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Research Article

Screening of 30 advanced common bean (*P. vulgaris,* L) lines for short cooking time using two different methods

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Abstract :
An experiment was conducted at SUA to evaluate 30 bean lines along with 2 checks for cooking time. In this experiment, two different methods (Matson and Bags method) were compared. After being harvested the lines were stored for three months followed by screening for cooking time and descriptive sensory evaluation. The data obtained were subjected to analysis of variance (ANOVA) and New Duncan Multiple Range Test (NDMRT) using MSTAT-C software. Descriptive sensory evaluation data were subjected to K – means cluster analysis using SPSS software. Correlation coefficients (r) between cooking time, seed characteristics and sensory evaluation determined. Results of this work showed significant differences among bean lines in seed size and hydration capacity. Bean lines EG10R51, EG10R25, EG21R35, EG21R31, EG10R11, EG10R28, EG21R34, EG21R5 and EG21K7 absorbed more than 1000g of water per kilogram of seed, thus termed as of good hydration capacity. There was a significant difference in cooking time among bean lines tested and between the two cooking methods. In Bags method, the range of cooking time was from 24 to 53 minutes while in Matson method the cooking time ranged from 29 to 83 minutes. Among them, EG10R51, EG21R5, EG10K4, EG10R11, EG10R28, EG21R30, EG10R44, EG21R31 and EG21K5 had significantly longer cooking time in Bags method than in Matson cooker while lines EG21K5, EG21R36, and EG10K6 recoded significantly longer cooking time in Matson device compared to Bags method. Bean lines EG10R43, EG10K4, EG21R30, EG10R44, EG21R17, EG10R49, EG21R52 and EG21R18 were classified as fast cooking under Matson method but clustered as moderate cooking time under bags method. Small seeded seeds absorbed more water compared to large seeded seed. It was concluded that Bags method of screening for cooking time is best over Matson method due to its low cost of materials and ability to cook many lines at a time. Therefore, Bags method can be adapted as a new efficient screening method for common bean cooking time.

Key words:
Cooking quality, Matson method, Bag method and *Phaseolus vulgaris* L.

Introduction

Common bean (*Phaseolus vulgaris* L.) is an ancient pulse crop originating in Central and South America. From these regions arose a wide array of beans differing in color, shape, and size (Gepts and Debouck, 1991). These visual characteristics are the basis for the characterization of today's bean market classes. The common bean (*Phaseolus vulgaris* L,) is one of the most important grain legumes crops of Tanzania. (Mushi and Edge, 1989; Kamala, 1989). The common bean (*Phaseolus vulgaris* L.) could have been domesticated independently in Central and South America.

Legumes are often called "the poor people's meat," however, they might be better known as the "healthy people's meat." Many legumes, especially soybeans, are demonstrating impressive health benefits.

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Legumes contain many important nutrients and phytochemicals, and when combined with grains, they form a complete protein. It is well known that a significant problem with legumes in general that they do not soften easily and remain hard even after two or more hours of cooking in boiling water. The phenomenon of hard-to-cook legumes is very common especially in the frequently consumed common beans (*Phaseolus vulgaris*).

According to Reyes and Paredes (1993), the grain quality of common beans is determined by factors such as acceptability by the consumer, soaking characteristics, cooking quality, and nutritive value. Cooking time is one of the quality variables of beans in the market worldwide. Some bean varieties cook faster than others. In Tanzania Kabanima and Uyole 84 varieties cook slow; Uyole 94, Uyole 96, Wanja, Urafiki, Uyole 03, Kablanketi and Masusu cook fast; Uyole 98, Uyole 04 and BILFA – Uyole cook very fast (Hillocks, 2006). Cooking time in beans is becoming a very important market trait worldwide because the cooking process consumes fuel and time.

Cooking fuel is becoming a very important constraint in both rural and urban areas in Tanzania. For example, high costs of electricity, natural gas, kerosene and charcoal in urban and high cost of getting firewood in rural areas has created the habit of consumers to prefer fast cooking bean varieties. In Tanzania, a local bean variety known as "Kablanketi" originating from the Southern Highlands is now the preferred bean in Dar es Salaam and other big towns because it cooks fast, tastes sweet, and produces a reddish broth (Wortmann *et. al.,* 2004).

Materials and methods

Seeds of 32 bean lines (30 + 2) from the bean project in the Department of Crop Science and Production at Sokoine University of Agriculture were used in this study. These were EG10R13, EG21R4, EG21R29, EG21R5, EG10K4, EG21R3, EG10R28, EG10R49, EG10R44, EG21R17, EG21R31, EG21R30, EG21K6, EG10R25, EG10K1, EG10K2, EG21K7, EG10R43, EG10R11, EG10R42, EG21R35, EG21R18, EG21R34, EG21K5, EG10R51, EG21R28, EG21R36, EG10R12, EG10R13, EG10K6, ROJO and KABLANKETI . These lines are from crosses Kablanketi × SUA 90 and Kablanketi × Rojo. Kablanketi and Rojo varieties were used as controls. Each of the 32 bean lines was planted in a single row plot. The plant spacing was 10cm × 50cm and each row was 10m long such that it contained about 100 seedlings at emergency. After harvest, the seeds were stored at the seed storage facility of the Department of Crop Science and Production, SUA, for three months.

After three months of storage, the bean lines were screened by using the two methods; Matson bean cooker method (Matson) and bags method. Matson cooking device was used as the conventional method while bags method (Minnar and Magwela, 2006) was used as a new method for testing cooking time of beans.

In Matson method, 25 seeds from each line was sampled and their weight obtained by using top-pan balance. Then they were soaked for four hours in distilled water and re-weighed to obtain the second weight. The amount of water absorbed was obtained by subtraction of the two weights. Thereafter, the 25 seeds from each line were filled in each of the 25 cylindrical holes of the Matson cooking device in such a way that the piercing steel rods were in contact with the surface of each of the bean seed from top. The Matson cooker was set at 95°C and cooking timing started. Cooking was considered ready when the tip of the steel rod has completely dropped through the bean seed thereby piercing the seed.

In bags method two holes were made on the top side of the lager plastic bag by using a regular paper-hole punch and plastic bags hung using their punched holes, with a 20cm metal rod on large cooking container. The small plastic bag was weighed and the weight recorded. Beans were added to a smaller bag until about 5.0 grams of seeds and their number recorded. 60 ml of water was then added to the large plastic bag. Smaller bags were put into the larger bags and samples placed on rods through the holes of the larger bag and placed in a container in an upright position. Then the samples were held at 20 - 25°C for 16 hours using an incubator (the samples were soaked for 16 hours, any pigmentation leaching was noted). Then a rod was placed through the holes in the larger plastic bag, such that there were 12 bags per rod. The bags were then placed on the rod into a big pot of boiling water, such that bags were hanging into the water from the rods. The time required for the water to rise to 95°C was recorded again. Timing commenced when the temperature reached 95°C. After the predetermined cooking time, the plastic bags were removed. The ending time of cooking was recorded. The ideal time was when the majority of samples were fully cooked, but not over-cooked, therefore some samples were under-cooked and some over-cooked. Smaller bag was lifted to allow cook water to drain back into the larger bag. Broth was poured from the large bag into a container or glass beaker and covered with lid. Broth was kept for sensory evaluation (broth was kept warm). This was done by placing containers in an incubator set at about 50°C.

The experimental design used was completely randomised design (CRD) with four replications. Each method was conducted separately and the results were compared. The experiment was carried out in laboratory at the Department of Food Science and Technology Department laboratory, Sokoine University of Agriculture, Morogoro. Tanzana. Data obtained (cooking time in both methods and hydration capacity), were subjected to analysis of variance (ANOVA). Significant differences between means were determined using New Duncan Multiple Range Test (NDMRT). All data were analysed using MSTAT-C analysis software.

Results and discussions

There was significant differences ($P< 0.05$) among bean lines tested in mean cooking time under two different methods. When mean cooking time of same line was compared across different methods, T – test showed only 12 lines (37%) out of 32 tested significantly different ($P \leq 0.05$) in mean cooking time. Among these lines, EG21R5, EG10K4, EG10R28, EG21R30, EG10R44, EG21R34,

EG10R43, EG21R3, EG10R13, EG10K1, EG21R17, KABLANKETI, EG10R49, EG21R29 and EG21R18 had significantly longer cooking time in Bags method than in Matson cooker while lines EG10R42 and EG21K7 recoded significantly longer cooking time in Matson device compared to Bags method. It was also found that among the small sized beans, there were some bean lines that cooked fast in one method but longer in another method (Table 1).
When cooking time was classified into long, medium and short cooking time different methods resulted into different cluster ranges (Table 2 and 5). Bags method had fast cooking time ranging from 24 – 33 minutes (cluster mean 30.78), medium cooking time ranging from 33.1 – 43 minutes (cluster mean 42.97) and long cooking time ranging from 43.1 – 53 minutes (cluster mean 50.96). In the other hand, Matson cooker method fast cooking time ranged from 29 – 40 minutes (cluster mean 36.81), medium cooking time ranged from 40.1 – 55 minutes (cluster mean 45.30) and long cooking time was ranging from 55.1 – 83 minutes (cluster mean 73.88).

Mean cooking times of both methods were ranked in order of shortest to the longest cooking time. The lines EG10R25, ROJO, EG21R31, EG21R34, EG21R5, EG21R35, EG10K6, EG10R52, EG21R18, EG21K5, EG21R17, EG21R36, EG21R4 and EG10R13 were found to rank as fast cooking lines, while the lines EG10K2, EG10R43, EG10K4, EG10R12, EG10R28, EG21R30, EG10R44, EG21K6, KABLANKETI, EG10R49, EG21R29 and EG21R28, ranked medium. The lines EG21R3, EG10K1, EG10R11, EG10R42, EG21K7 and EG10R51 ranked as having the longest in cooking time.

When the tested bean lines were classified into long, medium and short cooking time, cluster analysis (Table 5) showed that bean line EG21R34, EG10R25, and EG21R35 were classified in the first cluster under both methods. These lines showed to have the shortest cooking time, and the cooking time of these lines ranked short compared to standard variety Kablanketi. On the other hand, bean line EG21R3 and EG10R51 were classified as slow cooking lines by both methods.

Bean lines EG10R43, EG10K4, EG21R30, EG10R44, EG21R17, EG10R49, EG21R52 and EG21R18 was classified as fast cooking under Matson method but clustered as moderate cooking time under bags method. These results suggest that cooking method might have significant effect on the screening for fast cooking and may affect the selection for fast cooking to some extent.

When the ranks of bean lines in two methods were compared, spearman's rank correlation showed non-significant weak relationship between cooking time in two methods (r = - 0.253). This relationship show that at least some of the lines cook faster in one method but not necessarily in the other method. To some extent, this shows that the methods of screening for cooking time can influence selections for fast cooking bean.

Most of the lines that ranked fast cooking are the crosses of Rojo, including rojo itself. SUA 90 is a new variety that has been stated to be of excellent cookability (Mhile, 2002). The results observed in this study are therefore the combination of the characteristics of the two bean varieties SUA 90 and Rojo.

According to Mkanda *et. al*., (2007), people are generally concerned about cooking time for two reasons. First, long cooking time results in increased consumption of fuel. Most families use firewood as fuel, which is increasingly becoming scarce and expensive. Therefore, it would be to the advantage of families that consume beans to choose varieties that are fast cooking. Secondly, if beans take long time to cook, they demand a lot of time from the person responsible for cooking. In many developing countries, women have the responsibility for cooking, and their time could be better spent on the many other responsibilities that demand their attention. Bean lines EG10R25, EG21R31 and EG21K5 were cooked in less than 25 minutes similar result to that which was observed for common bean cultivars of the group carioca evaluated in São Paulo (Lemos *et. al*.,. 2004).

Conclusions

Cooking time is an important trait in the breeding of common beans (*Phaseolus vulgaris* L.), especially when beans are prepared and consumed in the household. Results of this work showed significant variation in cooking among bean lines tested under two different methods. Bean lines EG21R34, EG10R25, and EG21R35 can be considered as fast cooking as they classified in low cluster under both methods, while bean lines EG21R3 and EG10R13 are classified as slow cooking.

In this work, the two screening methods were found to be different, with regards to practicability and availability of materials. In bags method 12 lines could be tested at the same time as they can be loaded in 12 bags separately and boiled together while in Matson cooker only one line could be tested by one device or two lines if two devices were available as one device can accommodate only one variety. All the equipments required in Bags method

were bought at affordable price at the town shops in Morogoro. Equipments required in Matson method are relatively expensive. The device itself is a problem here at SUA since there are only two devices available at the Food Science Department. The device is bought overseas at a high cost compared to any of the material used under bags method. From these two vivid reasons it can be concluded that Bags method of screening for cookability is best over Matson method due to is low cost materials and ability to cook many lines at a time.

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Table 1. Mean cooking time of bean lines under two different methods

Common Bean Lines	Cooking Time (Minutes)			Rank	Probability of T test
	Bags Method	Matson Device Method	Mean		
EG10K2	43:30^{defghi}	48:00^{cde}	45:45	21	0.391
EG10R51	43:45^{defghi}	82:15^{a}	63:00	27	0.018
EG21R34	35:00^{kl}	33:45^{fg}	34:23	4	0.211
EG10R43	42:00^{efghij}	40:30^{cdefg}	41:15	16	0.278
EG10K4	44:45^{cdefgh}	43.00^{cdefg}	42:23	18	0.034
EG10R12	41:15^{ghij}	43:45^{cdef}	42:30	19	0.138
EG21R3	51:30^{ab}	49:00^{cdefg}	50:15	24	0.098
EG10R13	42:00^{ab}	40:30^{cdefg}	40:08	12	0.084
EG10K1	53:15^{a}	47:00^{cde}	50:08	23	0.091
EG21R5	37:30^{cd}	32:45^{fg}	35:08	5	0.001
EG10R28	45:45^{cdef}	47:45^{efg}	46:45	22	0.012
EG10R25	25:45^{m}	28:30^{g}	27:08	1	0.436
EG21R30	46:00^{cde}	35:45^{efg}	40:53	13	0.015
EG21R4	35:45^{kl}	43:15^{cdef}	39:30	11	0.203
EG10R44	41:15^{cdefg}	42:00^{cdefg}	41:08	15	0.014
EG10R11	42:30^{efghij}	65:30^{b}	54:00	25	0.038
EG10R42	48:45^{bc}	51:30^{c}	50:08	22	0.072
EG21R35	37:00^{l}	39:30^{cdefg}	38:45	6	0.061
EG21K6	40:45^{hij}	43:45^{cdef}	42:15	17	0.049
EG21R17	40:15^{cdefg}	37:45^{efg}	39:00	9	0.052
ROJO	27:15^{m}	31:15^{fg}	29:15	2	0.005
EG21K7	52:45^{a}	55:45^{cd}	54:45	26	0.45
KABLANKETI	44:30^{cdefgh}	43:45^{cdef}	44:08	20	0.394
EG10R49	41:30^{fghij}	40:30 ^{cdefg}	41:00	14	0.183
EG21R31	25:45^{m}	42:00^{cdef}	33:53	3	0
EG21R29	42:45^{efghij}	41:15^{cdefg}	42:00	15	0.142
EG21K5	26:15^{m}	51:30^{c}	38:53	8	0.012
EG21R36	35:45^{kl}	42:30^{cdef}	39:08	10	0.026
EG10K6	33:30^{l}	42:15^{cdef}	37:53	7	0
EG10R52	38:45^{jk}	37:00^{efg}	37:53	7	0.328
EG21R28	42:00^{efghij}	43:00^{cdef}	42:30	19	0.129
EG21R18	40:00^{ij}	37:45^{efg}	38:53	8	0.137
Mean	41:02	42:45	61:38		
LSD $_{(0.05)}$	3.7	10.5	7.1		
SE	1.3	3.7	2.5		
CV (%)	6.36	17.55	11.96		

Means followed by the same letter (s) within the column do not differ significantly at $P \leq 0.05$ according to DNMRT. 0 in the table represents values that were less than 0.001

Table 2. Ranking of the cooking Time of the common bean lines

Lines	Rank	
	Bags	Matson
EG10R25	1	1
ROJO	2	3
EG21R5	5	3
EG21R34	6	4
EG21R30	7	5
EG10R52	8	6
EG10R28	21	7
EG21R17	21	7
EG21R18	9	7
EG10R13	26	8
EG21R3	10	9
EG10R44	20	9
EG21R35	9	10
EG10K4	19	11
EG10R43	13	12
EG10R49	12	12
EG21R29	15	13
EG21R31	1	14
EG10K6	5	15
EG21R36	7	16
EG21R28	13	17
EG21R4	7	18
EG10R12	11	19
EG21K6	10	20
KABLANKETI	18	20
EG10K1	28	21
EG10K2	16	22
EG21K7	27	23
EG10R42	24	24
EG21K5	23	24
EG10R11	14	25
EG10R51	17	26

Table 3. Cooking time clusters under two different cooking methods

Bean line	Cluster group in Matson method	Cluster group in Bags method
EG10K2	2	2
EG10R51	3	2
EG21R34	1	1
EG10R43	1	2
EG10K4	1	2
EG10R12	2	2
EG21R3	3	3
EG10R13	3	3
EG10K1	2	3
EG21R5	1	3
EG10R28	1	2
EG10R25	1	1
EG21R30	1	2
EG21R4	2	1
EG10R44	1	2
EG10R11	3	2
EG10K3	2	3
EG21R35	1	1
EG21K6	2	2
EG21R17	1	2
ROJO	1	1
EG21K7	2	3
KABLANKENTI	2	2
EG10R49	1	2
EG21R31	2	1
EG21R29	2	2
EG21K5	2	1
EG21R36	2	1
EG10K6	2	1
EG10R52	1	2
EG21R28	2	2
EG21R18	1	2