Effect of germination process on nutrients and phytochemicals contents of faba bean (*Vicia faba* L.) for weaning food preparation

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Effect of germination process on nutrients and phytochemicals contents of faba bean (Vicia faba L.) for weaning food preparation

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Abstract: Faba bean is an important cheap source of legume protein, which can be used as a substitute for animal protein and used to produce weaning food. Two levels of germination duration were applied and mixture design was used to prepare the weaning food flours of roasted barley, germinated faba bean, and carrot powder. The flour ratios used were barley 50–70%, faba bean 25–35%, and carrot 5–15%. A significant decrease in condensed tannin was observed during germinations (11.13–4.5 mg/100 g for 48 h and to 2.26 mg/100 g after 72 h). After 72 h of germination its protein content increased by 3–4%, carotenoid content from 0.051 to 0.085 mg/g and the Fe and Zn mineral content increased significantly. Crude protein content of the weaning food ranged from 15.1% to 16.25%. The iron content of the raw faba bean, 48-h germinated faba bean and 72-h germinated faba bean, carrot powder, flour blends and control was 6.60, 6.75, 6.82, 3.60, 4.39 and 2.90 mg/100 g, respectively. Germination process improved the nutrient and reduced tannin contents of the prepared flours.

Subjects: Food Additives & Ingredients; Food Chemistry; Food Engineering; Food Laws & Regulations

Keywords: faba bean; germination; iron; protein; tannin

ABOUT THE AUTHOR
Hagos Hailu Kassegn has published peer-reviewed articles in the areas of food safety, thyme herbal tea development, cereal chemistry, weaning food preparation and preparation of training manual and consulting to technical and vocational college instructors in the area of Honey Beverage Processing. He has conducted assessments of food safety issues in the cow milk supply chain in urban and per-urban areas of Tigray, Ethiopia. The information in the current perspective article is important for safe food preparation and enhancing nutrient contents of weaning food. Malnutrition affects children and women of low income society in developing countries. Information can support households and communities to minimize malnutrition of children and women.

PUBLIC INTEREST STATEMENT
Food lacking the necessary ingredients cannot help people to sustain healthy life. Feeding children separate crops and un-processed grains will not fulfil their nutritional requirement. Preparation of weaning food by mixing of roasted barley flour, germinated faba bean flour and carrot powder have improved nutrient content. The nutrient increment that occur during faba bean germination are mainly due to the breakdown of complex compounds into a simpler form. The germination process significantly decreases the concentration of nutrient-binding components found in non-germinated faba bean due to leaching out in to water. The high prevalence of malnutrition occurring in developing countries can be minimized by introducing such simple processing technology. The product has a major role in fulfilling of the vitamin A, iron and zinc requirement for low income community having micronutrient deficiency.
1. Introduction

Legumes provide a high proportion of dietary fibre in the diet and they have been successfully used as part of the dietary treatment of diabetes Brand, Snow, Nobhan, and Truswell (1990). It has an impact in lowering blood cholesterol levels Soni, George, and Singh (1982) and Singh, George, and Soni (1983), which indicates their possible therapeutic importance. Pritchard, Dryburgh, and Wilson (1973) & Hove, King, and Hill (1978) reported that the values of the dietary fibre 15–30% seems to depend on the seed variety

Faba bean (Vicia faba, L.) is one of the oldest crops and ranks sixth in production among the different legumes grown in the world after soybean, peanut, beans, peas and chickpeas (Milner, 1973). It also contains a large amount of proteins, carbohydrates, B-group vitamins and minerals. The protein content of faba bean ranges from 20% to 41%, values which depend on the variety Chavan, Kute, and Kadam (1989). Faba bean seeds contain 51–68% of carbohydrate of which 41–53% is constituted by starch, and it is also a good source of dietary minerals such as, phosphorus, potassium, calcium, sulphur and iron. Calcium content of faba bean ranges from 120 to 260 mg/100 g dry mass Chavan et al. (1989).

Although faba bean seeds are considered to be one of the most nutritious plant foods, certain anti-nutritional factors limit their biological value and acceptance as a food. This is the reason why
the seeds have to be processed using methods such as germinating, fermentation and cooking before being consumed (Abusin, 2015). Germination of faba bean improves protein digestibility at a lower level than cooking. It also degrades proteins to simple peptides and improves crude protein, non-protein nitrogen and crude fibre content Elmaki, Babiker, and Tinay (1999). Germination decreases lysine, tryptophan, sulphur and total aromatic amino acids, but most contents are still higher than proposed by the WHO & United Nations University (2007).

Formulation of weaning food rich in protein, carbohydrate, minerals and other nutrients at the high proportion to complement breast milk and infant feeding will bring about the end of the children high mortality rate typical of developing countries UNICEF (1998). Weaning foods, whether manufactured or locally prepared must satisfy the nutritional requirement of infants and should also be soft and semi-solid in texture (Ugwu, 2009). It is mostly prepared in the form of thin porridge or gruels Silvia et al. (2007). Development of nutrient foods is guided by the following principles of high nutritional value to supplement breastfeeding, acceptance, energy density, low anti-nutritional content and use of local food items (Dewey & Brown, 2003; Pelto, Levitt, and Thairu (2003). The objective of this study was to investigate the effect of germination process on the nutrients and phytochemicals of faba bean for weaning food preparation. The final product may have a great contribution to minimize the high incidence of mothers and children malnutrition in countries, Ethiopia.

2. Materials and methods

2.1. Samples
The barley, faba bean and carrot were purchased from Maichew and Adishiho local markets found in the Southern highlands of Tigray Region, Ethiopia. Samples were placed in labeled dry plastic bags and taken for analysis to Food Science and Post-harvest Technology laboratory, Haramaya University Institute of Technology, Ethiopia.

2.2. Experimental design
A simple mixture design was used to study the effect of the mixtures of barley (B), germinated faba bean (Fb) and carrot powder (C) flours to prepare weaning food products. The flour ratio used was barley 50–70%, faba bean 25–35% and carrot 5–15%.

2.3. Preparation of barley flour
Barley was dried to a uniform moisture content of 10% so as to suppress the differences in moisture content on roasting behaviour. The conditioned grain was roasted at 280 ± 5°C for 20 s in a traditional sand roaster. The roaster consisted of an iron pan having a diameter of 920 mm and depth of 600 mm. The barley grain was vigorously stirred with the sand to ensure uniform heating Sharma et al. (2011). It was immediately removed from the hot sand by sieving and spreading on a marble slab for cooling. It was ground in the cyclone sample mill (model 3010-081P, Colorado, USA) to pass through ≤710 µm sieve to obtain barley flour.

2.4. Faba bean germination process
Faba bean grain was soaked in tap water (1:5, w/v) at room temperature (≈23°C) for 12 h, and the water was drained off and the grain allowed to sprout. During germination, the wet grains were covered with moist fine cloth and kept in a dark place at a temperature of about (≈23°C) for 48 and 72 hrs. The germinated beans were dried at 50°C over night in a drying oven (model 101-1A. China) (Khalil & Mansour, 1995). After drying the faba bean was roasted in an iron pan at a temperature of 200°C for about 15 min until golden brown colour was developed. The roasted beans were cooled and ground to pass ≤710 µm sieve and kept at cool and dry room until used.

2.5. Preparation of carrot powder
To inactivate peroxides, the sliced carrots (10 mm) handled in a muslin cloth were subjected to hot water blanching (100°C) for six minutes (Ranganna, 1986). The blanched sample was immediately cooled to room temperature under running cold water and then spread on a sieve tray to drain. After
this step, the carrot was dried at temperature of 70°C for 24 h. in an oven (model 101-1A, China) and was ground (model A11 basic, IKA, China) to pass ≤710 µm sieve Uddin, Ainsworth, and İbanoğlu (2004).

2.6. Proximate composition

The proximate composition (carbohydrate, fat, crude fibre, protein, moisture and ash) of the raw barley, faba bean and carrot powder and the blended flours were determined using the method of AOAC (2000). The nitrogen content of the samples was determined by the micro-Kjedhal method. The nitrogen value obtained was multiplied by 6.25 to convert it to crude protein. The weight difference method was used to determine moisture and ash levels while crude fat of the samples was determined using the Soxhlet apparatus with petroleum ether as solvent. The carbohydrate content was determined by calculation using the difference method

\[
\text{%Carbohydrate} = \left(100 - \% \text{protein} - \% \text{fat} - \% \text{moisture} - \% \text{ash} - \% \text{fiber}\right)
\]

The various proximate parameters were all reported in percentages AOAC (2000). The calorific value of the gross food energy values (kcal/100 g sample) of each sample was estimated using the Atwater factors for protein (4), fat (9) and carbohydrate (4) Zou, Moughan, Awati, and Livesey (2007).

\[
\text{Food energy} = (\% \text{crude protein} \times 4) + (\% \text{fat content} \times 9) + (\% \text{carbohydrates} \times 4)
\]

2.7. Mineral analysis

The dried, powdered samples were first digested with nitric acid and perchloric acid and then the aliquots were used for the determination of iron and zinc contents which was also read by atomic absorption spectrophotometer AOAC (1990). Minerals were determined with their specific hollow cathode lamps at wavelengths specified by the manufacturer. Standards and reagent blanks were run at regular intervals to ensure consistent instrument performance. All samples were analysed in triplicates. The mineral content was calculated by using the following formula:

\[
\text{Fe/Zn, mg/1000g} = \frac{(\mu g/ml) \times 100}{\text{sample mass, g(db)}}
\]

Where: \((\mu g/ml)\) is the absorbency concentration reading of sample

2.8. Analysis of antinutritional factor and antioxidant activity

2.8.1. Total carotenoid

Carotenoid was extracted by homogenizing carrot tissue of 5 g in 30 ml of acetone/ethanol (50:50) solution. The homogenate was filtered under suction in a Buchner funnel and washed with acetone/ethanol solvent until it became colourless. The filtrate was adjusted to 100 mL volume with acetone/ethanol. An aliquot of the total carotenoid solution was placed in a 1 cm cuvette and colorimetric measurement was made using spectrophotometer at 470 nm. The amount of total carotenoid was calculated as described by (Gross, 1991).

\[
\text{mg carotenoid/g tissue} = \frac{(AxVx10000)}{A1%xG}
\]

Where: \(A = \text{absorbance at 470 nm; } V = \text{total volume of solution; } G = \text{gram of sample; and } A1\% = \text{specific extinction coefficient (2500)}\).

2.8.2. Condensed tannins

Condensed tannin was analysed by Vanillin–HCl methods of Price, Van Scyoc, and Butler (1978). The sample was milled (model 3010-081P, Colorado, USA) just to pass ≤750 µm sieve. About 200 mg of the sample was weighed into a screw capped test tube and extracted with 10 mL methanol by vortex mixing for 20 min. Then it was centrifuged (model 1020 D.E, UK) at 3000x g for 10 min. The Vanillin (5 mL) reagent was mixed with 1 mL of sample extract at 1 min interval to one test sample set and for the blank (1 mL) only 5 mL of concentrated HCl was added in methanol 4% at 1 min interval. The
supernatant was used for the analysis after warming up along with the Vanillin-HCl reagent in a water bath (Model GLS 400, England) at 30°C. Sample 1 mL of the sample extract was taken in a duplicate for each sample (one for mixing with Vanillin reagent and the other for blank) to be deducted from sample absorbance. Then it was immediately incubated in a water bath at 30°C for 20 min. After 20 min the absorbance was immediately measured at 500 nm in 1 min interval as per the sequence used for mixing. The sample absorbance was deducted from the blank and the value was estimated from the catechin equivalent (CE) standard curve Price et al. (1978).

2.8.3. Ferric reducing antioxidant power (FRAP)

The FRAP was measured as described by Zhao et al. (2008). The flour sample of 0.5 g was extracted with 1 mL of 80% methanol on wrist action shaker for 2 h. The extract was mixed with 2.5 mL of phosphate buffer 0.2M pH 6.6 and 2.5 mL of 1% potassium ferricyanide was added, followed by the incubation at 50°C for 20 min. Trichloroacetic acid solution (10%) was added to the mixture and then centrifuged at 3000 g for 10 min. The upper layer of solution 2.5 mL was mixed with 2.5 mL distilled water and 0.5 mL ferric chloride 0.1%. The absorbance of the mixture was measured at 700 nm. Increase in the absorbance of the mixture is an indicator of increased FRAP. A standard curve was prepared using various concentrations of ascorbic acid and the results were reported as µmol ascorbic acid equivalents/g of flour.

3. Results and discussion

3.1. Proximate composition of barley, faba bean, carrot flours and their blends

The effect of germination on the proximate composition of faba bean seeds and blended flours are presented in Table 1. The moisture, crude fat content and fibre of the non-germinated faba bean are significantly lower (p < 0.05) than that of the germinated faba bean, while their crude protein, total carbohydrate, ash and total metabolizable energy content was higher. All results were compared to the control value/non-germinated barley flour. Germinated faba bean has lower moisture value than raw faba bean. This may due to oven drying and roasting after germination. The moisture content of all the blended flours was ranged from 5.30 to 5.49%. This lower moisture contents of the blended flours were fit to packaging and transport Oduro, Ellis, Sulemana, and Oti-Boateng (2007).

Results showed that the ash content of raw barley, faba bean and carrot powder was 2.31, 2.30 and 5.50%, respectively and that of the germinated faba bean at days two and three were 2.71 and 2.55% and it is closely agreement with the reported value of Elsheikh, El Tinay, and Fadul (1999) (3.09 to 3.54% ash content). The ash content of blended flours ranged from 3.30 to 4.12%, while the control value (barley flour) was 2.24%, which shows significant increase at P < 0.05 in blending with germinated fava bean and carrot powder. The ash content of the blended flours of 0.5% barley, 0.35% germinated faba bean and 0.15% carrot powder had the highest amount of ash 4.12%. This indicates the increment of mineral content with the addition of the germinated faba bean and carrot powder. Although the other blended flours had low ash content ranged from 3.3 to 3.55%, they are acceptable by the (Protein Advisory Group, 1972) standard which recommended that the ash content should not exceed 5%.

Crude fibre content of germinated faba bean was lower than that of raw seeds and the germination process causes significant decrease in crude fibre content. Changes in fibre content may attribute to the fact that part of the seed fibre may be solubilized enzymatically during seed germination (El Maki et al., 1999). The crude fibre content of the control barley flour 5.68% was higher than that of blended flours ranged from 4.9 to 5.48%.

The observed decrease in the fat contents of the germinated seeds might be due to the increased activities of the lipolytic enzymes during germination. They hydrolyze fat to simpler products which can be used as a source of energy for the developing embryo and it is same as the reported value was made for bambara groundnuts reported by (Elegbede, 1998). A fat composition of the prepared
Table 1. Proximate composition of barley, fababean, carrot flours and their blends

| Samples | GD | Moisture % | Ash % | Fiber % | Fat % | Protein % | Carbohydrate % | Energy Kcal |
|---------|----|------------|-------|---------|-------|------------|----------------|-------------|
| B       | 9.50 ± 0.02b | 2.31 ± 0.04d | 5.68 ± 0.07b | 2.70 ± 0.05a | 12.5 ± 0.30c | 67.31 ± 0.50b | 343.54b |
| Fab     | 11.0 ± 0.10a | 2.30 ± 0.10e | 1.31 ± 0.02c | 1.55 ± 0.02b | 26.40 ± 0.03d | 56.44 ± 0.29e | 345.31b |
| C       | 5.71 ± 0.02d | 5.50 ± 0.05a | 11.00 ± 0.3a | 1.00 ± 0.01d | 7.50 ± 0.18e | 69.29 ± 0.15a | 316.1c |
| FB2     | 5.72 ± 0.02dc | 2.71 ± 0.05c | 1.20 ± 0.02d | 1.30 ± 0.04c | 29.71 ± 0.20b | 59.36 ± 0.22d | 367.98a |
| FB3     | 5.75 ± 0.03c | 2.75 ± 0.12b | 1.15 ± 0.04e | 1.25 ± 0.03c | 30.60 ± 0.30a | 58.50 ± 0.33c | 367.65a |

Ingredients

| Ingredients | Preparation of weaning food flours |
|-------------|-----------------------------------|
| Runs        | B       | FB     | C     | FB2    | 5.30 ± 0.12 | 3.30 ± 0.05e | 5.0 ± 0.03c | 1.60 ± 0.01a | 15.10 ± 0.2h | 69.70 ± 0.1a | 353.60 |
|             | B2      | 0.6    | 0.35  | 0.05  | 5.35 ± 0.03 | 3.42 ± 0.02c | 4.95 ± 0.04c | 1.55 ± 0.02b | 15.80 ± 0.1de | 68.93 ± 0.5 | 352.87 |
|             | B3      | 0.55   | 0.3   | 0.15  | 5.44 ± 0.02 | 3.35 ± 0.05d | 5.31 ± 0.02b | 1.41 ± 0.01d | 15.96 ± 0.1d | 68.53 ± 0.12 | 350.65 |
|             | B4      | 0.5    | 0.35  | 0.15  | 5.36 ± 0.03 | 4.12 ± 0.13a | 5.68 ± 0.04a | 1.41 ± 0.01d | 16.00 ± 0.18c | 67.63 ± 0.15 | 347.21 |
|             | B5      | 0.55   | 0.35  | 0.1   | 5.50 ± 0.05 | 3.50 ± 0.02b | 5.32 ± 0.02b | 1.45 ± 0.02c | 16.25 ± 0.00a | 67.98 ± 0.1 | 349.97 |
|             | B6      | 0.65   | 0.25  | 0.1   | 5.49 ± 0.00 | 3.31 ± 0.01e | 5.30 ± 0.01b | 1.46 ± 0.02c | 15.75 ± 0.00d | 68.69 ± 0.05 | 350.90 |
|             | B7      | 0.6    | 0.3   | 0.15  | 5.30 ± 0.04 | 3.55 ± 0.03b | 5.12 ± 0.05c | 1.45 ± 0.0c  | 15.78 ± 0.1f | 68.80 ± 0.04 | 351.37 |
|             | B8      | 0.65   | 0.3   | 0.05  | 5.32 ± 0.09 | 3.33 ± 0.02d | 4.80 ± 0.05d | 1.44 ± 0.01c | 16.21 ± 0.1b  | 68.90 ± 0.3 | 353.40 |
| Mean       | 5.38 ± 0.1 | 3.48 ± 0.3 | 5.16 ± 0.24 | 1.47 ± 0.05 | 15.86 ± 0.4 | 68.65 ± 0.5 | 351.25 |
| Range      | 5.30-5.49 | 3.3-4.12 | 4.9-5.48 | 1.41-1.60 | 15.1-16.25 | 67.99-69.55 | 347.21-353.6 |
| Cont.      | 1       | 0      | 0     | 0     | 5.5 ± 0.05 | 2.51 ± 0.05 | 4.82 ± 0.01 | 1.41 ± 0.00 | 10.5 ± 0.05 | 75.26 ± 0.25 | 355.73 |

Values are in mean ± STDEV. Means within a column with the same letter are not significantly different (p > 0.05). Where: B is raw barley, Fb is raw fababean and C is carrot powder. GD is germination duration, FB is germinated Fababean, FB2 and FB3 are germinated Fababean at days 2 and 3 and B1 to B8 is run of blended ratio and Cont. is roasted barley used as control.
weaning food flours had ranged from 1.41 to 1.60% and it agrees to below the recommended fat level for weaning foods (Protein Advisory Group, 1972) which is about 10%. Hence, a food sample with high fat content is more liable to spoilage than one with a lower fat content.

The obtained crude protein content of the control (barley flour), non-germinated faba bean, carrot powder, germinated faba bean’s at days two and three was 12.5, 26.40, 7.50, 29.71 and 30.60%, respectively. Germination increased protein content of faba bean seeds from 26.40 to 30.60% (Table 1). The high protein contents of the prepared weaning flours were contributed by the germinated faba bean. According to FAO/WHO UNU (1985) a minimum protein content of 15% is required for maximum complementation of amino acids in foods and growth, thus, the weaning food satisfy the protein demand of infants Sanni, Onilude, and Ibidapo (1999). Statistical comparison of the protein contents of the germinated and non-germinated faba bean shows a significant difference at 95% confidence level in agreement with the reported value of Alonso, Aguirre, and Marzo (2000). The crude protein content of the flour blends ranged from 15.10 to 16.25% indicating higher crude protein as compared to the control (10.5%). This may due to the high protein nature of germinated faba bean. Our result validates earlier reports of increased protein content during germination of various cereals, legumes and other seeds (Inyang & Zakari, 2008); Yagoub, Mohammed, and Baker (2008).

The germination process slightly decreased the total carbohydrate contents as compared to the control value, while their total metabolizable energy content was higher. The decreased carbohydrate levels of the germinated faba bean might be due to an increase in α-amylase activity (Lasekan, 1996) α-Amylase breaks down complex carbohydrates to simpler and more absorbable sugars which are utilized by the growing seedlings during the early stages of germination. The total metabolizable energy content of the flour blends ranged from 347.21 to 353.6 kcal/100 g shown in Table 1. The calories in an infant’s diet are provided by protein, fat and carbohydrates (Harper, 2003). The carbohydrate caloric contents of the flour blends ranged 67.99–69.55%. The carbohydrate caloric contents for both products (control and blends) were slightly higher than that of (Protein Advisory Group, 1972) of 50–60%, whereas the protein contents fall within the recommended range of 10–20%. This denotes that the flour blends would supply the needed energy to meet infants’ growth demands.

The significant improvement in the protein content of the faba bean will have changed after germination progress, and it could be partly explained by the renewal of protein synthetic activity by certain enzymes following absorption of water uptake. The nutrient changes that occur during germination are mainly due to the breakdown of complex compounds into a simpler form.

3.2. Mineral composition of barley, faba bean, carrot flours and their blends

The iron and zinc contents of raw barley, faba bean, carrot and germinated faba bean seed and flour blends are presented in Table 2. The iron content of the raw barley and faba bean, germinated faba bean (FB2 and FB3), carrot powder and the control value were 3.21, 6.60, 6.75, 6.81, 3.60 and 2.90 mg/100g, respectively, whereas the zinc content of the flours blends ranged from 3.81 to 3.96 mg/kg. However, the iron and zinc contents of the flour blends were higher than the control value and non-germinated faba bean.

All of the flour blends value examined had iron contents ranged from 4.35 to 4.42 mg/100g. The result of raw and germinated faba bean were in agreement with a reported value of 5.97 to 7.47 mg/100g Al-Numair, Ahmed, Al-Assaf, and Alamri (2009). There was no significant (p > 0.05) difference in iron contents of germinated faba bean. The high value of iron found during the germination process could be due to the loss of divalent metal bond (Ca, Fe & Zn), which became low because of their binding to protein and also the formation of tannin-cation protein complexity (Lee & Karunanithy, 1990). The increase in the iron content of faba bean as germination progressed is in agreement with the findings of Kumari, Krishnan, and Jolly (2014) for soybean.
The availability of zinc from germinated faba bean was enormously increased as a result of germination (Table 2). The germination of faba bean at FB2 and FB3 have no significant effect on zinc content (p > 0.05). The zinc content of the flour blends which ranged from 3.81 – 3.96 mg/100g was higher than that of control value. The germination process of faba bean slightly increase the zinc value which it may be due to loss of divalent metal and their binding to protein and the formation of phytate-cation protein complex that were known to leach out on soaking and germination process (Lee & Karunanithy, 1990).

Hence, the blending of barely flour with germinated faba bean resulted in improvement of the iron and zinc content of weaning food preparation to be used as complementary food.

3.3. Antioxidant and condensed tannin contents of barley, faba bean, carrot flours and their blends

3.3.1. Total carotenoids

Carotenoids are an extensive group of naturally occurring fat-soluble colorants. Beta-carotene, as an antioxidant, has been shown to act as an immune modulator, quench singlet oxygen, and reduce peroxyl radicals at a low partial oxygen pressure (Vithalrao and Sharead, 2016). The total carotenoid content of barley, raw faba bean and carrot powder was 0.026, 0.051 and 46.48 mg/g, respectively (Table 3). There was not significant (p > 0.05) difference in the total carotenoid contents of the germinated faba bean at FB2 and FB3. The carotenoid content of the flour blends ranged from 2.42 to 7.15 mg/100g and it was higher that of the control value 0.12 mg/100 g. This might be due to the addition of carrot powder in flour blends. It indicates the fortification of carrot with cereals and legumes to enrich the carotenoid content of the flours.

Table 2. Mineral composition of barley, fababean, carrot flours and their blends

| Sample Code | GD        | Fe, mg/100g | Zn, mg/100g |
|-------------|-----------|-------------|-------------|
| B           | -         | 3.21 ± 0.14d| 2.95 ± 0.0c |
| Fb          | -         | 6.60 ± 0.02b| 6.30 ± 0.1b |
| C           | -         | 3.60 ± 0.05c| 2.25 ± 0.04d|
| FB2         | 48 hrs/2 days | 6.75 ± 0.03a| 6.35 ± 0.02a|
| FB3         | 72 hrs/3 days | 6.81 ± 0.02a| 6.36 ± 0.00a|

Ingredients

| Runs | B | Fb | C | GD | Fe, mg/100g | Zn, mg/100g |
|------|---|----|---|----|-------------|-------------|
| B1   | 0.7 | 0.25 | 0.05 | FB2 | 4.35 ± 0.02 | 3.81 ± 0.02 |
| B2   | 0.6 | 0.35 | 0.05 | FB2 | 4.39 ± 0.03 | 3.85 ± 0.02 |
| B3   | 0.55 | 0.3 | 0.15 | FB2 | 4.38 ± 0.01 | 3.86 ± 0.02 |
| B4   | 0.5 | 0.35 | 0.15 | FB2 | 4.40 ± 0.02 | 3.83 ± 0.00 |
| B5   | 0.55 | 0.35 | 0.1 | FB3 | 4.42 ± 0.02 | 3.96 ± 0.02 |
| B6   | 0.65 | 0.25 | 0.1 | FB3 | 4.37 ± 0.02 | 3.94 ± 0.02 |
| B7   | 0.6 | 0.3 | 0.15 | FB3 | 4.41 ± 0.03 | 3.88 ± 0.02 |
| B8   | 0.65 | 0.3 | 0.05 | FB3 | 4.39 ± 0.00 | 3.92 ± 0.00 |
| Mean |     |     |     |     | 4.39 ± 0.03 | 3.41 ± 0.07 |
| Range|     |     |     |     | 4.35–4.42 | 3.81–3.96 |
| Cont. 1 | 0 | 0 | 0 | | 2.90 ± 0.03e | 2.71 ± 0.05f |

Values are in mean ± STDEV. Means within a column with the same letter are not significantly different (p > 0.05). Where: B is raw barley, Fb is germinated and roasted fababean and C is dried carrot powder. GD is germinating duration, FB2 and FB3 are germinated fababean at days 2 and 3, B1 to B8 is blended ratio and Cont. is roasted barley used as control.

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A cereal-based weaning food formula is a possible way. The product has a major role in fulfilling the vitamin A requirement for the people with a low income having this micronutrient deficit.

### 3.3.2. Condensed tannins contents

The condensed tannin content of raw faba bean, FB2 and FB3, which was shown in Table 3 were 11.13, 4.50 and 2.26 mg/100g respectively. The germination process significantly decreased the concentration of tannins in faba bean. Alonso et al. (2000) reported that the condensed tannin content of raw faba bean was 15.00 mg/100g which was higher than that of tannin content of raw faba bean found in this study, which might be due to the varietal and environmental difference. Germination reduced the content of tannin fourfold (Table 3). There was no significant (P > 0.05) difference in the total carotenoid contents of the germinated faba bean FB2 and FB3. The decreased value in the tannin content of faba bean germination may be attributed to the increasing activity of poly phenol oxidase and other catabolic enzymes, which is in agreement with the reports of Deshpande et al. (1986; Khandelwal, Udipi, and Ghugre (2010).

The condensed tannin content of the complementary food ranged from 1.12 to 2.71 mg catechin equivalent/100 g.

The observed reduction in tannin content after germination was a result of formation of hydrophobic association of tannins with seed proteins and enzymes. In addition, loss of tannins during germination may also be due to the leaching of tannins into the water (Shimelis & Rakshit, 2007) as well as washing during germination and binding of polyphenols with other organic substance such as carbohydrate or protein Saharan, Khetarpaul, and Bishnoi (2002).

Table 3. Condensed tannin, Ferric reducing antioxidant power (FRAP) and total carotenoid content of barley, fababean, carrot flours and their blends

| Sample code | GD     | Con. Tannin (Mg/100g) | FRAP (µmol AA/g) | Total carotenoid (mg/g) |
|-------------|--------|-----------------------|------------------|------------------------|
| B           | 1.25 ± 0.11a | 59.41 ± 4.26a | 0.026 ± 0.004a |
| Fb          | 11.13 ± 1.11a | 26.76 ± 2.40a | 0.051 ± 0.003a |
| C           | 0.58 ± 0.00a  | 54.42 ± 0.72a | 46.48 ± 0.845a |
| FB2         | 4.50 ± 0.00b  | 19.72 ± 0.75b | 0.078 ± 0.001b |
| FB3         | 2.26 ± 0.00c  | 21.55 ± 0.40b | 0.085 ± 0.001b |

Values are in mean ± STDEV. Means within the column for each constituent with the same letter are not significantly different (p > 0.05). Where: AA is ascorbic acid equivalent. B1-B8 is blended samples 1 to 8; B is raw barley, Fb is germinated and roasted fababean; C is dried carrot powder. GD is germination duration. FB2 and FB3 are fababean germinated at days 2 and 3.
3.3.3. Ferric reducing antioxidant power (FRAP)
The reducing power is an indicator of presence of antioxidant activity Lee, Woo, Kim, Son, and Jeong (2007). The availability of FRAP in raw barley, faba bean, and carrot powder were found 59.41, 26.76 and 54.42µmol Acetic Acid/g, respectively, while the corresponding values obtained the germinated faba bean at days two and three were 19.72 and 21.55 µmol AA/g (Table 3). There was a significant difference on FRAP between the germinated faba bean (FB2 and FB3) (P < 0.05). The roasted barley shows an increment of FRAP when compared to the raw barley (Table 3).

Sharma et al. (2011) reported the sand roasted barley had FRAP value of 62.6 to 83.4 µmol AA/g, while microwave cooked barley had FRAP value 54.6 to 67.3 µmol AA/g. Thus, sand roasting increased the FRAP value of barley. The Maillard reaction products, which were generated during the roasting might have contributed to enhance the FRAP Woffenden, Ames, Chandra, Anese, and Nicoli (2002). Carrot powder also contained a high content of FRAP (54.42 µmol AA/g). The FRAP detected in the flour blends ranged from 46.51 to 51.82 µmol AA/g. All the flour blends had lower value than the control. This was due to the mixing ratio, roasting and germination duration of faba bean. The combined effect of roasted barley, germinated faba bean and carrot powder mixture at different ratios show significant decrease in FRAP (p < 0.001).

4. Conclusion
Germination did not affect significantly on the proximate composition of faba bean, except for protein and ash contents. Roasting and germination of barley and faba bean and mixing with carrot powder in the preparation of weaning foods were found to increase the iron, zinc, protein and carotenoid contents, while there was a decreased in condensed tannin content. There were minor changes in carbohydrate and metabolizable energy contents during germination in the final flour blends but these were not statistically significant. Finally, cereals-legume mixture with the addition of carrot powder resulted in an increase in some essential nutrients required for complementary food.

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Authors’ contributions
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Availability of data and materials
This developed weaning food has improved the mineral and protein content, reduction of the anti-nutritional factor content by germination of faba bean that increase mineral absorption and mixing of carrot powder also increase the vitamin A in the weaning food. Therefore, we expect complementary feeding application of this weaning food flours will have minimized the malnourished households at rural communities.

Consent for publication
All authors (Hagos, H.K., Lijalem TW and Teklebrhan WA) agreed to publication of the manuscript to this journal (Cogent Food and Agriculture).

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Not applicable.

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