Turkish Journal of Agriculture - Food Science and Technology, 12(s1): 2104-2111, 2024
DOI: https://doi.org/10.24925/turjaf.v12is1.2104-2111.7121

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Assessment of Field Performance and Nutritional Quality of Mung Bean (*Vigna radiata* L.) for Food Diversification

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ARTICLE INFO

Research Article

Received : 11.09.2024
Accepted : 04.11.2024

Keywords:
Food diversity
Mineral composition
Mung bean
Sensory properties
Seed yield

ABSTRACT

This research was carried out to evaluate the field performance of some mung bean accessions and their nutritional composition for inclusion in household diet. Twenty-one (21) accessions of mung bean were evaluated in the early and late season of 2022 at Ile-Ife, and in the early season at Kishi out-station of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Nigeria. The experiment was established according to randomized complete block design with three replications. Agronomic and yield data were collected. Six of the mung bean accessions were randomly selected and analyzed for proximate, mineral composition and sensory properties along with two cowpea varieties as standard checks. MB-3, 6, 14 and 15 produced the highest seed yield across the locations (Ile-Ife early season, Ile-Ife late season, and Kishi early season). However, the performance was generally better in the early season than in the late season. The mung bean samples had slightly lower protein values than the standard checks. The mung bean samples had considerably higher mineral levels ($p \leq 0.05$) than the control samples. Moin-moin (processed bean cake) made from some of the mung bean samples compared favorably with that from Ife brown cowpea (standard check). This work revealed good adaptability of the mung bean accession to southwest agro-ecology of Nigeria. It also revealed better nutritional quality of mung bean relative to cowpea for inclusion in household meals.

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Introduction

On a global scale, there were more than 700 million people who experienced extreme food insecurity in 2018. (FAO, 2019). Because of this, many have resolved to taking cheap diet mainly carbohydrate. This has accounted for the high level of malnutrition most importantly in children and women in the reproductive age. Malnutrition in all its forms is thought to cost society up to US$3.5 trillion annually (UNICEF, 2018). Cowpea, often referred to as ''the meat for the poor'' in Nigeria is now beyond the reach of the masses. National Bureau of Statistics (NBS) (2017) data showed a price increase of 44.15% for cowpea between May 2016 and May 2017. Between 2020 and 2021, the price has increased by 116.7% and there is no sign of fall in price. Animal protein that could be an alternative source is by far beyond the reach of the populace due to its outrageous price. The possible strategy for attaining nutrition and food security in African is through exploitation of underutilized legumes such as mung bean, lima bean and bambara groundnut.

Mung bean, [*Vigna radiata* (L.) Wilczek], is an underutilized legume in the same family and genus with cowpea. The self-pollinating mung bean crop has a diploid chromosome number of 2x = 22. The seeds are free from anti-nutritional factors, but rich in essential amino acids particularly lysine (504 mg/g) (Minh, 2014); minerals such as iron, zinc, phosphorus and magnesium; and vitamins including selenium. Mung bean is easier to cook unlike other less commonly consumed legumes, with easy digestibility and less flatulence. Its protein content (21-31.32 %) is higher than that of soybean (18-22 %) and kidney bean (20-30 %) (Shevkani et al. 2015). Previous research findings revealed that flavonoids concentration in mung bean seeds ranged between 125 – 352 mg QE / 100g seed (Wang et al. 2021), while that of cowpea ranged between 7.46- 23.95 mg QE / 100g seed (Sombie et al. 2018). Flavonoids are secondary metabolites that are in charge of the qualities of flavor, color, and aroma in food of plant origin (Dias et al. 2021).

The distribution of mung bean all over the world is due to its short growth cycle, wide adaptability and its ability to fix nitrogen to the soil (Yi-Shen et al. 2018). Mung beans thrive in temperatures between 25 and 35 °C and 400 to 500 mm of rain spread evenly over 60 to 90 days of growth. It survives in a variety of soil types, such as red laterite soils and sandy loams with a pH range of 6.3 to 7.2. For optimal growth, the soil should have a slight acidity. With up to 41% of the world's production, India is the leading producer of mung beans, followed by China, Bangladesh, Pakistan, and Myanmar (Pataczek et al. 2018).

Despite its potential, the small seed size, inadequate farming practices and restricted availability of better cultivars limits using of mung bean (Mbeyagala et al. 2016). Also, there is little research on the agronomic potential and nutritional properties of different mung bean accessions especially in Nigeria. Unraveling the potential of mung bean as a substitute to cowpea and other prominent legumes through research is an important strategy to improve the adoption of mung bean in household diets in Nigeria and other African countries, thereby tackling the challenges of food and nutrition insecurity and food diversity.

The goal of this research therefore is to (1) examine the field performance of some accessions of mung bean, (2) determine the nutritional quality of the crop for possible inclusion in household diets nationwide.

Materials and Methods

Twenty-one (21) mung bean accessions were evaluated in the early and late cropping season at Ile-Ife (rain forest ecology), and only in the early season at Kishi (savanna ecology) out-station of the Institute of Agricultural Research and Training (IAR&T), Nigeria in 2022. The early season planting was between May- August, while late season planting was between August-November, 2022. The two locations with the seasons (Ile-Ife early season, Ile-Ife late season and Kishi early season) are to be referred to as "Environment" in this study. Soils in Ile-Ife are generally classified as ultisols with low nutrient reserves and high gravel content. They are slightly to strongly acidic with low available phosphorus and high exchangeable bases. The average temperature and rainfall at Ile-Ife in 2022 were 25.3ºC and 1509mm, respectively. The wettest month was September with average rainfall of 225mm. Kishi soils are classified as Arenic kandiudults according to USDA taxonomy. The soil is sandy with low cation exchange capacity (CEC) and potassium deficiency. The average temperature and rainfall at Kishi in 2022 were 28ºC and 1050 mm, respectively. The wettest month was June with average rainfall of 150mm. The accessions were obtained from the International Institute of Tropical Agriculture (IITA), Nigeria. Three replicates in a randomized complete block comprised the experimental design. The plot measured 2.4 by 2.4 meters making 5.76m^2, with 0.6 meters separating rows and within rows, and two seedlings per stand were maintained at field establishment. Metolachlor 960g E.C. at 1.44kg ai/ha was the pre-emergence herbicide that was sprayed at planting while manual weeding was carried out on the field as necessary. Magic Force (Lambdacyhalothrin 15% + Dimethoate 300 g L-1) was used to suppress pest insects in fields throughout both their vegetative and reproductive phases.

Data were gathered on plant height, days to first and 50% flowering, days to first and 50% pod formation, pod length, days to maturity and seed yield. Using the meter rule, the height of the plant was measured in centimeters, from the ground surface to the tip where the plant branched. Days to first and 50% flowering was determined by keeping track of the days following planting to the day the first flower was noticed and when the flowering reached 50% respectively, per plot. The BBCH growth stage code is presented in Table 1. Days to first and 50% pod formation was recorded by counting the number of days from planting to the day the first pod was noticed and when the pod formation reached 50% per plot, respectively. Pod length (in centimeter) was taken as the average length of ten randomly selected pods per plot. Days to maturity is regarded as the number of days from the time of sowing until when 75% of the pods are dry. Seed yield was taken after threshing the dry harvested pods per plot. The chaff was removed and weight of the seeds was recorded per plot as seed yield in kg/m^2.

To assess the nutritional qualities, six of the mung bean accessions were randomly selected based on seed color, pod length and yield performance on the field for proximate analysis and mineral composition test, together with two cowpea genotypes namely- *Ife brown* (improved variety) and *Cotonou* (land race) as control. Seeds of the mung bean and cowpea samples are presented in Figure 1. The mung bean along with the cowpea samples were also processed into Moin moin, a popular bean cake in Nigeria, for sensory evaluation. Proximate analyses of mung bean and cowpea seeds were done using the guidelines provided by AOAC (2005).

Data analyses

Mean, standard error, coefficient of variation and range were estimated. Combined analysis of variance (ANOVA) for the Ile-Ife early season, Ile-Ife late season and Kishi early season (here referred to as "Environment") was performed using Proc GLM of SAS. Duncan Multiple Range test was utilized for means separation.

Genotypic and phenotypic coefficient of variation were computed according to Singh and Chaudhary (1979) as:

$$PCV = \sqrt{\sigma^2 ph}/\bar{x} \times 100$$

$$GCV = \sqrt{\sigma^2 g}/\bar{x} \times 100$$

where
PCV : Phenotypic coefficient of variation
GCV: Genotypic coefficient of variation
$\sigma^2 ph$: Phenotypic variance;
$\sigma^2 g$: Genotypic variance;
$\bar{x}$: Mean

Table 1. Phenological growth stages and BBCH- identification keys of bean

Growth stage	Code	Description
0. Germination	00	Dry seed
	01	Beginning of seed imbibition
	03	Imbibition completed
	05	Radicle emergence
	07	Hypocotyl with cotyledons breaking through seed coat.
	08	Hypocotyle arch visible
	09	Emergence; (cracking stage)
1. Leaf development	10	Cotyledon completely unfold
	12	2 full leaves
	13	3rd true leaf (first trifoliate leaf) unfolded
	19	9 or more leaves unfolded
2. Formation of side shoots	21	First side shoot visible
	22	2nd side shoots (and this continues)
	29	9 or more side shoots visible
5.Inflorescence emergence	51	First flower buds visible
	55	First flower buds enlarged
	59	First petals visible, flowers still closed.
6. Flowering	60	First flowers opened
	61	10% of flower open
	62	20% of flower open
	63	30% of flower open (and this continues)
	65	50% of flower open
	67	Majority of petals fallen or dry
	69	End of flowering: first pods visible
7: Development of fruit	71	10% of pods have reached typical length
	72	20% of pods have reached typical length
	73	30% of pods have reached typical length
	75	50% of pods have reached typical length (and this continues)
	79	Pods: individual beans easily visible
8: Ripening of fruit and seed	81	10% of pods ripe Seeds beginning to mature
	82	20% of pods ripe
	83	30% of pods ripe (beans hard)
	85	50% of podsripe (beans hard)
	86	60% of podsripe (beans hard)
	89	Fully ripe: pods ripe (bean hard)
9: Senescence	97	Plants dead
	99	Harvest product

Source: https://en.m.wikipedia.org/wiki/BBCH-scale_(bean)

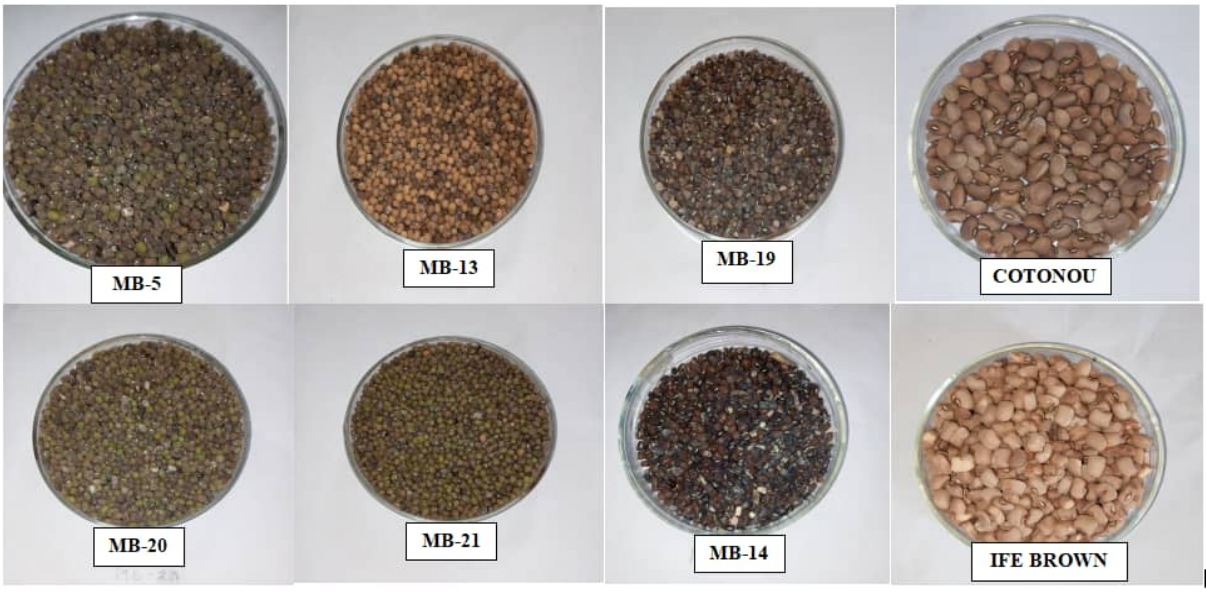

Figure 1. Seeds of the mung bean and cowpea samples

Results and Discussion

Mean square of environment was highly significant for all attributes under investigation (Table 2), this indicates the environment's influence on the traits expression. Belay et al. (2019) also observed significant environmental (year) variation for the traits they studied aside for number of pods per plant. Mean square of genotype was significant for most of the traits except days to 50% podding, days to maturity and seed yield. Significant mean square of genotype for plant height, number of days to flowering, number of days to first pod and pod length. Similar findings were reported on genotypes of mung beans by Kassa et al. (2018), Belay et al. (2019) and Yoseph et al. (2022). Mean square due to genotype by environment interaction was not significant for all the traits measure aside for number of days to 50% pod formation, implying that the accessions behaved differently across the environment for this trait.

The accessions exhibited wide ranges for all the traits studied. Mean value for plant height was observed to be 88.14 cm (Table 3). MB-8, 10, 11 and 19 were the tallest (> 100cm). The mean days to first flowering was (41.63) days, with MB-21 flowering and setting pod earliest, while MB-5 and MB-8 flowered and set pod latest. The mean number of days to 50% flowering and pod formation was 46 and 51days respectively meaning that pod formation takes average of 5 days after flowering. Mean pod length was 8.53 cm with MB-9, MB-4 and MB-17 having the longest pods (9.50 cm, 9.51 cm and 9.61 cm respectively) and MB-21 having the shortest pods (4.6 cm). Mean seed yield was 0.51kg/m^2 with MB-3, 6, 14 and 15 having the highest seed yield ranging between 0.74 - 0.94kg/m^2 MB-21 recoded the lowest seed yield (0.15kg/m^2). The shortest pod length produced by accession MB-21 could have contributed to its low seed yield value. Similar findings was reported by Aysun (2004) on longer pods of cowpea producing better yield than those with shorter pods. Mean days to maturity for the mung bean accessions was 73 days, with MB-7 reaching maturity earliest in 68 days and MB-10 had the highest mean days to maturity (78.50 days) (Table 3).

Table 2. Mean squares from combined analysis of variance for agronomic traits in the mung bean accessions at Ile-Ife early, Ile-Ife late season and Kishi early season of 2022

Source	df	PH	DFF	D50F	DFP	D50P	PL	DTM	SYD
Env	2	5349.12**	661.64**	273.06**	793.08**	211.83**	48.86**	752.89**	22.25**
Rep (Env)	6	727.77	8.25	24.28	9.41	17.84	0.31	38.87	0.58
Gen	20	515.98**	71.98**	77.53**	61.78*	37.50	16.88**	39.86	0.36
Env x Gen	40	179.93	9.02	13.51	29.61	25.42**	0.30	35.89	0.3
Error	120	108.89	7.52	11.42	30.74	9.62	0.34	37.07	0.16

PH: Plant height (cm); DFF: Days to first flowering; D50F: Days to 50% flowering; DFP: Days to first podding; D50P: Days to 50% podding; PL: Pod length (cm); DTM: Days to maturity; SYD: Seed yield (kg/m^2); Env: Environment (Ile-Ife early season, Ile-Ife late season and Kishi early season); Gen: Genotype; Rep.: Replicate; cm: centimeter **: significant at p=0.01, *: significant at P=0.05

Table 3. Mean performance of the 21 mung bean accessions for agronomic traits at Ile-Ife early season, Ile-Ife late season and Kishi early season of 2022

Accession	PH	DFF	D50F	DFP	D50P	PL	SYD	DTM
MB-1	78.56	40.89	45.89	44.56	51.00	9.21	0.26	70.50
MB-2	92.89	42.00	48.33	45.78	51.22	8.89	0.53	74.33
MB-3	80.56	41.22	45.56	44.33	49.00	8.91	0.74	71.83
MB-4	84.50	41.89	47.11	45.33	50.89	9.51	0.60	72.17
MB-5	99.40	47.89	53.57	49.44	56.83	8.60	0.48	69.50
MB-6	98.22	42.11	48.14	45.33	50.43	9.12	0.94	70.33
MB-7	80.78	41.56	46.44	43.75	50.56	8.89	0.69	67.50
MB-8	102.61	48.22	52.67	50.38	56.00	8.91	0.39	74.67
MB-9	78.11	40.67	44.89	43.00	50.75	9.50	0.47	74.83
MB-10	110.00	40.11	46.56	44.78	52.22	5.09	0.08	78.50
MB-11	103.50	42.63	48.50	45.88	52.00	9.25	0.48	76.17
MB-12	85.00	41.11	44.43	49.11	48.57	8.83	0.57	74.17
MB-13	80.56	40.33	44.33	41.56	50.22	9.33	0.34	73.00
MB-14	88.72	41.00	45.88	41.50	49.88	8.60	0.88	74.33
MB-15	86.72	43.33	48.78	45.22	51.63	9.07	0.88	75.83
MB-16	86.89	40.33	44.00	42.38	47.89	9.22	0.63	72.50
MB-17	83.06	40.67	44.56	43.00	50.44	9.61	0.36	72.00
MB-18	75.56	41.75	46.38	45.13	51.13	9.14	0.43	74.00
MB-19	102.50	41.11	46.67	45.22	51.63	4.99	0.20	76.83
MB-20	82.06	41.78	48.11	45.44	51.13	8.72	0.56	74.00
MB-21	88.33	33.67	38.56	39.11	46.67	4.60	0.15	73.67
Mean	88.14	41.63	46.46	44.77	50.78	8.53	0.51	73.37
SE	1.50	0.34	0.36	0.48	0.33	0.13	0.05	0.58
CV%	11.84	6.58	7.27	12.38	6.11	6.88	78.18	8.30
Range	38.33-116	28-56	34- 60	29- 70	40- 49	3.92- 11.4	0- 3.1	39- 87
PCV	81	43	43	39	29	47	28	25
GCV	65	41	39	28	16	46	11	8

PH: Plant height (cm); DFF: Days to first flowering; D50F: Days to 50% flowering; DFP: Days to first podding; D50P: Days to 50% podding; PL: Pod length (cm); DTM: Days to maturity; SYD: Seed yield (kg/m^2); SE: Standard error; CV: Coefficient of variation; cm: centimeter; kg: kilogram

The extent of environmental impact on any given character is reflected in the magnitude of the difference between PCV and GCV values. Large difference indicates high environmental influence, while small difference indicates high genetic influence. In this study, values of PCV were marginally greater than GCV for most traits, this implies that the expression of those traits has less of environmental influence, however traits like number of days to maturity and seed yield/plot which had high difference between the two parameters indicates a higher environmental effects. PCV and GCV values were categorized by Deshmukh et al. (1986) as above 20% were considered high, between 10-20% as moderate and less than 10% as low. PCV and GCV values were high for most of the traits, while number of days to 50% podding and seed yield had high PCV and moderate GCV values this indicates that those accessions exhibit much variation with respect to these traits and selection on them will be effective. High PCV and low GCV values was observed for days to maturity, this implies that selection based on their performance will be misleading. The greater influence of environment observed for number of days to maturity was also reported by Meena et al. (2017) in pea plants. The results obtained in this study was however contrary to the findings of Sharma et al. (2018) who reported low PCV and GCV scores for plant height, number of days to first flowering, number of days to 50% flowering and pod length.

An analysis of the mung bean accessions' yield performance in each environment is shown in Table 3. All the accessions performed best in the early season at Ile-Ife, a rain forest zone, with mean seed yield of 1.20 kg/m^2 followed by early season at Kishi, a savannah zone, with mean seed yield of 0.25 kg/m^2. The yield performance was however poor in the late season at Ile-Ife with mean seed yield of 0.01 kg/m^2. The high seed yield obtained in early season at Ile-Ife could be attributed to the moderate to high rainfall during the season which seems to favour mung bean production, coupled with the slightly acidic soil. The poor performance in the Ile-Ife late season could however be due to excessive rainfall around the time (225mm in September, 2022 alone). Asfaw et al. (2012) reported similar finding in a mung bean multi-locational trial.

The accessions vary significantly in their mean performance. MB-6, 14 and 15 performed best in the early season at Ile-Ife, with seed yield of 2.27, 2.01 and 2.28 kg/m^2, respectively, followed by MB-3 and MB-7. MB-4, 8, 16 and 17 performed best at Kishi with mean seed yield ranging between 0.41 - 0.56 kg/m^2 followed by MB-3, 7, 14 and 15. Despite the poor performance of the accessions in the late season at Ile-Ife, MB-3 and MB-4 had the highest seed yield of 0.04 and 0.03 kg/m^2 respectively. Across all the three environments, MB-3, 6, 14 and 15 had the highest seed yield with mean yield ranging between 0.74 - 0.88 kg/m^2, these accessions were also characterized with moderate plant height, therefore they are recommended as candidate accessions to be considered for improvement. Accessions 6, 14 and 15 were also identified as the best performers at Ile-Ife in the early season, each producing seed yield greater than 2 kg/m^2. These accessions could be recommended to farmers for improved yield.

The result of the proximate analyses and mineral composition of selected mung bean and cowpea seeds (control) is presented in Table 4. The proximate analyses of food reveal the basic nutrients and the specific amount of such nutrients in the food. The result revealed that mung bean seeds were higher in carbohydrates than the standard checks (Cotonou and Ife brown). Also, the mung bean seeds had lower values for protein in comparison to the cowpea samples. The report of USDHHS (2019) stated that a diet that will support growth comprise of 45-65 % carbohydrate, 10-35 % protein and 20-35 % fat. All the mung bean samples had carbohydrate and protein values within the USDHHS specified range hence it implies that it is sufficient to support the growth of the consumers. The selected mung bean accessions also had significantly lower values ($p \leq 0.05$) for fat and fibre when compared with the cowpea samples. The percentage fat in the mung bean seeds and the control cowpea seeds was far below the standard value of 20-35% fat (USDHHS, 2019). Fat content in the mung bean seeds ranged between 3.18 - 3.48 %, while COT and IFbr had 4.16 % and 4.27 % fat content respectively. Generally, legumes are low in fat, therefore, they are not abundant in vitamins that dissolve in fat, such as A, D, E, and K (Albrahani & Griavis, 2016). The only exception is soybean with 30.31 % fat and groundnut with 47.8 % fat (Erbersdoblar, et al. 2017). To balance the requirement for fat intake in mung bean and other legume diets, consumers will need to add consumable oil during food processing. Fibre content of mung bean seeds ranged between 4.15 - 4.27 %. This value will provide between 16.6 – 17.1 % and between 10.92 - 11.2 % of the Recommended Daily Allowance (RDA) for fibre in women and men respectively (Soliman, 2019). The proximate values obtained for ash were significantly higher ($p \leq 0.05$) in the mung bean than in the cowpea varieties. This result was reiterated in the result of mineral analysis. The ash content of a food is an indication of the mineral contents of that food. For most of the minerals analyzed in this study, the mung bean seeds had significantly higher values ($p \leq 0.05$) than the control cowpea samples (COT and IFbr), particularly for Mg, S, and Na, which showed significantly lower values ($p \leq 0.05$) in the control samples compared to the mung bean samples. Among the mung bean accessions, MB-20 had highest values for Fe (4842.50 mg/kg). The values for Fe in MB-20, MB-21 and MB-13 were significantly higher ($p \leq 0.05$) than value obtained for the two cowpea varieties, whereas all the mung bean accessions had better values than Ife brown cowpea variety (3100 mg/kg). The highest values for Zn were found in MB-5 and MB-13 (460.75mg/kg, 448.00mg/kg), while the least value was found in MB-21 (357.25mg/kg). The concentrations of zinc and iron in the mung bean seeds showed that consumption of 100 g of mung bean seeds will meet more than 100 % of the RDA for zinc and iron. The RDA for zinc is 6 mg/day, 8 mg/day and 11 mg/day for children, women and men respectively (Nazanin et al. 2013), whereas the value for iron is 10 mg/day, 8-15 mg/day, and 10-12 mg/day for children, women and men respectively (CDCP, 1998).

Table 4. Seed yield (kg/m^2) of the twenty one (21) mung bean accessions at Ile-Ife early season, Ile-Ife late season and Kishi early season of 2022

Accession	Ile-Ife early season	Ile-Ife late season	Kishi early season	Across
MB-1	0.67def	0.012bcd	0.10b	0.26bcd
MB-2	1.38abcdef	0.008bcd	0.21ab	0.53abcd
MB-3	1.80abcd	0.040a	0.37ab	0.74ab
MB-4	1.07abcdef	0.030ab	0.45ab	0.52abcd
MB-5	1.15abcdef	0.003d	0.20ab	0.45abcd
MB-6	2.27ab	0.002d	0.22ab	0.83a
MB-7	1.63abcde	0.002d	0.30ab	0.65abc
MB-8	0.76cdef	0.001d	0.41ab	0.39bcd
MB-9	1.18abcdef	0.001d	0.24ab	0.47abcd
MB-10	0.16f	0.028abc	0.09b	0.09d
MB-11	1.07abcdef	0.004d	0.21ab	0.43abcd
MB-12	1.44abcdef	0.012bcd	0.27ab	0.57abc
MB-13	0.85cdef	0.005d	0.09b	0.32bcd
MB-14	2.01abc	0.018bcd	0.32ab	0.78ab
MB-15	2.28a	0.010bcd	0.34ab	0.88a
MB-16	1.32abcdef	0.005d	0.56a	0.63abc
MB-17	0.64def	0.006d	0.43ab	0.36bcd
MB-18	0.99bcdef	0.007cd	0.15ab	0.38bcd
MB-19	0.43ef	0.004d	0.15ab	0.19cd
MB-20	1.27abcdef	0.005d	0.11b	0.46abcd
MB-21	0.25f	0.014bcd	0.18ab	0.15cd
Mean±SE	1.20±0.10	0.010±0.002	0.25±0.03	0.49±0.04

Means with different alphabets within the same column are significantly different at p<0.05

Table 5. Proximate analyses and minerals composition of the selected mung bean and cowpea samples

Proximate analysis					
Sample	CHO %	Protein %	Fat %	Fibre %	Ash %
MB-5	56.14±0.21a	19.57±0.23c	3.21±0.12b	4.25±0.11c	4.89±0.13a
MB-13	56.29±0.34a	19.64±0.31c	3.18±0.31b	4.17±0.31c	4.86±0.22a
MB-14	56.25±0.22a	19.29±0.22c	3.23±0.23b	4.27±0.61c	4.67±0.16b
MB-19	56.40±0.41a	19.48±0.11c	3.27±0.19b	4.23±0.42c	4.79±0.19a
MB-20	55.87±0.21b	20.16±0.14b	3.48±0.11b	4.15±0.16c	4.53±0.22b
MB-21	56.16±0.32a	19.79±0.24c	3.34±0.23b	4.21±0.29c	4.72±0.13b
COT	48.79±0.36c	24.49±0.23a	4.16±0.22a	6.81±0.19a	4.17±0.21c
IFbr	49.33±0.22c	24.78±0.22a	4.27±0.18a	5.69±0.11b	4.28±0.14c
Minerals composition					
Sample	Mg (mgkg-1)	S (mgkg-1)	Na (mgkg-1)	Zn (mgkg-1)	Fe (mgkg-1)
MB-5	427.25±2.74b	556.37± 7.24d	1041.25±4.52c	460.75±4.27a	3622.50± 3.36c
MB-13	435.50±5.05a	651.36± 5.00c	1105.00±7.95a	448.00±4.12b	4695.00±16.47a
MB-14	405.25±4.77c	664.93± 5.70c	977.50 ± 7.79e	374.00±5.04d	3057.50±13.37f
MB-19	410.00±3.11c	712.43± 3.11b	1020.00±4.62d	360.75±3.65e	3252.50±10.43d
MB-20	402.75±4.26c	658.15 ± 1.62c	1062.50±7.45b	383.75±2.94d	4842.50±11.67a
MB-21	385.75±2.32e	1126.31±7.58a	998.75 ± 8.37d	357.25±6.11e	4737.50±12.42a
COT	395.00±2.12d	312.11 ± 5.75e	913.75 ± 7.39f	415.00±5.23c	4090.00±15.31b
IFbr	399.00±4.39d	271.14 ± 7.24f	807.50 ± 6.17g	415.75±4.32c	3100.00±13.34e

Values are means of three determinations ± SEM; Means with different alphabets within the same column are significantly different at p<0.05; COT = Cotonou; IFbr= Ife brown; CHO = Carbohydrate; SEM: Standard error of mean; Mg = Magnesium, S = Sulphur, Na = Sodium, Zn = Zinc, Fe = Iron

The sensory evaluation of Moin-moin (bean cake) samples prepared from the selected mung bean revealed that consumers preferred Moin-moin made from MB-20 over other mung bean samples, citing its superior color, appearance, flavor, texture, and taste (Table 5). The flavor, texture, and taste scores for most mung bean samples were significantly better ($p \leq 0.05$) than the control samples (COT and IFbr). Notably, Moin-moin from MB-19 and MB-21 were the least accepted, while Moin-moin from other mung bean samples were well accepted and comparable to Ife brown. However, Moin-moin from Cotonou (COT) was not well accepted. The overall acceptability of Moin-moin from MB-20 was higher, although not significantly different ($p \leq 0.05$), from Ife-brown Moin-moin. The preference for Moin-moin made from mung bean seeds, particularly MB-20, can be attributed to their high flavonoid content, which is responsible for their desirable color, fragrance, and flavor characteristics. This finding supports earlier research by Ibeogu et al. (2021), who stated that Moin-moin from mung bean seeds scored higher than those from lablab and cowpea seeds due to their high flavonoid content.

Table 6. Sensory evaluation of Moin-moin (bean cake) prepared from the mung bean and cowpea samples

Sample	Colour (1-9)	Appearance (1-9)	Flavour (1-9)	Texture (1-9)	Taste (1-9)	Overall acceptability (1-9)
MB-5	6.86 ±0.1c	7.00 ±0.1b	6.86 ±0.3a	7.14 ±0.1a	6.57 ±0.2b	6.80 ±0.2b
MB-13	7.13 ±0.1b	7.00 ±0.1b	6.71 ±0.2b	7.00 ±0.1b	6.71 ±0.1a	6.80 ±0.2b
MB-14	6.71 ±0.1d	7.14 ±0.2a	6.42 ±0.2c	6.14 ±0.2d	6.57 ±0.2b	6.60 ±0.3b
MB-19	5.33 ±0.2f	5.00 ±0.1d	5.14 ±0.1d	4.86 ±0.3f	4.71 ±0.1c	4.00±0.1d
MB-20	7.43 ±0.1a	7.14 ±0.2a	6.86 ±0.1a	7.14 ±0.2a	6.71 ±0.2a	7.50 ±0.1a
MB-21	3.57 ±0.2g	3.57 ±0.1e	4.00 ±0.2f	4.50 ±0.3g	3.52 ±0.2e	4.20 ±0.2d
COT	5.86 ±0.2e	5.86 ±0.1c	5.00 ±0.1e	5.43 ±0.1e	4.57 ±0.1d	5.00 ±0.2c
IFbr	7.43 ±0.1a	7.14 ±0.2a	6.43 ±0.3c	6.71 ±0.2c	6.57 ±0.1b	7.20 ±0.2a

Values are means of 20 determinations ± SEM; Means with different alphabets within the same column are significantly different at $p<0.05$; COT = Cotonou; IFbr= Ife brown; SEM = Standard error of mean; (1-9): 1 for least and 9 for highest.

Previous research findings revealed that flavonoids concentration in mung bean seeds ranged between 125 – 352 mg QE / 100g seed (Wang et al. 2021), while that of cowpea ranged between 7.46- 23.95 mg QE / 100g seed (Sombie et al. 2018), which may explain the consumer preference for Moin-moin made from mung bean seeds.

Conclusion

Adaptability and nutrient assessment of any introduced crop is vital in crop improvement. This research revealed that mung bean is well adapted to the southwest ecology of Nigeria, however, excessive rainfall limits its yield. Seed yield was better at Ile-Ife early season, which may be attributed to the slightly acidic nature of the soils and the moderate to high rainfall at the period which favored its growth. Mung bean has protein content level comparable to that of cowpea and is richer in some major mineral elements such as iron and zinc, and could therefore be included in household diets. MB-5, 13 and 20 are high in nutritional contents, while MB-3, 6, 14 and 15 had good yield performance across the study locations. These accessions could be selected for further breeding work.

Acknowledgements

The authors appreciate the technical assistance of the members of staff in the study locations and in the Agricultural Value Addition laboratory of the Institute.

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