Hydration and culinary profile of improved common bean (*Phaseolus vulgaris L*) cultivars

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Abstract

Fifteen improved bean cultivars were evaluated for their culinary properties against landrace (control) from different growth altitudes cultivated in Rwanda. Standardised methods were adopted to analyze properties of soaked and unsoaked beans: cooking time, water absorption capacity and percentage splitting of the seed coats, broth pigment and texture of the cooked beans. Cooking time for soaked beans (μ = 55.2 min) was less compared to unsoaked beans (μ = 133.3 min) across all growth altitudes. Water absorption during cooking by soaked bean (μ = 5.4 gm) was only slightly less than unsoaked beans (μ = 6.6 gm). Mean splitting of beans during cooking by soaked beans (μ = 29.8 %) was more than unsoaked beans (μ = 8.6%). Pearson correlation analysis was positive between soaked and unsoaked seed variants for cooking time, water absorption and splitting of seed coat and cotyledon but not significant at 5% level. Majority of the bean cultivars (93.75%) cooked well upon soaking. Yet, evaluation of soaked beans across different growth altitudes was not significant at 5 % level when compared with control for cooking time and water absorption. This concluded that the improved varieties did not influence the culinary properties of soaked beans irrespective of growth altitude. Texture of all soaked and cooked cultivars showed almost similar texture within 50min of cooking, except Gasirida which remained undercooked. Broths of all cultivars, irrespective of soaking, were pigmented (88%) except RWV3006 and CAB2.

Key words: Bean culinary, bean hydration, water absorption capacity, splitting of seed coat; finger press characteristics, growth altitude

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Introduction

Production of dry beans is an important activity in Rwanda because it is an essential dietary staple food crop. Legumes play an important role in human nutrition, especially among low-income groups in developing countries. Beans are the primary source of dietary proteins in Rwanda as they supply 65% of national dietary proteins compared to 4% from animal sources, so it provides both food and nutritional security. Beans also contribute a generous amount of energy (32%); and micronutrients such as iron, zinc and B vitamins that promote normal human body and cognitive growth and development. Due to their diversified nutritional content and predominant protein supply in Rwandan diets, beans are regarded as a near-perfect food. It is estimated that beans cover 22 – 30 % (270,000 to 320,000 ha) of cultivated land, with an annual production of about 290,000 tons (Rubyogo et al., 2007; Karinganire 2011). Rwanda also has the highest consumption rate in the world: around 60 kg per person compared to 17 kg in Africa.

Beans have significant amounts of soluble fibre and one cup of cooked beans can provide nine to thirteen grams of fibre. Soluble fibre can help lower blood cholesterol. Beans are also high in protein, complex carbohydrates, folate, and iron (Geil & Anderson, 1994). Rwanda, and several other countries like Brazil use beans as their staple food (Costa et al., 2006) supplying significant amounts of protein, calories, unsaturated fatty acid (linoleic acid), food fibre, mainly soluble fibre, besides being an excellent source of some minerals (iron and zinc) and vitamins (Berrios et al., 1999). Despite these advantages, bean grains have some undesirable characteristics that limit their acceptability or nutritional value, such as: hard-to-cook phenomenon, anti-nutrients or anti nutritional factors or limitation in some amino acids of high biological value (Jood et al., 1986; De-Leon et al., 1992; Vidal-Valverde and Frias, 1993; Barampama and Simard, 1994; Costa et al 2006). As such, Rwanda has one of the highest diversity of beans in Africa. It has so much variety in terms of colour, types and Rwandan farmers have immense knowledge on beans. However, the energy used in cooking beans is so expensive; in villages, firewood's are not only scarce, they affect the environment adversely apart from being time consuming. For low income groups, the reduction in energy (firewood / charcoal) cost is definitely a vital factor in choosing a specific cultivar. In solving such problems, cooking time evaluation is a priority before recommendation is given to a particular cultivar. Cooking, a hydrothermal process that involves texture softening due to starch gelatinization and protein denaturation is intended to make beans palatable and digestible after elimination of antinutrients. Unfortunately, bean processing methods in Rwanda are still traditional and unimproved; cooking beans can take around (3-4 hours) of boiling on charcoal or firewood even among the city dwellers. The rapid pace of today's technologically advanced world does not provide ample time to have such prolonged time for cooking. The cooking of un-soaked dry beans takes much energy in the form of firewood, charcoal while even gas and electricity is not economical. The significance of this study focuses on providing relevant information about the changes in the culinary characteristics due to agronomic or breeding improvements and relationship of growth altitude with culinary characteristics. This study will also help processors to identify quick cooking attributes of the improved cultivars of beans that would be easy to process. While for home processing, it would provide details of selecting varieties that are economical to cook and save cooking time which otherwise under traditional circumstances would require 3-4 hours. Therefore the objective of the study was to determine the influence of growth altitude and cultivars of beans on the hydration capacity and culinary properties by determining their cooking time, assessing the water imbibed during soaking and cooking; determine the percentage splitting of seed coat and cotyledon during cooking and to subjectively evaluate sensory attributes perceived by finger press test and determination of colour of broth after soaking and cooking using five point rating scale.

Materials and Methods

Bean cultivars and their characteristics: Rwanda has various agro-climatic zones and beans are cultivated at various altitudes. Details of the fifteen bean cultivars in Rwanda *viz.,* MAC44, MAC9, RWR2361, CAB2, RWR2154, RWR2245, Gitanga, RWV3006, RWV3316, RWV2070, RWV2887, G2331, RWV2872, RWV 3317, RWR 1129 that were used for the study were released either in 2010 or 2012. These cultivars suitable to either high altitudes, mid and low altitudes or high and mid

Altitudes (Table 1). The landrace Gitanga grown throughout the country served as control.

Table 1 - Bean cultivars and their altitude

Bean Variety	Year of release	Growth altitude
GITANGA	Land race (control)	All agro-climatic zones
RWR 2361	2012	high altitudes
CAB 2	2010	high altitudes
RWV 2887	2012	high altitudes
RWV 3316	2012	high altitudes
RWV 3317	2012	high altitudes
GASIRIDA	2010	high and mid altitudes
RWR 1129	2010	high and mid altitudes
RWV 3006	2012	high and mid altitudes
G 2331	2010	high and mid altitudes
RWV 2872	2012	high and mid altitudes
RWV 2070	2010	high and mid altitudes
MAC 44	2010	mid and low altitudes
MAC 9	2010	mid and low altitudes
RWR 2154	2010	mid and low altitude
RWR 2245	2010	mid and low altitude

Sample preparation and cooking method: Bean hydration blanching, and thermal processing are important to the final quality of the product (Matella *et al.,* 2013). Fifteen new bean cultivars and the land race were obtained from Rwanda Agriculture Board (RAB). Healthy seeds were sorted and rinsed several times thoroughly with deionized water to remove all kinds of impurities. Fresh deionized water was used in soaking for all the experiments. Soaking of beans was conducted at 22 °C for 16 h. The following method is the procedure standardised by University of Pretoria (Mwangwela *et al.,* 2007) that compared well with the Matson Bean Cooker that is usually used. Ten seeds of each bean variety were weighed and soaked overnight in 60ml of deionized water for 16 hours. The soaked water was incubated at 50^0C for further sensory evaluation, while the soaked beans were drained, and the seeds were subjected to cooking. Cooking was done by placing each variety in small heat stable zip lock bags punched at the bottom that were placed in larger zip lock bags containing 60ml of deionized water. The large plastic bags containing samples were hung in a parallel position in a saucepan with boiling water. The electric heat plate was used to heat the saucepan and hold the water at boiling temperature.

Determination of cooking time: A sample of 100g of bean seed was soaked in deionised water for 16hrs and then drained. The drained sample was placed in the zip-lock bags and cooked in boiling water. The duplicate sub-samples (10 seeds each) were taken using a spoon at a 2minutes interval and tested for softness by squeezing the seed between the fore finger and the thumb. Standardised tactile finger pressing test method (Mwangwela et al., 2007) that subjectively determined the cookability of beans was used to determine the cooking time. A seed is deemed to be cooked when it can be squeezed easily between the thumb and the forefinger (Kinyanjui, *et al.*, 2015) and this was the measure used. This was done so as to know the cooking time, water imbibed and solid loss during soaking and cooking, and other changes on the physical properties of the beans.

Splitting of cooked beans: the tendency of seeds to split during cooking was determined (Mwangwela *et al.,* 2007; Kinyanjui, *et al.,* 2015). The number of beans with split seed coats and cotyledons was counted as the number of splits. The percentage of splitting was calculated as follows:

$n/N * 100\%$ Where, number of split seeds = n; number of whole seeds = N

Evaluation of tactile attributes: subjective evaluation of broth in soaked and cooked solutions and finger pressing test (Kinyanjui, *et al.*, 2015) were used to determine the cooked texture of beans. For each cultivar, triplicates were conducted in all the experimental procedures described above.

Statistical Analysis

Results were subjected to Tests of Significance where μ represents the average score of cooking time, and correlation analysis by using a statistical analysis software system (SPSS Version 12.0, SPSS Inc., IL).

Results and Discussions:

Cooking time of beans:

Cooking characteristics of leguminous grains are widely evaluated as they influence the cooking time that contributes to its utilization. In this study, the cooking time of all unsoaked bean cultivars generally, was high which ranged from 95min for RWV2872 to 180min for Mac9. The cultivars showed considerable differences in cooking time among them. The probable reason for these differences in cooking time was due to the variation in bean cultivars. Figure 1 shows the cooking time of all the bean cultivars used in this study. In two different studies conducted by Mwangwela *e al*, (2007) and Kinyanjui, *et al.,* (2015) it was revealed that soaking enabled rapid high heat penetration during cooking and quicker cooking duration that compared well with this study. Studies by Hsieh., et *al.,* (1992) indicated maturation and growing location contribute to variation of cooking time. The highest and lowest cooking time for different bean cultivars across different altitudes is given in Figure 2.

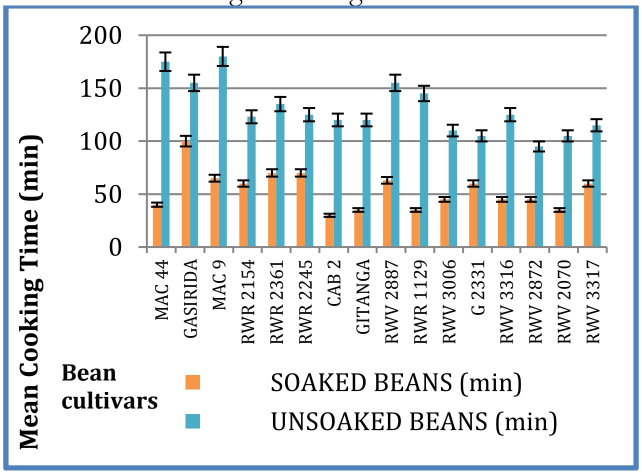

Fig 1 - Cooking time of all bean cultivars

Table 2 Splitting of beans in soaked and unsoaked beans

Splitting of beans	High splitting (%)	Low splitting (%)
Soaked	CAB 2 (50±23.33^{b})	Gasirida (20±8.16^{b})
Un-soaked	RW 2152(16.66±4.72^{a})	Gasirida (0)
	RW 2361 (16.66±4.72^{a})	RW 2887(0)
	RW 2872 (16.66±4.72^{a})	G2331 (0)

Note: different superscripts in the same row meansstatistical differences

Figure 2 reveals that un-soaked beans cultivars across all the altitudes consumed more cooking time than soaked beans. However, in mid and low altitude beans, RWR 2245 was found to have lower cooking time in comparison with high altitude and high and mid altitude.

Table 3 shows the mean cooking time and correlation result.

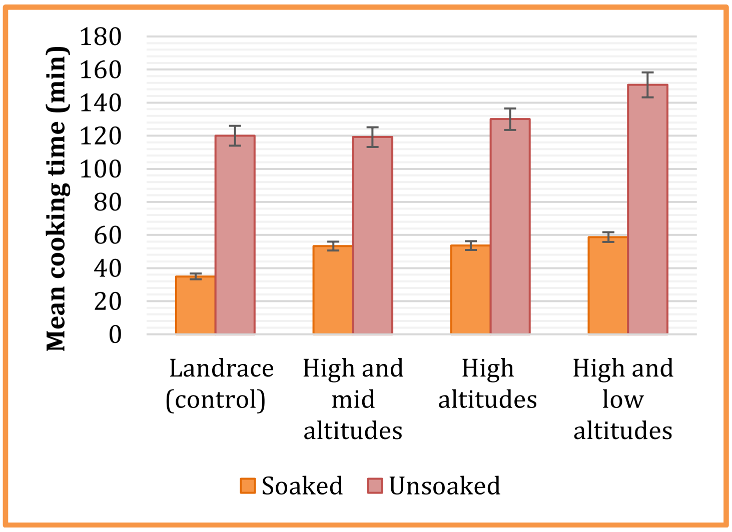

Fig 2 – Highest & lowest cooking time among bean cultivars from different growth altitudes

Table 3
Correlation analysis for cooking time of Beans

Growth altitude	Mean ± SD		Pearson Correlation
	Soaked	Un soaked	
Landrace	35	120	
High altitudes	53.6 ± 16.04	130 ± 15.81	r = 0.316
High and mid altitudes	53.33 ± 24.63	119.17 ± 24.58	p= 0.233
Mid and low altitudes	58.75 ± 13.15	150.75 ± 30.97	

The correlation analysis reveals a positive correlation between the cooking time of soaked and un-soaked bean variants. But the relationship was not significant at 5% level of significance ($r = 0.316$, $p= 0.233$). The mean cooking time across growth altitude showed differences for soaked beans and was more than the control bean variety (for high altitude $\mu = 53.6 \pm 16.04$, for mid altitude $\mu = 53.33 \pm 24.63$ and for low altitude $\mu = 58.75 \pm 13.15$). The mean cooking time for un-soaked bean also showed differences and was more than the control bean variety (for high altitude $\mu = 130 \pm 15.81$, for mid altitude $\mu = 119.17 \pm 24.58$ and for low altitude $\mu = 150.75 \pm 30.97$). Hence the significance of difference between the means was tested using ANOVA, the result of which is depicted in Table 4.

The ANOVA result in Table 3 shows that mean cooking time for both soaked and un-soaked bean cultivars were not significant at 5 % level of significance ($F=0.108$, $df = 14$, $p = 0.90$ for soaked beans and $F=2.092$, $df = 14$, $p = 0.17$ for un-soaked beans). Thus, it was concluded that growth altitude of the bean cultivars had no significant difference on the cooking time at 5 % level of significance.

This may be because Rwanda is already at a high altitude of 5194ft above sea level.

Table 4
Mean cooking time with growth altitude of bean variety*

Mean Cooking time with Altitude		Sum of Squares	Df	Mean Square	F	Sig.	Inference
Soaked	Between Groups	82.45	2	41.225	0.10798	0.898505	Not Significant
	Within Groups	4581.28	12	381.774			
	Total	4663.73	14				
Un-soaked	Between Groups	2404.82	2	1202.41	2.09188	0.166193	Not Significant
	Within Groups	6897.58	12	574.799			
	Total	9302.4	14				

ANOVA analysis

2. Imbibition of water in un-soaked and soaked beans during cooking

In bean processing, hydration or soaking is a vital step as it influences the physical, chemical and nutritional quality of the beans (Matella *et al.,* 2013) In many parts of the world, traditional legume cooking methods make soaking of the beans tender and therefore is used in meal preparation (Falmy *et al.,* 1999) In a study by Mwangwela *et al.* (2007) it was found that the typical soaking period ranges from 8 to 16 hours at ambient temperature to achieve 53% to 57% moisture content. Soaking beans before cooking reduces the cooking time due to onset of structural degradation of bean seed coat. Soaking of beans helps to activate the enzymes in the bean cell wall leading to the hydrolysis of pectin and polysaccharide present in them (Mwangwela *et al.,* 2007) Abbu-Ghannam (1998) opined that water absorption continues during cooking due to the added effect of cooking temperature and start solubilisation. In Figure 3 the differences in imbibition during cooking is shown.

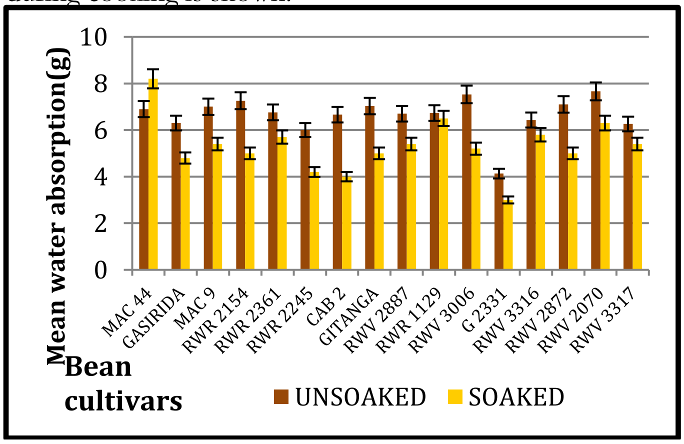

Fig 3 - Comparison of water absorption between soaked and un-soaked bean cultivars

The results as seen in figure 3 reveals that when soaked, the highest water absorption of 8.2g/10seeds was recorded for the bean variant MAC44 while the lowest water absorption of 3g/10seeds was recorded for G2331 bean. In the un-soaked bean cultivars, the highest water absorption was recorded for RWV2070 (7.66g/10seeds) and the lowest was recorded for G2331 bean seeds (4.13g/10seeds). As indicated by figure 3, cooking of soaked beans absorbs little water than un-soaked beans and this implies that soaking reduces the amount of water used during cooking.

Figure 4 depicts the mean water absorption of water during cooking across the altitude. It reveals that un-soaked beans in all the altitudes absorbed more water than soaked beans during the cooking process.

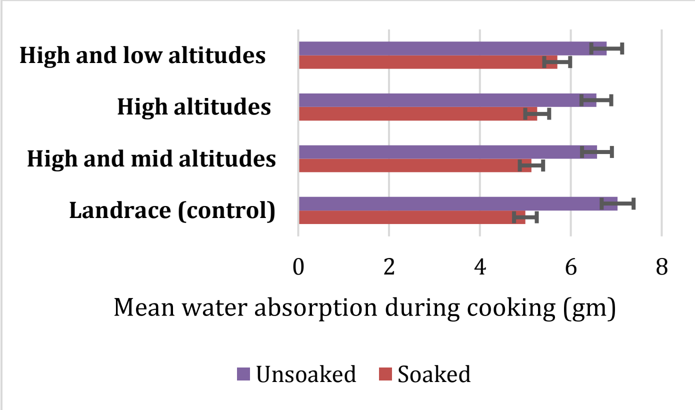

Fig 4 - Mean water absorption during cooking in bean cultivars from different growth altitudes

However, the un-soaked landrace bean which served as the control unit absorbed the highest water content on cooking. Thus, it is proved that soaking enabled rapid high heat penetration during cooking and quicker cooking duration compared with other similar studies (Mwangwela *et al.,* 2007; Kinyanjui, *et al.,* 2015). Water absorption during cooking of bean seeds is also related to the physical and chemical properties of the seed such as seed coat properties. When beans are soaked the water disperses into the starch granules and protein fractions within the beans; this facilitates cooking leading to protein denaturation and starch gelatinization (Azarpazhooh & Boye, 2012).

The correlation analysis for water absorption during cooking of soaked bean and un-soaked beans was also studied. The result is presented in Table 5. Water absorption of soaked and un-soaked bean variants during the cooking during cooking process was found to be positive. But the relationship was not significant at 5% level of significance ($r = 0.3158$, $p = 0.233$). Mean absorption of water during cooking is shown in Table 5. It shows that water absorption during cooking of soaked bean cultivars to be nearly the same when compared to the control bean variety (for high altitude $\mu = 5.26 \pm 0.726$, for mid altitude $\mu = 5.13 \pm 1.258$ and for mid and low altitude $\mu = 5.70 \pm 1.739$).

Table 5
Correlation analysis for water absorption during cooking of bean cultivars

Growth altitude	Mean ± SD (min) Soaked	Un soaked	Pearson Correlation
Landrace	5	0	
High altitudes	5.26 ± 0.726	6.562 ± 0.210	r = 0.3158
High and mid altitudes	5.13 ± 1.258	6.575 ± 1.299	p = 0.233
Mid and low altitudes	5.70 ± 1.739	6.790 ± 0.548	

Also, the mean water absorption for un-soaked bean was nearly the same irrespective of altitude but high when compared to control cultivars (for high altitude μ = 6.562 ± 0.210, for mid altitude μ = 6.575 ± 1.299 and for mid and low altitude μ = 6.790 ± 0.548). Hence the significance of difference between the means was tested using ANOVA the result of which is depicted in Table 6.

Table 6
Water absorption (in grams) with bean variety*

Mean Water Absorption in gms with Altitude		Sum of Squares	Df	Mean Square	F	Sig.	Inference
Soaked	Between Groups	0.804	2	0.402	0.2525	0.781	Not Significant
	Within Groups	19.105	12	1.592			
	Total	19.909	14				
Un-soaked	Between Groups	0.1436	2	0.072	0.09051	0.9141	Not Significant
	Within Groups	9.5202	12	0.793			
	Total	9.6638	14				

ANOVA

The ANOVA result in Table 6 shows that mean water absorption during cooking for both soaked and un-soaked bean cultivars were not significant at 5 % level of significance (F=0.2525, df = 14, p = 0.781 for soaked beans and F=0.09051, df = 14, p = 0.9141). Thus, it was concluded that growth altitude of the bean cultivars had no significant difference on water absorption during cooking time at 5 % level of significance.

3. Splitting of seed coat and cotyledons during cooking

Seed coats softened during cooking but those from hard-to-cook beans softened less than those from soft beans. It is possible that seed coats harden during tropical storage by a lignification-type mechanism (Rubyogo *e al.*,2007). However, during cooking pressure built-up within the seeds gave rise to the development of fissures in the seed coat, cotyledon and cell wall of the soaked and un-soaked beans. Figure 5 shows the mean splitting of seed coats between soaked and un-soaked bean cultivars on cooking.

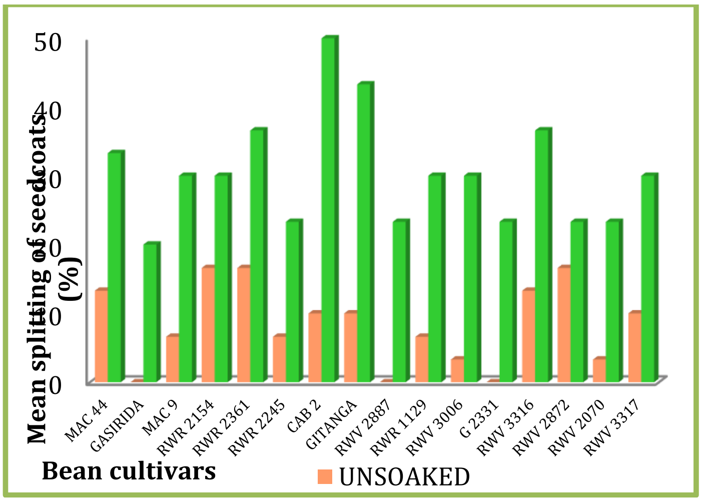

Fig 5 - Comparison of mean splitting of seed coats between soaked and un-soaked bean cultivars

It has been postulated that the incidence of splitting during cooking of bean seeds is positively related to the increase in water absorption during cooking (Matella et al., 201). In a comparative study by Hsieh et al. (1992) soaking seed for 0hr, 5 hr, 10 hr and 24hr, resulted in a small additional reduction in cooking times between 24hr compared to soaking for 10 hr.

Figure 6 depicts the mean splitting of cultivars across altitude during cooking. It reveals that soaked beans in all the altitudes showed more splitting than un-soaked beans during cooking. However, the control bean variety showed the highest splitting among all the bean cultivars.

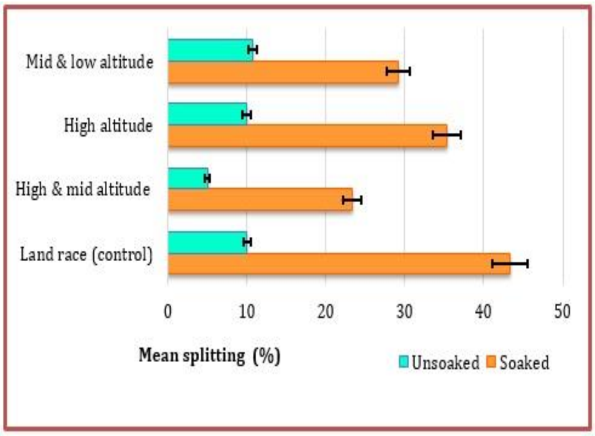

Fig 6 - Mean splitting (%) of bean cultivars from different growth altitudes

Table 5 shows the intensity of splitting among certain bean cultivars. High splitting was recorded in soaked CAB2 (50±23.33%) while uniform splitting was observed in three un-soaked cultivars of RW2152 (16.66±4.72%), RW2361 (16.66±4.72%) and RW2872 (16.66±4.72%). Low splitting grains were observed in Gasirida (20±8.16^{b}) while soaked. Amazingly no splitting in un-soaked grains of RW2887 and G2331 was observed. This vividly indicates that Gasirida, for instance, needs to be soaked before cooking.

Table 5 Splitting intensity of soaked and unsoaked beans (%)

Splitting of beans	High splitting	Low splitting
Soaked	CAB 2 (50±23.33)	Gasirida (20±8.16[b])
Un-soaked	RW 2152(16.66±4.72)	Gasirida (0)
	RW 2361 (16.66±4.72)	RW 2887(0)
	RW 2872 (16.66±4.72)	G2331 (0)

The Pearson correlation (2 tailed) analysis between soaked and un-soaked bean seeds in the splitting of the seed coat and cotyledon was evaluated to be positive (r = 0.47, p = 0.06) but was not significant at 5 % level (Table 6)

Table 6
Water absorption (in grams) with bean variety*

Mean Water Absorption in gms with Altitude		Sum of Squares	Df	Mean Square	F	Sig.	Inference
Soaked	Between Groups	0.804	2	0.402	0.2525	0.781	Not Significant
	Within Groups	19.105	12	1.592			
	Total	19.909	14				
Un-soaked	Between Groups	0.1436	2	0.072	0.09051	0.9141	Not Significant
	Within Groups	9.5202	12	0.793			
	Total	9.6638	14				

ANOVA

While analysing further, the mean percentage of bean splitting during cooking of various bean cultivars from different altitudes was found to be different. The percentage splitting for soaked bean cultivars in high altitude was found to be 35.3 ± 9.89, for mid altitude it was 24.983 ± 4.09 and for mid and low altitude it was 29.15 ± 4.198. These readings were considerably different from the control bean variant (land race 43.3). Similarly, the percentage of splitting for un-soaked Landrace bean (10 percent) was found to differ across the different latitude. Hence the significance of difference between the percentage means was tested using ANOVA. The result is depicted in Table 7.

Table 7
Percentage of bean splitting while cooking

Mean splitting with altitude		Sum of Squares	df	Mean Square	F	Sig.	Inference
Soaked	Between Groups	291.075	2	145.538	3.3069	0.07	Not Significant
	Within Groups	528.119	12	44.0099			
	Total	819.193	14				
Un-soaked	Between Groups	105.089	2	52.5443	1.4924	0.26	Not Significant
	Within Groups	422.509	12	35.2091			
	Total	527.597	14				

The ANOVA result in Table 7 shows that mean percentage of bean splitting during cooking for both soaked and un-soaked bean cultivars. The mean difference in the amount of splitting for soaked and un-soaked bean cultivars across different altitude was found not to be significant at 5 % level of significance (soaked bean F=3.3069, df = 14, p = 0.07, un-soaked bean F=1.4924, df = 14, p = 0.26). Thus, it was concluded that growth altitude of the bean cultivars did not result in any significant difference at 5 % level of significance for splitting of soaked and un-soaked beans during cooking time.

4. Subjective evaluation of bean attributes (broth pigmentation and tactile texture) in soaked and cooked water:

It is common practice to hold foods in the hand or squeeze them to sense their texture after cooking. The size of the object generally determines the method used. For small objects like the bean the forefinger and the thumb were used. When the bean is pressed, the distance moved is sensed by the person. The greater the distance it moved the bean was considered to be cooked. The bean broth contains apart from the protein content of the bean, various nutrients, including antioxidants, vitamins and minerals. The colour of the broth generally depends on the colour of the bean and the nutrient content in them. In this study both the finger test and broth pigmentation were evaluated on a 1-5 scale.

The sensory evaluation results of the sixteen different cultivars in pigmentation of the broth and texture when cooked is shown in Table 8.

Table 8
Broth Pigmentation and Tactile Texture

Bean Variety	Year of release	Growth altitude	Broth pigmentation	Finger press test for texture
GITANGA	CONTROL	Landrace	3	3
RWR 2361	2012	high altitudes	3	2
CAB 2	2010	high altitudes	2	3
RWV 2887	2012	high altitudes	4	2
RWV 3316	2012	high altitudes	4	3
RWV 3317	2012	high altitudes	3	4
GASIRIDA	2010	high and mid altitudes	4	3
RWR 1129	2010	high and mid altitudes	3	3
RWV 3006	2012	high and mid altitudes	2	4
G 2331	2010	high and mid altitudes	3	3
RWV 2872	2012	high and mid altitudes	3	4
RWV 2070	2010	high and mid altitudes	3	4
MAC 44	2010	mid and low altitudes	4	2
MAC 9	2010	mid and low altitudes	4	2
RWR 2154	2010	mid and low altitudes	3	3
RWR 2245	2010	mid and low altitudes	4	3

Thus, broth from all cultivars of both in soaked and in cooked was pigmented except RWV3006 and CAB2 which were not pigmented in their broth. The broth pigmentation was linked to the pigments leaching in water during soaking and cooking and this was also linked to the amount of water absorbed which also indicated the quick cooking attributes. Results obtained revealed that almost all the broth that were pigmented scored a mean value of 4.4. On the other hand, the finger press texture of all the cultivars cooked when soaked indicated almost the same mean value of texture (3.5) within 50min except Gasirida that was undercooked. The cultivars which became tender were those that had high water absorption capacity which also had shorter cooking time thus the high degree of softness reflected in the splitting of bean seeds.

Conclusion

Generally, cooking time of all bean cultivars were high and ranged between 95min (RWV2872 to 180min (Mac9) without much statistical differences between cultivars. This indicated that improvement in agronomic or breeding traits did not influence the culinary characteristics of the improved varieties of beans. Soaking revealed a dramatic decrease in cooking time for soaked compared to un-soaked beans (CAB2 and Gitanga can take 30min and 35 min respectively to cook). Among the fast soaked and cooked cultivars consumers should be encouraged for consumption and farmers for cultivation are CAB2, Gitanga, MAC44, RWR1129, RWV3006, RWV3316, RWV2872 and RWV2070 since their cooking time was considerably less and ranged from 30 to 50 minutes when soaked. While considering the growth altitude, it did not have any significant influence on mean cooking time, mean water absorption and mean splitting time of bean cultivars.

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