Common beans variability on physical, canning quality, nutritional, mineral, and phytate contents

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Abstract: Common beans are nutrient-rich crops, an important source of protein, micro minerals (Fe and Zn), and vitamins. Varieties of beans have been releasing by the Ethiopian Institute of Agricultural Research, but for some varieties, a comprehensive nutritional content was not studied. Therefore, the study aims to identify varieties having a better nutritional quality and canning quality, besides research has to be done for profiling. Results of the present finding revealed that significant differences were observed at P ≤ 0.05 for all analyzed parameters. The seed weight/100 seed, cooking time, and percent of non-soakers were varied respectively from 17.18–53.17 g/100 seed, 30.0–51.33 min, and 0.0–4.00%, meanwhile percentage washed drained weight and hydration coefficient value was found to be 60.06–64.47%, and 1.25–1.68. Visual appearance quality parameters; starchiness, clumping, and splitting degree were also enclosed and significant differences were observed. Proximate compositions such as fiber, ash, and protein contents were covered from 4.07–7.33, 3.62–4.60 and 17.96–25.73%, respectively.

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PUBLIC INTEREST STATEMENT
Common beans are nutrient-rich beans that can be used as an important source of protein, carbohydrate, minerals, and vitamins, but it has anti-nutritional factors having an adverse effect on bio-availability and accessibilities of nutrients.

In Ethiopia, common beans are consumed cooked as whole grain (Asabusa, Nifro, and Bokelet), and making flour (Shiro wote). More than forty varieties of common beans are released from the Ethiopian Institute of Agricultural Research Center. Not all varieties are the same for consumption and exporting standards due to genetic variability differences. As a result, variety has to identify having lower anti-nutritional value, higher protein, minerals, and better canning quality.

Therefore, the present findings found bean varieties having better nutritional, and canning qualities. From a nutrition perspective, this finding would help to select common bean varieties having low level of anti-nutritional factors, and high protein-mineral (Fe and Zn) contents used for human consumption as complimentary food preparation so as to prepare protein-mineral dense food products.
Iron and Zinc values also found in the array of 0.02–36.6 and 0.49–5.45 as measured by mg/100 g, and phytate value was found to be 8.1–23. 59 mg/g. According to this research finding PAN-182, G-4445, and Roba bean varieties were found best for canning purpose and nutritional quality. Therefore, selected bean varieties should be considered for developing bean-based protein and micronutrient-rich food, canning industry, and bean breeders.

**Subjects: Substitutes - Food Chemistry; Food Analysis; Nutrition**

**Keywords: Canning quality; micronutrient; proximate composition; phytate; physicochemical value**

1. **Introduction**

   Common bean (*Phaseolus vulgaris* L.) is a major grain legume, consumed worldwide for its edible seeds and pods (Heuze et al., 2013). It is rich in proteins, vitamins, complex carbohydrates, and minerals but low in lipids (Anton et al., 2008; Gathu et al., 2012). It is considered as “resource-poor meat”, an inexpensive source of protein, dietary fiber, and starch, and also used as a non-heme iron- protein source. Beans are present in a different color, size, chemical composition, and hardness and these differences of beans could arise from its intrinsic factors (genotype) or extrinsic factors (storage conditions, type of cultivation soil, agronomic practices, climatic, and technological factors) (Aghkhani et al., 2012; Gathu et al., 2012).

   Ethiopian Institute of Agricultural Research has been releasing more than fifty common bean varieties, but inclusive studies were not conducted for some varieties of beans during release. Even though the objective of the breeding research program is based on improving nutritional quality, stress tolerance, or resistance to pests and diseases (Angenon et al., 1999) but more emphasis has been given to the others, not for nutritional qualities. As a result; nowadays, nutritional quality profiling has got attention, and the Ethiopian Variety Releasing Committee stated that every released variety of any crop including common bean should be evaluated for their nutritional value besides other objectives. Currently, common bean breeders are targeted to improve beans’ nutrients especially protein, minerals (Fe and Zn) to overcome the protein-energy malnutrition and mineral deficiency prevalence in the country. As a result, the existing varieties of beans should be analyzed for their nutritional compositions to identifying the best varieties of beans. In Ethiopia, common bean is a major food legume used for both sources of protein, for local consumption for food security, and as an export crop for generating foreign currency (Tefera, 2006). Traditionally, common bean is consumed after being soaked in water and cooked, or after being canned. On the other hand, beans can also be flour for producing bean-based food products. In Ethiopia, the most traditional foods prepared from common beans are Asambuusa, Nifro, and Bokelet”, which is from shelled beans (whole grain).

   Presently, people are becoming more interested in consuming beans than in the past, because beans have nutrient-dense protein in light of an alternative to meat. As a result, consumers or food product developers should have to know the best common bean varieties, which are evaluated based on the beans’ culinary and commercial quality (color, shine, shape, and size). Therefore, the purpose of the present finding is to assess nutritional value, canning quality, cooking time, and common anti-nutritional factors of the released and popular common bean varieties which grow in the central rift valley of Ethiopia.

2. **Materials and methods**

   The research was conducted in Melkassa Agricultural Research Center of the Ethiopian Institute of Agricultural Research (EIAR) which is found in the central rift valley, 117 km away from Addis Ababa in the southeast direction located at 8024’N and 39 012’E and an altitude of 1550 meter above sea level. The mean minimum and maximum temperature of the environment is 13.8 and 28.6°C. Fourteen varieties of common bean which have a different color were included for this
study as shown in Figure 1, and all the common bean varieties were collected from rift valley areas of Ethiopia. The collected common bean varieties of seeds were cleaned by hand to remove any unwanted signs, and for each variety, about 3 kg were taken for the study and packed in plastic bags.

2.1. Methods

2.1.1. Physical parameter analysis

_Hundred seed weight_; Hundred (100) dry bean seeds were randomly selected, weighed and one hundred seed weight per number of seeds in 100 g with triplicate readings were taken and the average values of the triplicate were reported (P Balasubramanian et al., 1999).

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

(1)

**Number of Non-soakers**; Randomly, 400 bean seeds were selected and soaked in a 250 ml beaker (3:1) water to grain volume ratio at 27°C for 16 hours, and then water was drained. The non-soakers were picked-up by hand and counted, and the value was expressed as a percentage ratio.

\[
\% \text{Nonsoaker} = \frac{\text{Number of non-soaked beans}}{\text{Number of soaked beans}}
\]  

(2)

_Cooking time_; Mattson’s cooking device was used for estimating the cooking time of beans (Mattson, 1946) modified by (Jackson & Varriano-Marston, 1981). The device has a cooking rack with 25 hollow plungers and 25 cylindrical holes in the cooker. Bean was soaked for 16 hours at 27°C before cooking, and the soaked bean positioned into each of the cylindrical holes of the cooker so that, the piercing tip of the 90-g stainless steel rod is in contact with the surface of beans. The cooker was placed into 2 l of boiling water. Beans were judged as cooked, when a bean became sufficiently tender, the plunger enters the “cooked” bean and dropped a short distance through the hole in the saddle. Cooking time (minute) was recorded from the time of boiling started after submerging the cooker to the time of 50% penetrated through it (Morris, 1963), and triplicate data was taken.

2.1.2. Bean canning process

For each variety of bean sample equivalent to 100 g was accurately weighed, placed into mesh bags, soaked in water for 30 min at room temperature, and then blanched for 30 min at 78°C in which the balanced water containing 100 ppm of CaCl₂ solution (Uebersax & Hosfield, 1985). The samples were first drained and weighing, and then transferred into coded cans, and covered with boiling brine containing 100 ppm Ca²⁺, 1.3% NaCl, and 1.56% sugar. The cans were sealed and cooked in the autoclave (Vacuum release dynamic autoclave, VAM 903 01, India) at 115.6°C for
45 min. Then the cans of processed beans were stored for three weeks before opening for evaluation of canning-quality traits.

**Hydration Coefficient (HC);** The weight gained by imbibition during soaking and blanching was used to calculate the hydration coefficient (Van Der Merwe et al., 2006) as follows:

\[
\text{HydrationCoefficient} = \frac{\text{Massofsoakedbeans (g)}}{\text{Massofdrybeans (g)}}
\]  

**PWDWT;** Washed drained weight (WDWT) was determined after drained for 2 min (M. Uebersax & Hosfield, 1985), whereas Percentage Washed drained weight (PWDWT) was calculated as (Van Der Merwe et al., 2006) expressed as below.

\[
\text{PWDWT} = \frac{\text{Washeddrainedweight (g)}}{\text{Massofcancontent (g)}} \times 100
\]

2.1.3. **Visual appearance canned beans quality**
The degree of clumping, splitting, and viscosity/starchiness of canned beans was conducted in 20 semi-trained panelists with three (3) degree of clumping scales (1 = beans solidly clamped to the bottom of the can to 3 = no clumping), 10 scales for splitting (0 = splitted Extremely to 9 = completely un splitted) and 5 scales for starchiness (1 = very clear to 5 = extremely cloudy) as presented in Figure 2 (Balasubramanian et al., 1999).

2.1.4. **Proximate compositions**
Moisture, ash, crude fat, crude protein, and crude fiber were determined by (William, 2000) official methods of 925.10, 923.03, 920.39, 920.87, and 945.38, respectively, and their difference was taken to determine total carbohydrate content (Onwuliri & Obu, 2002)

\[
\text{Totalcarbohydrate} = 100 - (\%\text{moisere} + \%\text{ash} + \%\text{protein} + \%\text{fat})
\]

**Energy value;** It was quantified based on the three groups of nutrients (carbohydrates, fats, and proteins) (Edeoga et al., 2003)

\[
\text{FE} = (\%\text{TC} - \%\text{CF})x + (\%\text{TFx9}) + (\%\text{TPx4})
\]

Where, FE = Food Energy in kCal/g, TC = Total Carbohydrate, CF = Crude Fiber, TF = Total Fat and TP = Total Protein

**Phytate;** It was determined by (Latta & Eskin, 1980) methods, later modified by (Vaintraub & Lapteva, 1988), spectrophotometrically (GENESYS™ 10S UV-Vis Spectrophotometer, USA).

\[
\text{Phytate (mg/100g)} = \frac{(\text{As} - \text{Ab} - \text{intercept}) \times 10}{\text{slop} + \text{Swt} + 3}
\]

Where, As – sample absorbance, Ab – blank absorbance, 10/3 – dilution factor
Mineral Content; Mineral content was evaluated by acid digestion methods using AAS (Shimadzu—Model AA-7000). Briefly, 0.5 g of bean flour sample was weighed in an acid digestion tube, and then sample digested with one-milliliter nitric acid (HNO3) and seven milliliters of perchloric acid (HClO4). The extracted sample was read using Atomic Absorption Spectrophotometer with appropriate lamps (Horwitz, 2000).

3. Statistical data analysis
Statistical analysis was performed using MINITAB 23 software, one-way analysis of variance (ANOVA), and Tukey HSD Pairwise Comparison test for the comparison of means at $P \leq 0.05$.

4. Results
Several common bean varieties, which have a different seed shape, seed color, seed size, and class are under production in Ethiopia. Among the number of common bean varieties, some of them were subjected to nutritional, canning quality, cookability, and anti-nutritional analysis for the present study, and the results are presented in different tables and figures. The general characteristics of the selected common bean varieties such as seed (shape color, size, class, and type of purpose) are presented in Table 1.

Table 1. The general characteristics of selected common bean varieties

| Official Name | Local Name         | Seed Shape | Seed color | Seed size | Class      | Type       |
|---------------|--------------------|------------|------------|-----------|------------|------------|
| G-4445        | Awash-1            | Round      | White      | Small     |            |            |
| Mesoamerican  | Export             |            |            |           |            |            |
| PAN-182       | Awash-Melka        | Flat       | White      | Small     |            |            |
| Batu          | Batu               | Kidney     | White      | Large     | Andean     | beans      |
| Cranscope     | Cranscope          | Kidney     | Speckled   | Large     |            |            |
| SUG-131       | Demer              | Kidney     | Speckled   | Large     |            |            |
| DRK           | DRK                | Kidney     | Red        | Large     |            | Export     |
| Ecab-0056     | Ecab-0056          | Elongate   | Red mottled| Large     |            | Local      |
| G-2816        | Gofta              | Elongate   | Cream      | Medium    |            | Consumption|
| Ibado         | Ibado              | Elongate   | Red mottled| Large     |            |            |
| KATB-1        | KATB-1             | Oval       | Yellow     | Medium    |            |            |
| KATB-9        | KATB-9             | Oval       | Red        | Medium    |            |            |
| Dicta-105     | Nasir              | Round      | red        | Small     |            |            |
| Mesoamerican  | local and Export   | Roba       | Elongate   | Brown     | small      |            |

For the selected varieties of common beans, physical parameters such as seed weight/100 seed, cooking time, and percent of non-soaker seeds were analyzed, and results are presented in Figure 3. The highest seed weight per 100 seed was obtained from SUG-131 while the lowest is from G-4445 varieties.
Figure 3. The 100 seed weight, non-soakers and cooking time of the experimental common bean.

![Figure 3](image)

Figure 4. Canning qualities of the experimental varieties of common beans.

![Figure 4](image)

Carnscope variety being the highest by taking a longer cooking time whereas the shorter cooking time is obtained from Roba (30.00 min). In this study, the percent of being more unhydrated seeds of common bean was found in Ibado and the least was in DRK variety.

4.1. Canning quality of beans

Canning quality traits; percentage washed drain weight (PWDW), hydration coefficient (HC), clumping degree, starchiness/viscosity, and splitting degree were analyzed and presented in Figure 4. Percentage washed drained weight and hydration coefficient values varied from 60.06–64.47%, 1.25–1.68. On the other hand, the clumping degree, starchiness, and splitting degree of the tested varieties covered in the range of 1.71–2.40, 2.14–4.45, and 1.68–5.91, respectively.

Clumping degree; 1 = Extremely clumped, 2 = moderately clumped, 3 = clumping

Splitting degree; 0 = splitted Extremely, 1 = splitted very much, 2 = splitted moderately, 3 = splitted slightly, 4 = Either splitted or unsplitted, 5 = neither splitted nor unsplitted, 6 = unsplitted slightly, 7 = unsplitted moderately, 8 = unsplitted very much, 9 = completely unsplitted

Starchiness/viscosity; 1 = Very clear, 2 = moderately clear, 3 = slightly clear, 4 = moderately cloudy, 5 = Extremely Cloudy
4.2. Proximate compositions

Proximate compositions: moisture, ash, crude fiber, crude protein, fat, carbohydrates, and energy values were analyzed and results are mentioned in Table 2. In this study, G-2816 is being the highest protein content followed by PAN-182 while the lowest value was found at Cranscope varieties. Moisture is one of the factors that determine the shelf stability of the grain. Moisture content was not varied as expected among varieties, but the maximum difference was 1.4. Ash contents of the experimental varieties of common bean also in the range of 3.62–4.60 %. Other parameters such as fat and fiber content are covered in the range of 1.07–2.35 and 4.07–7.33. Likewise, energy and carbohydrate values were found in the array of 322.99–340.71 % & 58.79–66.29 %.

There are different anti-nutrients present in different crops, of which phytate is the most common in cereals and legumes. Anti-nutrients contribute to the reduction of bioavailability of minerals and proteins in our body from the ingested food matrix. In the present study, fourteen varieties of common bean’s phytate content were analyzed and its maximum and minimum value found in 23.59–8.1 mg/g, and the results are presented in Figure 5.

The electrolytes such as K and Na were found 1954.7–3846.7 and 18.06–50.77 mg/100 g range, whereas the other minerals such as P, Mg, and Ca obtained between 604. 481–1207.20, 144.74–559.85, and 51.71–438.36 mg/100 g respectively and the data are presented in Figure 6.

Most deficient minerals of food such as Fe and Zn were included in this study, and their values varied from 0.02–36.6 and 0.49–5.45 mg/100 g as mentioned in Figure 7.

5. Discussion

Grain legumes play an important role in the world’s food and nutrition requirements, especially in the dietary pattern of low-income groups. Common bean is one of the grain legumes that can be

| Varieties | Moisture | Ash | Fat | Fiber | Protein | CHO | FE |
|-----------|----------|-----|-----|-------|---------|-----|----|
| G-4445    | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| Awash-2   | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| PAN-182   | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| Batu      | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| Cranscope | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| SUG-131   | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| DRK       | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| ECAB-0056 | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| G-2816    | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| Ibada     | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| KATB-1    | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| KATB-9    | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| Dicta-105 | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| Roba      | 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|
| Grand mean| 5.55     | 3.74| 1.61| 6.00  | 17.96   | 66.29| 327.50|

Means followed by the same letter within a column are not significantly different at P ≤ 0.05.
used as a source of protein in developing countries. It is morphologically variable and adaptable to different environments, this brought to have a different nutritional composition because it is influenced by various factors; genotype, geographical origin, environmental, and growing conditions (Broughton et al., 2003). So, knowing of its nutritional quality would have a direct impact on the improvement of quality breeding and nutrient-based food product developments. Commercial quality beans that are targeted by breeders have a good characteristic of color, shine, shape, and size. The color and size of the beans are the first attributes evaluated by consumers and playing a decisive role in the acceptance of the product (Gathu et al., 2012) but the nutritional compositions and other culinary parameters are the second.

In this investigation, most of the basic parameters have been tested and presented in different tables and figures. Weight of seed per 100 seed, cooking time, and percent of non-soakability was shown a significant difference at $P \leq 0.05$, and their values covered in the range between 17.18
53.17 g/100 seed, 30.0–51.33 min, and 0.00–4%, respectively. For eight varieties of common bean (Shimelis & Rakshit, 2005) reported that seed weight/100 seeds, % unhydrated seed, and cooking time were obtained in the range of 16.91–43.940 g/100 seeds, 1.52–40.33%, and 22.50–41.70 minutes.

As reported by numerous scholars, cooking time, percent of undehydrated, and seed weights among bean varieties have different, and this could be due to genotype and environmental variability. (Teshome & Emire, 2012) the research report found that the cooking time for five dry bean varieties was found to be 24.00–35.33 min, whereas (De Barros & Prudencio, 2016) for 7 common beans from 22.67–43.67 min, most of our research data result has fallen in this range. Moreover, (Mkanda et al., 2007) studied six dry bean varieties grown in different locations, and cooking times were found to be 42.4–97.8 minutes, which was taken much time, and the report significantly different from our results. According to the author cooking time and bean texture can be influenced by many factors such as variety, growth site, and storage conditions, besides physicochemical properties of the cotyledons and the skin. Cooking time is one of the main considerations for evaluating the quality of crops like pulses. Beans that require more time to cook are not preferable to the consumers because when beans stay for a long time on heat, it will lose the nutrient as well also increased energy expenditure. On the other hand, bean seeds that have a higher percentage of non-soaker are not readily cooked, it would increase cooking time, and make beans undesirable.

5.1. Canning quality of dry beans
Canned bean products are suitable for urban areas of Africa (Siddig & Uebersax, 2012) to consume beans, and it has distinctive colors and provides excellent consumer acceptance (Uebersax, 2006). The bean varieties can be used for the canning industry should meet the specific standards, besides its yield potential. In the present finding, percentage washed drained weight, hydration coefficient, and physicochemical properties (clumping degree, starchiness, and splitting degree) were evaluated for the selected bean varieties. The statistical data results of the physicochemical properties revealed, significant differences at $P \leq 0.05$. Percentage of washed drained weight values were higher in PAN-182 varieties while in DRK was being the least. On the other hand, Awash-2 and DRK varieties had got the highest value in the hydration coefficient but on the contrary, Dicta-105 and Roba varieties the lowest.
The hydration coefficient for bean processors is an important criterion because it is related to the canning yield (Van Loggerenberg, 2004). If the hydration coefficient is low, a larger amount of beans is required to fill a given can volume while a higher hydration coefficient is associated with improved canning yield (Ghaderi et al., 1984). The optimum hydration coefficient value for common beans is considered as 1.82–2.0 for the industry (Parthiba Balasubramanian et al., 2000), for well-soaked beans. In this finding, all common bean varieties have shown a lower hydration coefficient value than the recommended. As result, extra time is required, for weight gained by imbition to increase the hydration coefficient. Even if, the hydration coefficient value is different for different bean sizes, beans included in this study did not fulfill canning quality requirements within a given time. As (Warsame & Kimani, 2014) research report, the hydration coefficient in large and small bean seeds was recorded from 1.43–1.63 and 1.35–2.13. The hydration coefficient of large and small bean seeds of the present finding is in agreement with the above reports except for some varieties. The percentage washed drained weight of large and small bean seeds values (Warsame & Kimani, 2014) covered in the range of 65.1–71.65% and 61.2–71.13%. The current results for small bean seeds are convenient with the above reports but not for large seeds. Nevertheless; based on the existing canning standard all the varieties evaluated in this study meet the desired 60% of percentage washed drained weight (P Balasubramanian et al., 1999; Van Loggerenberg, 2004).

5.2. Visual appearance quality of canned beans
Clumping degree, starchiness, and splitting degree of beans were analyzed subjectively, and significant variation was observed at \( P \leq 0.05 \). The visual appearance quality of canned beans is considered to be the major quality evaluation standard. However, all bean varieties may not have the same acceptable quality, because consumer preference is often affected by the occurrence of bean discoloration, the hardness of beans, and breakage of seed coat after the canning process (Wassim et al., 1990).

During the canning process, bean seed coats may or may not be split but if the seed coat splits, it will affect appearance, making canned beans starchier/viscous. The more beans coat splitted, the more beans would be clumping and becoming unacceptable to consumers (Van Loggerenberg, 2004). As stated by (Van Loggerenberg, 2004) beans of better canning quality should maintain their integrity in the canning medium. Maximum and minimum splits of beans were observed for Carnscope and DRK with the value of 1.68 and 5.91. Soft texture and little split of beans are preferential to consumers. The highest adhering degree was obtained from Awash-2 (1.71) varieties whereas the least from SUG-131 (2.40). Starchiness, awash-2 varieties being moderately clear than did others whereas Dicta-105 is cloudy.

In general, physicochemical characteristics of beans such as splits, size, shape, and uniformity recommended being as important criteria for canning quality beans (Ubersax & Hosfield, 1985). In this investigation, statistical differences for canning quality were detected at \( P \leq 0.05 \), and this could arise from genetic variation (Gathu et al., 2012).

5.3. Proximate compositions
The moisture content of beans found to be 9.47–10.87 g/100 g, and the findings are in agreement with (Shimelis & Rakshit, 2005) who found, that 9.08–11.01 g/100 g. Moreover, Gouveia et al. (2014) found that the moisture content for 59 accessions of common bean varieties ranged from 6.45–16.6 g/100 g. As reported by (Nagrale et al., 2018) the sixteen mung beans varieties moisture varied from 5.26 to 10.90 which is in accordance with the present findings.

Ash represents the total mineral contents of the grains. Statistical differences at \( P \leq 0.05 \) for ash content were obtained, and the highest ash content was obtained from PAN-182 with a mean value of 4.60% while the lowest was found from DRK (3.62%) varieties. The current research output has a similarity with (Mesquita et al., 2007) and (De Almeida Costa et al., 2006) findings who found that ash content of common beans varied from 2.86 to 4.40 g/100 g, and also mung beans found
from 3.1% to 4% (Varma et al., 2018) for sixteen varieties. Roba bean variety had shown a lower crude fiber content than did the others but Ecab-0056 was the maximum which is 7.33%. Among bean varieties, statistical differences were found at $P \leq 0.05$, and the outcomes of the present finding are convenient with (Teshome & Emire, 2012) research report but higher than (Shimelis & Rakshit, 2005). Dietary fiber is considered essential for optimal digestive health (Aldoori & Ryan-Harshman, 2002); protects against cardiovascular diseases and type 2 diabetes. Therefore, the bean varieties Ecab-0056 and G-2816 which have a higher fiber content than did other varieties could be an alternative solution for the above problem.

The protein content of beans was significantly different at $P \leq 0.05$, and the protein content of cranscope (17.96%) variety being the lowest whereas G-2816 (25.73 %) and PAN-182 bean variety were the higher. The maximum crude protein content found in this study is lower as compared to the (Gouveia et al., 2014) research report, which found 18.55–29.69% from 52 accessions of common beans. Nevertheless, as described by (Shimelis & Rakshit, 2005) protein content of evaluated common bean varieties covered from 17.956–22.073%, which falls in the range of the current study. As compared with mung bean protein content reported by (Li et al., 2010), ranging from 24.26% to 28.50%, the present results of common beans are found to be comparable, but much lower than Faba bean which is obtained from 31% to 34% (Rahate et al., 2020).

Batista et al. (2010) revealed that the protein digestibility of raw beans varied from 25% to 60%, but can be increased up to 93.2%, depending on the bean variety and cooking process. Even though legume proteins, are not completely digestible unlike animal protein, they will help us to combat protein-rich nutrient deficiency problems in our country. As a result, the beans which have a higher protein content should emphasize, to make them easily accessible for the community through modern breeding system. Beans contain only a minor quantity of lipids with a majority of unsaturated fatty acids (Anderson & Hanna, 1999). In this finding, the maximum total fat content was 2.35% (KTAB-9) and the result is similar to the value reported by Kan et al. (2017).

More of the energy required for our body came from carbohydrates (Aremu et al., 2009), which is readily exchangeable to energy, and also covered the major percent of the grain content. From the present finding, the higher value of carbohydrate was found from Cranscope while the lower was found from G-2816 bean variety. This result is found to be greater than the result of (56.528–61.563%) reported by (Shimelis & Rakshit, 2005), but lower than (De Barros & Prudencio, 2016), who obtained from 69.89% to 72.47%.

### 5.4. Mineral compositions

In this investigation micro and macronutrients are analyzed, those are the most important minerals from the dietary perspective as they play vital functions in the organism (Navarra & Lipkowicz, 2004). The mineral contents of the analyzed beans are presented in Figures 6 and 7. Statistical analysis showed that the bean varieties were significantly different in their mineral contents at $P \leq 0.05$. Both Batu and PAN-182 varieties of common bean have found the highest value of Ca, Fe, and Zn than did the other varieties. Phosphorus, potassium, magnesium, and calcium contents of the present finding is in harmony with (Triwari & Singh, 2012) research report whereas micro-nutrients (iron and zinc) contents in convenient with (Meyer et al., 2013) report.

The nutritional compositions of common beans may be influenced by their genotype/varieties, environmental conditions (location, soil, and climate), and period of cultivations (Wu et al., 2016). The iron content in this study meets the recommended daily intake (RDI) for all target groups whereas zinc content is equal to the recommended daily intake (RDI) for children 4–5 years (Nkundabombi et al., 2016). As a result, varieties of beans that have a higher value of micronutrients are required, to fight against micronutrient deficiency which is widely spreading across the world especially in Africa.
5.5. Anti-nutritional factors
Common beans contain good nutritional quality, in contrast, they contain anti-nutritional factors that reduce the bio-accessibility and bioavailability of nutrients. Hence, anti-nutritional factors are induced by tannins, phytates, protease inhibitors, and lectins. Among the anti-nutritional factors, phytate was evaluated, and as presented in Figure 5, the findings tell us that phytate content significantly different at $P \leq 0.05$. The variability of the result may arise from the genotype and environmental conditions (location, soil, and climate) as stated by (Affify et al., 2011). Findings indicate that the Ecab-0056 (8.10 mg/g) variety of beans had the lowest while Awash-2 (23.59 mg/g) had the highest phytate content. The present findings are consistent with the previous research reports of (Meyer et al., 2013; Pedrosa et al., 2015) who found that 2.6–25.1 mg/g dry weight.

Phytate interacts with basic protein residues and can inhibit digestive enzymes such as pepsin, pancreatin, and amylase (Agostini & Ida, 2006). It can also chelate with cations and decrease nutritional value leading to micronutrient deficiencies (Kumar et al., 2010). The interaction of phytate with proteins, vitamins, and several minerals is one of the factors that limit the nutritive value of dry beans. Numerous studies suggest that also phytate reduces, the biological availability of dietary copper and manganese, iron, magnesium, and zinc. Therefore, beans that have higher phytate content may not be a choice for the consumers due to their adverse effect on protein digestibility and mineral bioavailability.

6. Conclusions
In the present investigation, results revealed that significant differences were observed at $p \leq 0.05$ for their physical parameters, proximate composition, mineral content, canning qualities, and phytate values. However, despite the differences, some of the common bean varieties had shown high protein, fiber, micro, and macronutrient contents and has a better canning quality than others. PAN-182, Awash-2, G-4445, G-2816, Batu, and Roba common bean varieties have found a better nutritional value, as result, they can be used as a complement for new product development to increasing nutritional qualities, and for food security to create a healthy society. The findings could have a significant implication for reducing the protein energy, and micronutrient (Fe and Zn) deficiency prevalence in the community using higher protein-mineral enriched common beans through formulating and commercializing fortified complementary foods. The researcher recommends that tannin, trypsin inhibitors (protease inhibitors), protein quality, and bioavailability of micronutrients (Fe and Zn) should be studied for the selected bean varieties.

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Disclosure statement
The authors declare that there are no conflicts of interest.

Data availability
The data that support the findings of this study described in figure are available from the corresponding author, upon reasonable request.

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