18^{N.S}$
Overall acceptability	8.13±0.22	8.13±0.22	7.9±0.13	8.1±0.23	7.8±0.13	8.0±0.08	7.4±0.21	7.8±0.15	7.1±0.06	7.6±0.01	0.18	0.37	0.51	$0.445^{N.S}$

R1 - room temperature R2 - refrigeration temperature

mean value replicates of 3 ± SD value

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