Physico-chemical and Canning Quality Characteristics of Common Bean Varieties

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Abstract

The highest 100 seed weight was recorded for variety Deme and Hirna with the values of 53.17g and 51.46g, respectively, and the lowest was for Awash-1, SARI-I and Dursitu with 17.18g, 18.03g and 18.14g, respectively. Significantly, longer and shorter cooking time was observed for Batagoni with 93.00 min and for Ecab-0081 and Fedis, both with 29.00 min, respectively. The range of hydration coefficient was between 1.252 and 1.683, where variety Gofta had the least while Awash-2 had the highest value. The maximum washed drained weight was recorded for variety Awash Melka with the value of 64.47g and the minimum was observed for DRK with the value of 60.06g. Nutritional quality parameters also significantly varied from 9.230% (Chore) to 10.868% (Batu) for moisture, from 3.519% (Beshibeshi) to 4.700% (Omo95) for ash, from 0.8427% (Sarii) to 2.857% (Hundane) for fat, from 4.080% (Roba) to 8.893% (Kufanzik) for fiber, from 16.575% (Dinkinesh) to 25.98% (Tinike) for protein. In addition, from 58.215% (hundane) to 68.144% (Dinkinesh) for CHO.more over,314.75Kcal/g (Ramadan) to 340.71 Kcal/g (KATB-9) for food energy. Phytate concentration also ranged from 8.081 to 23.636 mg/g for variety Awash- 2 and Ecab-0056, respectively. Therefore, it was concluded that released common bean varieties could be grouped and selected for desirable traits and purposes based on their inherent physicochemical and canning quality characteristics.

Introduction

especially in the dietary pattern of low-income group of people in developing

inexpensive sources of protein, dietary fiber, and starch. As they contain almost two to three times more protein than cereals, they are good sources of supplementary protein when added to cereal grains and root crops, which are low in essential amino acids. In addition to protein, common beans are good source of dietary fiber and starch (Perla *et al.*, 2003). In Ethiopia, common bean (*Phaseolus vulgaris* L.) is the most important major food legume, which is used either as a source of protein for local consumption or as an export crop to generate foreign currency (Tadele, 2006). It is also an important

opia, providing an

economic advantage to farmers as an alternative source of protein, cash income, and food security. Since its introduction to the northern parts of the country around the 16th century (Shimelis and Rakshit, 2005), common bean is often grown as cash crop by small scale farmers and used as a major food legume in many parts of the country where it is consumed in different types of traditional dishes (Habtu, 1994).

The area devoted to common bean production in Ethiopia is 359235 ha with a total production of 0.41M tones and average yield of 1.2 t/ha (CSA, 2012/13). It is mainly grown in eastern, southern, south western, and the central Great Rift Valley areas of the country (Habtu *et al.*, 1996). The crop has a wide range of adaptation and its productivity greatly varies depending on ecological factors, cropping systems and agronomic practices. It is one of the most important grain legumes grown in the lowlands of Ethiopia, particularly in the central rift valley of the country. In these areas, smallholder farmers grow white beans for export and food type colored beans for household consumption.

Previously, improved bean varieties have been released by research centers in the country based on only their yield potential and drought and disease resistance levels. However, nowadays, the Ethiopian institute of Agricultural Research has also designed a strategy to profile and document physicochemical and nutritional quality parameters of crop varieties, including common bean. Therefore, the purpose of this study was to analyze and document quality profile of common bean varieties grown in Ethiopia, as the output will enable researchers and other end users to get base line information on nutritional composition of the varieties for future studies.

Materials and Methods

Sample collection and Preparation

Forty-two varieties of common bean, which have been collected from rift valley areas of Ethiopia, were evaluated for different physicochemical and canning quality attributes in this study. Seeds of all the collected varieties were hand cleaned to remove some foreign materials, physically damaged beans and bean with fade color and undesirable type of shape. About 2 kg cleaned and pure seed sample was taken from each variety and packed in plastic bags.

Physical properties

Hundred seed weight: Randomly selected 100 dry bean seeds were weighed and the average weight of each seed was calculated as:

$$\text{Weight per seed} = \frac{\text{Weight of beans}}{\text{Total count of the beans}}$$

The readings were taken in triplicate and average values of the triplicate samples were reported (Balasubramanian *et al.*, 1999).

Number of non-soakers: The non-soakers (NS) were picked-up by hand and then counted and the value was expressed as percentage.

$$\% \text{ NS} = \frac{number\ of\ bean\ non\ soakers}{total\ number\ of\ soaked\ beans} \times 100$$

Cooking time: Cooking time was estimated according to the method of Mattson (1946), modified by Jackson and Varriano-Marston (1981) using the Mattson cooking device.

Bean canning process

Triplicate bean samples each with 100g were accurately weighed, placed into mesh bags, soaked in water for 30 min at room temperature and, then, blanched for 30 min at 78^{o}C in water containing about 100 ppm of $CaCl_2$ solution (Uebersax and Hosfield, 1985). The samples were first drained and after weighing, transferred into coded cans and covered with boiling brine containing 100ppm Ca^{++}, 1.3% NaCl and 1.56 % sugar. The cans were sealed and cooked in autoclave at 115.6^{o}C for 45 min, followed by instant cooling. Then, the cans of processed beans were stored for three weeks prior to opening for evaluation of canning-quality traits (Uebersax and Hosfield, 1985).

Canning quality of dry beans

Hydration coefficient (HC): The weight gained by imbibitions during soaking and blanching was used to calculate the hydration coefficient (Uebersax and Hosfield, 1985) as follows:

$$HC = (Mass\ of\ soaked\ beans\ in\ g)/(Mass\ of\ dry\ beans\ in\ g)$$

Washed drained weight (WDWT) and Percentage Washed drained weight

(PWDWT): WDWT was determined according to the procedure suggested by Uebersax and Hosfield (1985), while PWDWT was calculated as follows (Van der Merwe *et al*., 2006).

$$PWDWT = (Washed\ drained\ weight\ in\ g)/(Mass\ of\ can\ content\ in\ g)$$

Sensory quality of canned beans

Degree of clumping: it was rated based on 1 to 3-point scale (1 = beans solidly clumped to the bottom of the can and 3 = no clumping),

Splitting Beans: 1 to 10 point scale was used (with 1 indicating the maximum (completely broken) and 10 the minimum number of split beans (without any cracks or loose skins)

$$\text{Percent of seed coat splitting} = \frac{\text{Numbers of beans with splitting in one can}}{\text{Total numbers of beans in one can}} \times 100$$

Viscosity/starchiness: 1 to 5 point scale was used (1 = very clear and 5 = extremely cloudy) (Balasubramanian *et al*., 1999).

Nutritional quality parameters

Moisture, total ash, crude fat, crude protein and crude fiber contents were determined by AOAC (2000) official methods of 925.10, 923.03, 920.39, 920.87 and 945.38, respectively. Whereas, the difference was taken to determine total carbohydrate content (Total Carbohydrate (%) = 100 - {Moisture (%) +Protein (%) + Fat (%) + Ash (%)}).

Energy value was quantified based on the three groups of nutrients: carbohydrates, fats and proteins (Birch, *et al*. 1980). Hence, the gross food energy was calculated as: FE = {(%TC-%CF) x 4} + (%TFx9)+(%TP x4), where, FE = Food Energy in Kcal/g, TC = Total Carbohydrate, CF = Crude Fiber, TF = Total Fat and TP = Total Protein. Anti-nutritional analysis was done by estimating the content of phytic acid of the varieties, which was determined by spectrophotometry method following the procedure developed by Latta and Eskin (1980) and later modified by Vaintraub and Lapteva (1988).

Statistical data analysis

Statistical Analysis Software (SAS) Version 2.0 using one-way analysis of variance (ANOVA) and all pair wise comparisons were done for mean values using Least Significant Difference (LSD) test at < 0.05 P level (Steel et al., 1997) analyzed all the triplicate data

Results and Discussion

Bean physical properties

Mean values of the physical properties of common bean varietires, such as number of non-soakers per 400g seeds; 100 seed weight and cooking time, were presented in Table 1. The highest 100 seed weights were recorded for variety Deme and Hirna with mean values of 53.17g and 51.46g, respectively, while Awash-1, Dursitu and SARI-I exhibited lower values (17.18g, 18.14g and 18.02g, respectively). Cooking time is one of the main considerations in evaluating pulse quality. As longer cooking time results in a loss of nutrients and could affect the preference of end users. In the present study, significantly, longer cooking time was observed for variety Babile and Batagoni with 74.66 and 93.00 min, respectively, and the least cooking time was recorded for Ecab-0081 and Fedis with an equal value of 29.00 min. The shorter cooking time suggests the better nutritional quality and the best customer preference. Therefore, based on this study, varieties Ecab-0081 and Fedis have the best cooking quality. According to the research report of Derese and Shimelis (2012) for five dry bean varieties, the range of cooking time was 24.00 to 35.33 min. Furthermore, as reported by Shimeles (2004), cooking time was within the range of 19.5 to 41.7 min for eight dry been varieties. In the present study with 42 varieties of dry bean, the cooking time range was almost similar with the previously reported values with the exception of a few varieties.

Canning quality of dry beans

Canning is the heat sterilization process during which all living organisms in food and in can are killed. It prolongs the shelf life of beans without affecting the nutrients. Canning undergoes in different steps such as soaking (to remove the dust particles), blanching and cooking. The purpose of soaking and blanching prior to autoclaving is to ensure uniform and complete WU to prevent further expansion of beans in the can. Secondly, soaking prevents the presence of hard seeds in the canned product (Priestly, 1978), ensures product tenderness and improves color (Uebersax *et al.*, 1987). The main purpose of blanching is inactivation of enzymes, which might produce off-flavors. In addition, to soften the product and remove gasses to reduce strain on can seams during retorting (Jones and Beckett, 1995). The blanching process is also responsible for the increase of bean moisture content to the final (50   55 %) and the removal of dry bean flavor and odor (Priestly, 1978). In the present study, varieties were grouped in their canning quality and only 14 selected from each group were tested for the most sensitive parameters. Accordingly, all the parameters listed in Table 2 had different values for various common bean varieties. This revealed that canning quality of beans depends on the variety or genetic makeup and the environment.

Table 1. General characteristics of common bean and their physical properties

Variety Name	Seed Shape	Seed color	Seed size	Class	Type	Non-soaker/400 seed (%)	100 seed weight (g)	Cooking time (min)
Awash-1	Round	White	Small	Mesoamerican	Ex	2.25	17.180^{s}	42.667^{f-h}
Awash-2	Round	White	Small	Mesoamerican	Ex	0	21.863^{pq}	34.000^{m-s}
Awash-melka	Flat	White	Small	Mesoamerican	Ex	3	24.567^{n}	33.000^{n-s}
Ayenew	Elongate	Pinto	Medium	Andean beans	LC	0	37.922^{g}	41.000^{g-j}
Babile	Kidney	Red	Large	-	-	0	37.076^{gh}	74.667^{b}
Batagoni	-	-	Small	-	-	6.967	24.586^{n}	93.000^{a}
Batu	Kidney	White	Large	Andean beans	LC	2.25	44.010^{e}	31.000^{q-s}
Beshibesh		Cream	Small	Mesoamerican	-	0	24.195^{n}	46.333^{d-f}
Cherecher	Oval	White	Small	Mesoamerican	-	0	26.777^{m}	42.333^{f-i}
Chore	Kidney	White	Small	Mesoamerican	-	0	20.000^{r}	42.667^{f-h}
Crascope	Kidney	Speckled	Large	Andean beans	Ex	1.5	44.893^{de}	51.333^{d}
Deme	Kidney	Speckled	Large	Andean beans	Ex	0	53.172^{a}	31.333^{p-s}
Dinkinesh	Elongate	Red	Small	Mesoamerican	-	0	23.518^{no}	34.667^{l-r}
DRk	Kidney	Red	Large	Andean beans	Ex	0	44.122^{e}	37.667^{h-n}
Dursitu	Elongate	Red motteled	Small	Mesoamerican	LC	1.35	18.144^{s}	35.333^{k-q}
Ecab-0056	Elongate	Red motteled	Large	Andean beans	LC	0.5	46.001^{d}	34.000^{m-s}
Ecab-0081	Elongate	Red motteled	Large	Andean beans	LC	0	36.782^{gh}	29.000^{s}
Fedise	Elongate	Red motteled	Large	Andean beans	LC	0	43.367^{e}	29.000^{s}
GLP-2	Elongate	Red mottled	Large	Andean beans	LC	2.678	43.475^{e}	37.000^{j-o}

Gobe Rash	Elongate	Red motteled	Large	Andean beans	LC	1.689	40.820^{f}	44.667^{e-g}
Gofta	Elongate	Cream	Medium	Andean beans	LC	1	38.036^{g}	48.333^{de}
Haramaya	Elongate	cream	Medium	Andean beans	LC	0	29.831^{l}	46.667^{d-f}
Hirna	Kidney	red	Large	-	LC	4.5	51.463^{b}	31.333^{p-s}
Hundane	Oval	Red mottled	Large	-	-	0	33.627^{jk}	38.000^{h-n}
Ibado	Elongate	Red mottled	Large	Andean beans	LC	4.25	48.665^{c}	35.667^{k-q}
KATB-1	Oval	Yellow	Medium	Andean beans	LC	0	33.237^{k}	31.333^{p-s}
KATB-9	Oval	Red	Medium	Andean beans	LC	0	41.129^{f}	31.333^{p-s}
KUfanzik		Pinto	-	-	LC	0	35.820^{hi}	64.333^{c}
Lehodo	Flat	White	Medium	Andean beans	LC	3.235	38.255^{g}	39.333^{h-l}
Melkadima	Elongate	Red	Large	Andean beans	LC	3.453	44.712^{de}	40.000^{g-k}
Mexikan -142	Round	White	Small	Mesoamerican	Ex	0	19.810^{r}	38.667^{h-m}
Nasir	Round	red	Small	Mesoamerican	LC and Ex	1.25	21.785^{q}	32.333^{o-s}
Omo-95	Elongate	Red	Small	Mesoamerican	LC	0	24.158^{n}	39.333^{h-l}
Ramadan			Medium		LC	0	34.060^{jk}	62.000^{c}
Red Wolaita	Elongated	Red	Small	Mesoamerican	LC	0	22.134^{o-q}	37.333^{i-o}
Roba	Elongate	Cream	Small	Mesoamerican		2.25	23.492^{n-p}	30.000^{rs}
SARI-I	Elongate	Red	Small	Mesoamerican	LC and Ex	1.545	18.028^{s}	65.000^{c}
SER-119	Kidney	Red	Small	Mesoamerican	LC and Ex	1	25.019^{n}	31.333^{p-s}
SER-125	Kidney	Red	Small	Mesoamerican	LC and Ex	1.5	26.699^{m}	30.000^{rs}
Tatu	Elongate	White	Medium	Andean beans	LC	2.325	37.690^{g}	40.333^{g-k}
Tinike	Kidney	red	Large			0	34.980^{ij}	31.667^{p-s}
Waju			medium		LC	0	32.735^{k}	36.333^{j-p}
					Grand Mean		33.044	41.079
					CV		3.04	7.63
					LSD		1.6324	5.0916

Means followed by different superscripts within a column are significantly different at P <0.05. LC = local consumption and Ex = export.

hydration coefficient (HC); percentage washed dry weight and percentage of water uptake. The HC ranged from 1.25-1.68, where variety Gofta and Awash-2 exhibited the least and the highest values, respectively. The optimum HC value of common bean is considered as 1.82 for industrial use (Hosfield, 1991) and is characterized as well-soaked bean. HC indicates the increase in dry bean mass due to water uptake during soaking, relative to the dry state (Hosfield *et al*., 1984b). The lower HC value shows less water imbibitions and requires more time to imbibe water before canning.

Another important factor of canning quality of common bean is percentage washed drained weight (PWDW). In this study, the maximum PWDW was recorded for Awash Melka with the value of 64.47% and the minimum was observed for DRK with the value of 60.06%. Based on the existing canning standard, all the varieties evaluated in this study met the desired 60% of PWDW (Loggernberg, 2004; Balasubramanian *et al*., 1999).

Visualization of canning quality of beans

The maximum and minimum splits of (broken) beans were observed for variety ECAB-0056 and DRK with mean value of 1.70 and 5.86, respectively. Consumers prefer soft texture and little splits of beans, as soft texture of beans have direct relationship with that of seed breakdown. In the present study, Awash-2 was found to be the most clumping variety with mean score value of 2.215 and Nasir was the least clumping type. Clumping is directly proportional to starchiness/viscosity of canned beans and it is an indicator of poor canning quality.

Table2: Canning quality of fourteen dry bean varieties

Variety	HC	PWDW	Splitting degree (1-9)	Clumping degree (1-3)	Viscosity /starchiness (1-5)
Awash -melka	1.5790^{b}	64.469^{a}	4.350	2.450	2.050
Awash-1	1.5927^{b}	61.669^{cd}	3.600	2.800	2.200
Awash-2	1.6833^{a}	62.957^{a-c}	3.715	2.215	1.714
Batu	1.3667^{e}	61.084^{cd}	3.650	3.200	2.250
Cranscope	1.3457^{e}	62.816^{a-c}	1.857	2.572	2.214
Deme	1.4243^{d}	61.415^{cd}	3.950	2.600	2.400
DRK	1.4397^{d}	60.061^{d}	5.857	3.429	1.786
ECAB-0056	1.5277^{c}	60.901^{cd}	1.700	2.950	2.100
Gofta	1.307^{f}	61.450^{cd}	3.350	2.950	2.100
Ibado	1.4520^{d}	62.180^{b-d}	2.929	3.857	2.072
KATB-1	1.4207^{d}	62.385^{a-c}	3.600	2.450	2.100
KATB-9	1.4183^{d}	61.366^{cd}	3.500	2.600	2.200
Nasir	1.2520^{g}	61.978^{b-d}	3.786	4.214	1.929
Roba	1.3593^{e}	63.913^{ab}	3.900	3.450	2.000
Grand Mean	1.4406	62.046			
CV	1.53	2.09			
LSD	0.0368	2.1682			

Means followed by different superscripts within a column are significantly different at P <0.05. Sensorial analysis was performed based on the following score values. Splitting: 0=split extremely,1=split very much, 2= split moderately, 3=split slightly, 4=either split or unsplit, 5=neither split nor unsplit, 6= unsplit slightly. 7= unsplit moderately, 8= unsplit very much, and 9= completely unsplit. Clumping: 1=extremely clumped, 2=moderately clumped, and 3= no clumping. Viscosity/Starchiness:1=Very clear, 2=moderately clear, 3=slightly clear, 4=moderately cloudy and 5= extremely cloudy

Nutritional composition of common bean varieties

The contents of moisture, ash, fat, fiber, protein, and carbohydrate and food energy value of the dry beans are presented in Table 3. It was observed that the nutritional compositions of common

minimum and maximum values for moisture were 9.23 (Chore) and 10.87% (Batu), 3.52 (Beshibeshi) and 4.70% (Omo-95) for ash, 0.84 (Sari-i) and 2.86% (Hundane) for fat, 4.08 (Roba) and 8.89% (Kufanzik) for fiber, 16.58 (Dinkinesh) and 25.98% (Tinike) for protein, 58.22 (Hundane) and 68.14% (Dinkinesh) for CHO and 314.75

(Ramadan) and 340.71Kcal/g (KATB-9) for food energy, respectively. These results were consistence with the findings of Shimeles (2004) and Derese (2014).

Table 3. Nutritional compositions of common bean varieties (g/100g)

Variety	% Moisture	% Ash	% Total Fat	% Crude Fiber	% Protein	TCHO (%)	FE (Kcal/g)
Awash-1	10.263^{b-j}	4.1563^{g-i}	1.1410^{h-m}	5.6403^{i-m}	23.870^{c-f}	60.570^{o-q}	325.47^{m-p}
Awash-2	9.4650^{o-r}	4.5170^{bc}	1.5547^{d-f}	5.3557^{k-o}	24.266^{c-e}	60.197^{p-s}	330.42^{g-i}
Awash-Melka	9.7983^{i-q}	4.6000^{ab}	1.4013^{d-h}	6.3477^{f-h}	25.083^{a-c}	59.118^{q-t}	324.02^{n-q}
Ayenew	10.615^{a-c}	3.8403^{m-q}	2.361^{b}	5.3170^{l-o}	23.605^{d-g}	59.578^{q-t}	332.72^{e-g}
Babile	10.350^{b-h}	4.0803^{h-k}	1.3503e-j	5.6867^{i-l}	25.830^{ab}	58.390^{t}	326.28^{l-o}
Batagoni	9.6857l-r	3.7697 $^{p-s}$	1.4573^{d-g}	5.2597^{l-p}	21.245^{k-n}	63.842^{f-j}	332.43^{e-g}
Batu	10.868a	3.7753^{p-r}	1.3127^{f-l}	4.8880^{o-r}	18.314^{qr}	65.729^{bc}	328.44^{h-m}
Beshibesh	9.8437^{h-p}	3.5197 ^{t}	1.1540^{h-m}	4.4023^{r-t}	21.425^{j-n}	64.057^{e-i}	334.71^{c-e}
Cherecher	9.6650^{l-r}	4.0660^{h-l}	2.3557^{b}	5.3897^{k-o}	22.743^{f-j}	61.170^{n-p}	335.29^{b-e}
Chore	9.2303^{r}	4.6380^{ab}	1.3370^{e-k}	4.2237st	23.103^{e-i}	61.692^{l-o}	334.32^{d-f}
Crascope	10.398^{a-g}	3.7400^{q-s}	1.6097^{de}	5.9997^{h-j}	17.962^{r}	66.290^{b}	327.50^{i-m}
Deme	10.290^{b-i}	3.6493^{r-t}	1.2003^{g-m}	6.0630^{hi}	21.383^{j-n}	63.477^{g-k}	325.99^{l-p}
Dinkinesh	10.233^{c-k}	3.8497^{m-q}	1.1980^{g-m}	5.1837^{l-q}	16.575^{s}	68.144 a	328.92^{h-l}
DRk	10.078^{d-m}	3.6157st	1.2567^{g-m}	6.3967^{f-h}	22.229^{h-k}	62.820^{h-m}	325.92^{l-p}
Dursitu	10.516^{a-e}	4.5233 ^{bc}	1.3783^{d-i}	6.6630^{fg}	24.833^{a-d}	58.750st	320.08^{r-t}
Ecab-0056	9.7633^{j-q}	3.9170^{l-p}	1.4067^{d-h}	7.3313^{bc}	19.447^{pq}	65.466^{b-e}	322.99^{p-r}
Ecab-0081	9.9697^{f-o}	3.8090^{n-q}	1.0967^{j-n}	7.2433^{c-e}	20.341^{n-p}	64.784^{c-g}	321.39^{q-s}
Fedise	10.525^{a-d}	4.3343^{de}	1.0857j-n	6.2397^{gh}	22.393^{g-k}	61.662^{l-p}	321.03^{q-s}
GLP-2	9.5000^{o-r}	4.1700^{f-i}	2.0337^{c}	8.8437^{a}	21.275^{k-n}	63.022^{h-l}	320.11^{r-t}
Gobe Rash	9.3317^{qr}	4.0403^{i-l}	1.6430^{d}	5.8640^{h-k}	18.620^{qr}	66.365^{b}	331.27^{f-h}
Gofta	9.6300^{l-r}	4.3993^{cd}	1.4573^{d-g}	6.7340^{e-g}	25.725^{ab}	58.788st	324.23^{n-q}
Haramaya	9.5343^{n-r}	3.9647^{j-m}	1.0477^{l-n}	5.0330^{n-q}	24.028^{c-f}	61.425^{m-p}	331.11^{f-h}
Hirna	9.5323^{n-r}	3.9440^{k-n}	2.1727^{bc}	5.1343^{m-q}	21.708^{j-n}	62.643^{i-n}	336.42^{b-d}
Hundane	10.349^{b-h}	3.8333^{m-q}	2.8570^{a}	6.8110^{c-f}	24.746^{a-d}	58.215^{t}	330.31^{g-j}
Ibado	9.6033^{m-r}	3.7330^{q-s}	1.6443^{d}	5.0307^{n-q}	20.820^{l-o}	64.200^{d-h}	334.75^{c-e}
KATB-1	10.010^{e-n}	4.3113^{d-f}	1.0670^{k-n}	4.9750^{n-q}	21.292^{k-n}	63.320^{g-k}	328.15^{h-m}
KATB-9	9.8317^{i-q}	3.7937^{n-r}	2.3460^{b}	4.1307^{t}	18.781^{qr}	65.248^{b-f}	340.71^{a}
Lehodo	10.128^{c-l}	4.3383^{de}	1.3557^{e-j}	4.6787^{q-s}	21.924^{i-m}	62.253^{k-n}	330.20^{g-j}
Melkadima	9.6467^{l-r}	4.2817^{d-g}	1.9583^{c}	4.0823^{t}	17.698^{rs}	66.416^{b}	337.75^{a-c}
Mexikan-142	9.8983^{g-o}	4.3620^{de}	1.0193^{mn}	4.9097^{o-r}	21.694^{j-n}	63.027^{h-l}	328.42^{h-m}
Nasir	10.743^{ab}	4.2803^{d-g}	1.2397^{g-m}	4.7540^{p-s}	21.043^{k-n}	62.695^{i-m}	327.09^{j-n}
Omo-95	10.454^{a-f}	4.7000^{a}	0.8637^{n}	6.2320^{gh}	24.500^{b-d}	59.483^{q-t}	318.77^{s-t}
Ramadan	10.453^{a-f}	4.1170^{h-j}	1.3943^{d-h}	8.4857^{a}	21.657^{j-n}	62.379^{j-n}	314.75^{v}

Red Wolait	9.3603[p-r]	3.9337[k-o]	1.1123[i-n]	5.5843[i-m]	23.519[d-h]	62.075[k-n]	330.05[g-k]
Roba	9.7667[j-q]	4.1113[h-j]	1.9827[c]	4.0800[t]	21.533[j-n]	62.607[i-n]	338.08[ab]
SARI-I	9.7420[k-q]	4.5907[ab]	0.8427[n]	7.8160[b]	24.349[c-e]	60.476o-r	315.62[uv]
SER-119	9.9433[g-o]	4.2147[e-h]	1.4123[d-h]	6.8003[c-f]	22.081[i-l]	62.349[k-n]	323.23[o-r]
SER-125	9.8043[i-q]	4.2720[d-g]	1.1943[g-m]	5.4917[j-n]	22.326[g-k]	62.403[j-n]	327.70[i-m]
Tatu	10.565[a-d]	3.7863[o-r]	0.9937[mn]	6.7650[d-g]	20.702[m-p]	63.953[f-i]	320.50[r-t]
Tinike	9.6107[m-r]	4.0623[h-l]	1.0873[j-n]	5.9533[h-j]	25.980[a]	59.260[q-t]	326.93[k-n]
KUfanzik	9.7397[k-q]	3.7183[q-s]	1.3760[d-i]	8.8930[a]	19.592[o-q]	65.574[b-d]	317.48[t-v]
Waju	10.600[a-c]	4.5510[a-c]	1.1527[h-m]	7.2940			

varieties and environmental factors, such as growing condition, agricultural practice and location. In the present study, the lowest and highest concentration of phytate among the thirty-seven varieties of common bean was 8.08 and 23.636 mg/g for Ecab-0056 and Awash-2, respectively. In agreement with these results, it has been reported that the phytate concentration of common bean ranged from 6.00 to 25.10 mg/g dry weight (Maskus, 2010; Martinez Meyer *et al*., 2013; Derese *et al*., 2012; Pedrosa *et al*., 2015; Carvalho *et al*., 2015).

Conclusion and Recommendation

Bean varieties Awash-melka, DRK, Roba, Awash-1 and Awash-2 showed percentage washed drained weight greater than 60% in brine and 100-ppm calcium chloride, which satisfies the export standards. Results of the canning quality evaluation also suggested that these common bean varieties were appropriate for the canning purpose and thus, could be used as a row material for the bean canning industries. Among the varieties, ECAB-0056 showed the least phytate content, but with similar protein concentration as did the other varieties. However, variety Tinike, Awsh-melka and Gofta were found to be the best in terms of protein and low phytate content, as low phytate content of beans enhances the availability of mineral and digestibility of proteins in the gut. Therefore, some of these common bean varieties can be chosen for incorporation in weaning food mixtures and supplementary bean-based processed foods including fortified products, which might be used as an alternative to minimize the critical gap and the problem of protein malnutrition in the country.

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