Evaluating the Effects of water Imbibition on Cooking Time of Commonly Grown Bean (Phaseolus Vulgaris L) Genotypes in Semi-Arid Eastern Kenya

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Abstract:- Dry beans (*Phaseolus Vulgaris* L.) are important source of proteins, carbohydrates, essential elements and vitamins to both rural and urban households. However, cooking time is influenced by slow water imbibitions due to hard seed coats. An experiment was carried out in Seed laboratory of Kenya Agricultural and Livestock Research Institute (KALRO)-Katumani, Machakos, Kenya to evaluate the effects of water imbibition of commonly grown bean genotypes (KATX69, GLPX92, WAIRIMU, EMBEAN118, KATX56, EMBEAN14, KATB9, GLP2, KATB1, KATRAM, and KATSW-13) to cooking time in a complete randomized design with three replications. Data was collected on bean grains hardness, water imbibitions of bean varieties at different times and the effect of water imbibition on cooking time. The data collected was subjected to analysis of variance (ANOVA) using SAS (version 9.3.3) to detect differences between treatments. The results showed that KATX69 had the hardest seed coat while KAT SW-13 seed coat had the softest. In terms of imbibitions and cooking time, KATSW-13 and KAT B1 had the highest amount of water imbibed and cooked significantly faster than other varieties while GLP X92 took significantly the longest time to cook. The study recommends breeding of bean varieties with less permeable seed coat to aid in fast cooking as this would save cost on time and fuel.

***Keywords**:- Water Imbibitions Cooking Time, Phaseolus Vulgaris L, Hardness.*

I. INTRODUCTION

Globally, common bean (*phaseolus vulgaris L.*) is the most widely produced and consumed crop in the world with low lipid and high content in proteins, vitamins, complex carbohydrates and minerals (Gathu and Njage 2012, Barros and Prudencio 2016). Common beans are mostly consumed after cooking and those that require long cooking times are less convenient, more energy consuming, and therefore, with inferior nutritive quality, less desirable to consumers and processors (Wiesinger *et al.,* 2016). Prior to cooking, the beans are soaked in water for hours in order to soften them, reduce anti-nutritional substances, reduce cooking time and the cost of cooking fuel to improve the nutritional quality (Zamindar *et al.,* 2013, Ghasemlou *et al.,* 2013, Siah *et al.,* 2014, Njoroge *et al.,* 2015). Soaking of beans is an important process because it involves the absorption of water by cell wall and macromolecules like proteins and polysaccharides (Blochi *et al.,* 2008; Yang *et al.,* 2010; Raes *et al.,* 2014). During imbibition process the seed swell rapidly and changes in size and shape (Cheng *et al.,* 2010; Li *et al.,* 2016; Mwami *et al.,* 2017). The imbibed water activates enzymes and facilitates metabolism of the stored starch and protein in seed (Buckeridge *et al.,* 2000; Rajjou *et al.,* 2012) and thus, water imbibition is the most important event for ensuring seed coat permeability of water in cooking and energy generation for the commencement of faster cooking and supply of nutrients (Abebe and Modi, 2009). During the process of water uptake, the cell wall enlarges and seed coat becomes softened allowing oxygen diffusion for seed respiration. The amount of water to be imbibed for faster cooking depends on the genotype and species. Like for example in soybean out 50% water and maize around 34% (Tiwari *et al.,* 2014). The Physical properties, such as seed size and weight, seed coat and cotyledon characteristics, influence pulse cooking quality (Pirhayati *et al.,* 2011). The breeding of common bean for grain characteristics that cook faster is of great importance to bean consumers and the breeders of common bean varieties aim at developing varieties with faster cooking time and market acceptability for both the packaging industry and consumer preferences (Santos *et al.,* 2016). The loss in cooking quality is associated with the development of hardness in stored dry beans that are mostly preserved in dry storage at ambient temperature to maintain year-round supply of this important protein food source (Chávez-Servia *et al.,* 2014*).* Additionally, the long cooking time of some bean varieties discourage use especially in urban settings where time is often a major constraint (Anozie *et al.,* 2007; Katungi *et al*. 2011; Namugwanya *et al.,* 2014). Studies have shown that, bean genotypes are mostly evaluated for agronomic performance but are not systematically assessed for seed coat properties and cookability (Hamid *et al.,* 2016). Therefore, the purpose of the current study was to evaluate the effects of water imbibition in relation to cooking time of selected common bean varieties in semi-Arid region of eastern Kenya in order to enhance the consumption rate of the selected bean varieties by bean consumers.

II. MATERIALS AND METHODS

A. Description of the site

The bean genotypes used in this study were obtained from Kenya Agricultural and Livestock Research Organization, Katumani, Machakos County, Kenya, located at latitude $11^0$35'S: longitude $37^0$14'E, and 1560M above sea level.

B. Seed Management

The bean genotypes were grown and harvested in long rains of the year 2016. After harvesting the bean samples were naturally dried to a moisture content of 13% and placed in small paper bags measuring 15.5cm width and 18.5cm height and a capacity of 3kg of the grains and dusted with pesticide and stored under normal room temperature and relative humidity. The beans had been stored for between 5 and 8 months under normal temperature and humidity conditions.

C. Seed preparation

After retrieval from the storage, the whole grains of each of the bean genotypes were sorted by hand using a sieve of 2mm size to remove extremely small beans and broken ones, small stones, split seeds and defective seed coat or excessively dirty materials. These beans were cleaned and size-graded manually and categorized as follows: 20-30g-small, 31-40g-Medium, 41-50g-big. The bean genotypes were selected based on the field records from the previous seasons which showed the characteristics of each genotype and its yield stability over a range of conditions (biotic and a biotic stresses).The bean seeds were then rinsed with distilled water to eliminate insecticide residual before soaking and cooking. The grains were soaked in a container 8cm high, a diameter of 9.5 cm and a capacity of 1000ml with distilled water at varying soaking times of 3hr, 6hr, 12hr and 24hr.

Bean hardness was measured using crust hardness meter where grains were randomly taken from each category before and after soaking to measure the hardness of bean genotypes. Averages of six measurements were recorded from each bean genotype. Cooking time was monitored using an automated Mattson Cooker (MBC) to get the mean cooking time (CT) of beans. The grains were positioned on the cooking rack which has twenty five perorated saddles on the MBC that hold the grains. The vertical plunger on the MBC was placed on the surface of the grain, where it penetrated the grain after it sufficiently became soft and cooked. The cooking of the beans was proceeded by immersing MBC in a beaker with boiling water (98^0C) over a hotplate. Cooking time was recorded as the time in minutes needed to penetrate 50% of the beans; conventionally adopted as the falling time of the 13^{th} plunger on the beans. All measurements were replicated three times.

Fig 1:- The picture of bean varieties used in this study: 1 (KATSW-13), 2 (WAIRIMU), 3 (EMBEAN118), 4 (KATB9), 5 (EMBEAN14), 6 (KATB1), 7 (KATX69), 8 (GLP2), 9 (KATRAM), 10 (KATX56), 11 (GLPX92).

Fig 2:- Shows the cooking rack immersed in boiling water during cooking of the bean genotypes

D. Statistical analysis

Analytical determinations for the samples were performed in triplicate. A comparison of the means was ascertained with Fisher's protected least significant difference test (LSD) at ($p \leq 0.05$) level of significance using analysis of variance (ANOVA) SAS: 9.1.3 to detect differences between treatments.

III. RESULTS

A. Effects of bean grain hardness in Newton (N) in different bean genotypes

Differences in hardness of beans genotypes were observed (Table1). The bean genotypes varied significantly ($p \leq 0.05$) in hardness of their seed coats during various imbibitions times. At zero soaking time GLPX92 and KAT X69 were the hardest followed by KATB1, KATRAM, Embean118 and Wairimu which were not significantly different from each other followed by KATB1, KATWS-13, GLP2 and Embean14 which were not significantly different from each other followed by and KATX56 in that order. Overall, KATX69, was the hardest followed by KAT B9, GLP X92, KATRAM which were not significantly different from each other, followed by Embean 118, Embean and Embean 14, followed by KAT B9,Wairimu and GLP 2 which were not significantly different from each other, followed by KAT X56 and KAT SW-13 in that order.

GENOTYPE	0hr	3hr	6hr	12hr	24hr	Mean
GLPX92	32.06Aa	27.55Aa	18.89Be	13.45Cd	8.28Ce	20.05b
KATX69	31.39Aa	26.34Ab	20.00Bc	17.28Ca	9.56Da	20.91a
EMBEAN118	28.61Ac	22.28Af	19.33Bd	13.50Cd	8.39Ce	18.42c
WAIRIMU	28.56Ac	24.89Ad	14.67Bf	13.61Cd	8.06Ce	17.96d
EMBEAN14	25.55Af	23.22Be	18.56Be	15.44Cb	10.33Ca	18.62c
GLP2	25.78Af	20.67Bg	18.6B1e	13.94Cd	9.00Cd	17.6d
KATX56	23.06Ag	17.28Bh	13.66Cg	12.56Ce	9.89Cb	15.29e
KATB9	27.89Ad	25.50Ad	20.33Bb	16.61Ba	9.00Cd	19.87b
KATRAM	29.11Ac	25.55Bc	20.50Ba	14.55Cc	9.78Cc	19.90b
KATB1	30.67Ab	25.17Bd	15.06Cf	11.61Dg	7.44Df	17.99d
KATSW-13	27.17Ae	16.94Bh	12.61Bh	7.18Ch	5.83Cg	14.55f
C.V%	5.45	7.64	7.92	9.29	12.61	
LSD in columns LSD in across	0.71 5.38					

Table 1. Effects of bean grain hardness in Newton (N) in different bean genotypes

Means in the same row followed by different upper case letters (A, B,C) or in the same column followed by different lower case letters (a, b ,c, d) are significantly different at ($P < 0.05$) using Fisher's LSD

B. Comparison of water imbibitions (g) in different bean genotypes

Water imbibed by the beans increased with increase in soaking time (Table 2). Water Imbibition ability of bean genotype varied significantly ($p \leq 0.05$) among the bean genotypes. On average, KAT B1 and KAT WS-13 had the highest amount of water imbibed followed by KAT X56, KAT B9 and KATRAM which were not significantly different from each other followed by GLP 2, EMBEAN14, WAIRIMU,EMBEAN118,KAT X69 and GLP 2 which were not significantly different from each other.

GENOTYPES	0hr	3hr	6hr	12hr	24hr	Mean
GLPX92	0.00Aa	1.00De	4.33Ce	6.33Bf	11.00Ac	4.53d
KATX69	0.00Aa	3.33Ba	6.00Ac	7.33Ad	7.33Ag	4.80d
EMBEN118	0.00Aa	2.00Dc	4.00Cf	6.33Bf	9.33Ae	4.33d
WAIRIMU	0.00Aa	2.00Bc	6.00Ac	7.00Ae	7.33Ag	4.47d
EMBEAN14	0.00Aa	2.13Cb	6.00Bc	7.00Ae	8.00Af	4.63d
GLP2	0.00Aa	1.33Dd	4.33Ce	6.33Bf	11.00Ac	4.60d
KAT X56	0.00Aa	2.00Dc	5.33Cd	9.00Bc	12.33Aa	5.73b
KATB9	0.00Aa	2.00Cc	6.00Bc	9.00Ac	10.33Ad	5.47c
KATRAM	0.00Aa	1.33Dd	3.00Cg	10.33Bb	12.00Ab	5.33c
KATB1	0.00Aa	2.33Cb	7.00Bb	11.00Aa	12.00Ab	6.47a
KATSW-13	0.00Aa	4.00Ca	8.33Ba	10.33Ab	10.33Ad	6.60a
LSD in columns	0.67					
LSD in rows	1.6					

Table 2. Comparison of the amount of water (g) imbibed at different soaking time by different bean genotypes.

Means in the same row followed by different upper case letters (A, B,C,D) or in the same column followed by different lower case letters (a, b ,c, d, e, f, g) are significantly different at (P < 0.05) using Fisher's LSD

C. *Effects of Water Imbibition on Cooking Time of Bean Genotypes*

The bean genotypes decreased significantly ($p \leq 0.05$) in cooking time with increased soaking time (Table 3). On average, KAT B1 and KATSW-13 took the shortest time to cook followed by KAT X56, GLP 2 and EMBEAN 14 which were not significantly different from each other, followed by EMBEAN 118, KAT B9, WAIRIMU, KAT X69, KATRAM and GLP 92 in that order.

GENOTYPES	0hr	3hr	6hr	12hr	24hr	Mean
GLPx92	111.87Ac	96.95Bb	90.60Ba	80.16Ca	56.1D1b	87.14a
Katx69	109.09Ac	82.78Be	72.59Cb	72.93Cb	65.00aC	80.48b
Embean118	105.81Ad	90.06Ac	61.54Bc	57.12Bc	35.07Cd	69.92d
Wairimu	115.04Ab	92.38Bc	61.58Cc	51.98Cd	38.34Dd	71.86c
Embean14	108.59Ac	68.68Bf	61.16Bc	41.38Ce	33.43Cd	62.65e
GLP2	107.28Ac	88.71Bd	47.50Cf	38.60Ce	26.02De	61.62e
Katx56	107.13Ac	67.39Bf	48.68Ce	42.81De	33.03Dd	60.21e
KatB9	121.17Ab	85.35Bd	63.71Cc	57.03Dc	45.27Ec	74.51c
Katram	145.00Aa	100.95Ba	63.18Cc	48.00De	40.19Dd	79.46b
KatB1	97.80Ae	88.04Ad	45.16Bf	28.03Cf	21.76Ce	56.16f
Katsw-13	88.76Af	71.57Bf	57.31Cd	40.06De	31.58De	57.86f
LSD in column	6.97					
LSD in rows	11.25					

Table 3. Effects of soaking bean varieties on cooking time of bean genotypes

Means in the same row followed by different upper case letters (A, B,C,D) or in the same column followed by different lower case letters (a, b ,c, d, e, f) are significantly different at (P < 0.05) using Fisher's LSD

IV. DISCUSSION

A. Genotypic hardness of bean grains (N)

The observed differences in hardness (N) of beans genotypes in soaked and unsoaked state could be attributed to differences in the nature of the seed coat. This study agrees with an earlier study by Borji *et al.*, 2007 who attributed the differences in hardness of beans genotypes to differences in hardness of the bean seed coat. Similar findings were reported by Wani *et al*., 2017 who found differences in hardness of different seed genotypes.

B. Comparisons of water imbibitions among bean genotypes

The trend observed in imbibition of water by beans genotypes at different soaking times could be attributed to differences in the hardness of the seed coats. This concurs with earlier studies by Vasudeva and Vishwanathan (2010) and Mwami *et al.,* (2017) who attributed differences in water imbibition of different bean genotypes to differences in biochemical structure of seed coat of different bean genotypes which hinders the penetration of water even without the seed coat.

C. Effects of water imbibition on cooking time of bean genotypes

The observed differences in cooking time can be linked to the permeability of the bean seed coat which influences imbibition of water in the individual genotypes. Similar findings were reported by Borji *et al.,* (2007) and dos Santos Siqueira *et al*., (2013) who attributed differences in water imbibition by different bean genotypes to differences in hardness of the seed coat. A Study by Mwami *et al*., 2017 attributed poor imbibition of bean grains to hard seed coat which negatively affects cooking time as indicated in a similar study by Wani *et al*., 2017.

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