Nutrient Dense Dairy Product Diversification and Quality Evaluation

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Abstract: There are limited diversified dairy products manufactured in dairy industries, and an increased demand for diversified dairy products in Ethiopia. To this end, there is un-met demand for nutrient rich dairy diversified products. This research was conducted with the aim to perform product development and quality assessment of yogurt with some cereals and legumes with the implication for diversification of nutrient dense yoghurt products in order to explore market potential. Yoghurt enriched with cereals and legumes was investigated for nutritional, microbial, texture and viscosity analyses as well as sensory quality attributes. Yogurts were processed through inoculation of milk with Lactobacillus bulgaricus and Streptococcus thermophiles. Finger millet yogurt was significantly better in protein and minerals composition. Furthermore, fat and ash values were high in finger millet yogurt: 3.47 and 2.36 g 10^2g-^{1}; respectively. Common bean (Redwolaita variety) yoghurt had abundant concertation of calcium next to finger millet-yoghurt. The aerobic plate count ($2.3x10^2$ cfu ml^{-1}), coliform (<$1x10^1$ cfu ml^{-1}), yeasts and mold (<$1x10^1$ cfu ml^{-1}) of yoghurt comply with the microbiological standard requirements. Pathogenic bacteria such as *Salmonella, E. coli, S.aureus, Shigella spp* and *B.cereus* were absent in all the yogurt samples. The processed yogurt products possessed complementary effect of nutrient enhancement which is driven from cereals and legumes. The product has very good acceptability by panelists and revealed excellent nutritional composition. The processing technology also provided high nutrient dense, acceptable in quality and microbiologically safe products. The results from the proximate, physico-chemical, microbiological, and texture and viscosity analyses indicate that yogurt with cereals and pulses possess good nutritional composition. The processing technology provided microbiologically non-hazardous end products, and the results from the sensory evaluation of revealed that value added products can be a potential dairy product that fit to the lifestyle of consumers and get accepted. These findings further suggest investors currently involved in the dairy sector can produce products that fit into consumers' lifestyle by pioneering technology transfer of this research output in order to capture the un-met consumer demand for safe, nutritious, affordable and proprietary nutrient dense yogurt production.

Keywords: Cereals; Fermentation; Legumes; Milk; Nutrient dense; Quality; Yogurt

1. Introduction

Dairy products are an excellent source of nutrition and contribute to income generation. Given the considerable potential for smallholder income and employment generation from high-value dairy products, the development of the dairy sector in Ethiopia can contribute significantly to poverty alleviation and nutrition improvement. The excess demand for diversified and processed dairy products in the country is expected to induce rapid growth in the dairy sector. Factors contributing to this excess demand include rapid population growth, increased urbanization, consumer preference, consumer's income growth, population size, price of the product, price of substitutes and other factors (IDF, 2018; EIAR, 2013).

The long-term success of a dairy plant depends on getting the right products for the market on time. The achievement of a dairy plant depends on implementing competent processing operations and on its new product development capabilities. Thus, it is of paramount importance to assess the gap and pick the right, nutritious and health benefit of dairy product via innovative/adaptive research and technology transfer. Yoghurt is one of the utmost prevalent fermented milk products worldwide and has grown consumer acceptance as a healthy food. Yogurt clasps the secrets behind good health and have many nutritional characteristics (Staffolo *et al*., 2004). Nowadays, the nature of dairy products (yoghurt types) is, of course, changing to meet new consumer demands and/or expand into new market, but the essential characteristics of the products have not altered (Tamim and Robinson, 1999).

Cereal grains and leguminous seeds contain myriad components that are important and essential to human health. Studies have shown that dietary fibers and certain phytochemicals found in cereals and pulses can be key to health maintenance and disease risk reduction. Intakes of dietary fibers and phytochemicals have been associated with reduced risk of cancer, cardiovascular disease, diabetes, chronic inflammation, neural degeneration, and other chronic ailments and illnesses. These bioactives are, therefore, good candidates as ingredients for nutraceuticals and functional foods (Liangli *et al*, 2012). Accordingly, enrichment of yoghurt with cereals and grain legumes can improve the nutritional quality and important to human health.

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In the last five years (2012-2017) dairy industries emerged intensely in Ethiopia due to the increased demand of milk and milk products and good business opportunities. With the present trend characterized by market-oriented economy, the dairy sector appears to be moving towards a take-off stage. One of the indicators in the dairy sector motivation is that currently more than 89 private dairy industries operate in different parts of Ethiopia with various level of technology, processing capacity, and trained manpower.

The microbial quality of raw milk is crucial for the production of quality dairy foods. Hygienic milk production practices, proper handling, transportation and storage of milk, and mandatory pasteurization has decreased the threat of milk-borne diseases such as tuberculosis, brucellosis, and typhoid fever (De Buyser, 2001). There have been a number of food-borne illnesses resulting from the ingestion of raw milk, or dairy products made with milk that was not properly pasteurized or was poorly handled causing post-processing contamination. In milk, the microorganisms that are principally involved in spoilage are psychrotrophic organisms. Most psychrotrophs are destroyed by pasteurization temperatures, however, some like Pseudomonas fluorescens, Pseudomonas fragi can produce proteolytic and lipolytic extracellular enzymes which are heat stable and capable of causing spoilage. Some species and strains of *Bacillus cereus*, *Clostridium, Cornebacterium, Arthrobacter, Lactobacillus, Microbacterium, Micrococcus*, and *Streptococcus* can survive pasteurization and grow at refrigeration temperatures which can cause spoilage problems (Vasavada, 1988).

The consumer's interest in fermented dairy products is gaining momentum due to the development of new food processing techniques, changing social attitudes; scientific evidence of health benefits of certain ingredients (Stanton *et al*., 2001). The concept of diversification in this research lays on enrichment of yoghurt with grains in order to improve the nutrients in the final product, and exploit resource utilization via product diversification. Incorporation of cereals and legumes facilitate increment in composition of nutrients which are not viable in yogurt alone. The new (potential) diversified yogurt product was selected by taking into account the nutritional point of view, acceptability by the consumers, technology transfer options via adaptive research, health benefits to the society and resource mobilization.

The aim of the present work was, therefore, to design and develop yoghurt with cereals and legumes and undertakes evaluation of physico-chemical, microbiological and sensory quality attributes which in turn drive consumer preferences prior to the large scale production and introduction of the end product to the market. The outcome of this study will enhance and inform stakeholders in the dairy industry about the potential and implication of yoghurt diversification in Ethiopia.

2. Materials and Methods

2.1. Experimental Materials, Chemical and Reagents

The basic materials for yogurt production were cow's milk, dairy ingredients, various cereals and legumes such as finger millet, maize, common beans, broad beans, wheat and sorghum (Figure 1) and packaging materials. The grain legumes and cereals used in this study were collected from Melkassa Agricultural Research Center and Debrezeit Agricultural Research Center. Sufficient number of legumes and cereals samples were taken, rinsed five times in deionized water to eliminate any adhering substances, dried in ventilation oven at 65^{o}C for 24h. Cleaned and dried samples were placed in plastic containers and stored at room temperature before use. The processing and quality control equipment used include fermenter, incubator, sterilizer, pasteurizer, autoclave, texture analyzer, visco-analyzer and other milk processing apparatus.

The dairy ingredient specifically the direct vat set (DVS) freeze-dried thermophilic starter culture (FD-DVS, YF-L811 Yo-Flex®) for manufacturing of yoghurt consists of *lactobacillus delbrueckii* subsp. *bulgaricus* and *streptococcus thermophilus* was obtained from CHR HANSEN, Denmark (Figure 2). The direct vat set YF-L811 yoghurt starter culture is suitable to produce yogurt with very mild flavor, very high viscosity and very low post-acidification. The starter culture is suitable for cup set and presented in form of freeze-dried culture for direct inoculation. Recommended inoculation rate is 50U (one sachet) DVS culture for 250 liters' milk to be inoculated. The yogurt culture was stored at -18^{o}C before use.

All chemicals and reagents for nutritional composition, minerals and microbiological analyses were provided by Sigma-Aldrich (St. Louis, Missouri, USA) through local suppliers. All chemicals used were analytical grade.

Figure1. Finger millet and various pulses (Redwolayta, Awash and Tabor)

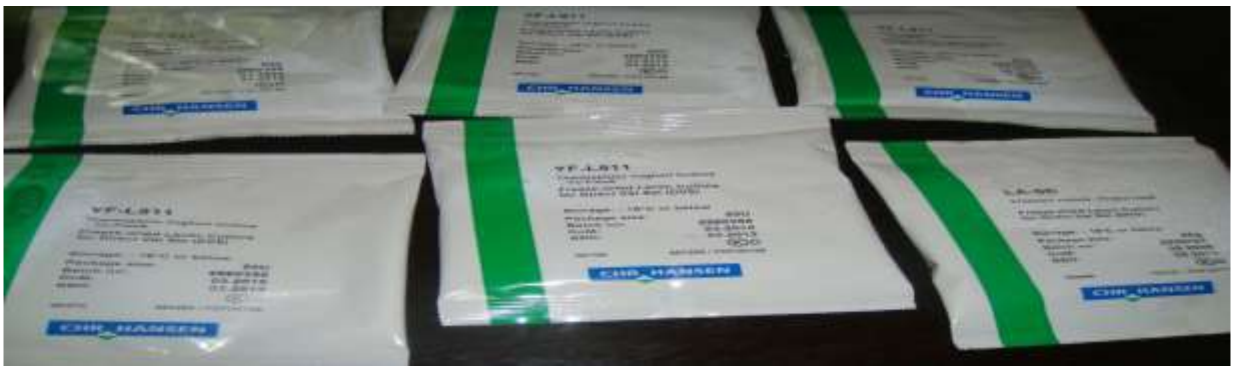

Figure 2. Thermophilic Yoghurt Culture, YF-L811 (Source: CHR HANSEN, Denmark)

2.2. Manufacturing of Yogurt with Cereals and Legumes

The main processing steps involved in set yogurt manufacture include the standardization of milk, homogenization, milk heat treatment, incubation/ fermentation, cooling and storage (Figure 4). Yogurt was prepared by fermentation of milk with bacterial cultures consisting of a mixture of Streptococcus subsp. thermophilus and Lactobacillus delbrueckii subsp. bulgaricus. The equipments used for set yogurt production were milk separator-standardizer, pasteurizer, homogenizer, packaging unit, incubator/bioreactor and autoclave. The starter culture was whipped at the top with disinfecting solution (70 % ethanol) and cut at the top of the sachet. To reduce bacteriophage infection, spatula, milk pails, milk cans, beakers, measuring cylinder, funnel and scissors were sterilized using sterilizer at 121 ^{o}C for 30 minutes (Sordina, Italy, 2006). Initially, the fermenter (40L, Bioengineering, England, 2005) (Figure 3) was sterilized at 121^{o}C using steam to maintain the safety of the starter culture and final product.

Figure 3. Fermenter (40l, Bioengineering, England, 2005)

Variety of yogurt products with cereals and legumes were produced at Addis Ababa University, Food Process Engineering Laboratory according to standard method described by Ramesh *et al*., (2006), Figure 4. Standardized, homogenized and pasteurized milk was used for product development. The various ingredients such as skim milk powder and stabilizer together with milk (50 liters) were then blended together in a mix tank equipped with agitation system. The mixture was heated to 95 ^{0}C with holding time of 30 minutes, stirred at 250 rpm in bioreactor. Foam and air introduction into the milk were avoided. Once the heat treatment has been completed, the milk is cooled to just above the desired incubation temperature (47^{o}C) to allow for heat loss during inoculation, and then dosed with a starter culture. The required amount of the yogurt starter culture to milk was calculated based on recommended inoculation rate and weighed with analytical balance (Explore Pro. Model EP214C, Switzerland, 2007). About a liter of milk was taken from the pasteurized and cooled milk to 45^{0}C and then after the weighed amount of freeze-dried granules of starter culture poured directly into milk. The mixed /prepared starter culture with milk was inoculated to the 50 litres fermenter and instantly the blades with slow agitation speed were switched on for two minutes to distribute the culture evenly.

Raw Milk

Skimmed Milk Powder, Stabilizer

Recombination

Hold For Hydrolysation

Homogenize at 150 bars

Pasteurization (90-95^{0}c for 10min)

Cool to 4^{0}C

Heat to 45^{0}c-47^{0}c

Inoculate with culture and mix gently at 43^{0}c-45^{0}c

Adding pre-cooked cereals and grain legumes at the bottom of the yoghurt cups

Filling and Packing in cups at 43^{0}c-45^{0}c

Incubate at 45^{0}c for 2-4hrs

Blast freezer/Cool to below 10^{0}c

Storage to 4^{o}C

Figure 4. Main processing steps in the manufacture of enriched set yogurt.

Cooked cereals and grain legumes were placed at the bottom of yoghurt cups and then the inoculated milk at pH of 6.7 was layered on top and immediately covered with the lid. The fermentation process took place in the cup at incubation unit. Finally, set yogurt (which includes cereals/legumes-on-the bottom) is formed in cup-package as lactic acid bacteria ferment lactose into lactic acid giving a continuous gel structure. The proportion of cereals and legumes to yoghurt weight was about 1:10. Then after, the products were incubated at 45°C to pH 4.3, and then subjected to flash cooling to below 10°C. The end products were cooled and stored at 4°C in order to slow down the physical, chemical and microbiological degradation. The physical attributes of yogurts, including visual whey separation and perceived viscosity, are crucial aspects of the quality and overall sensory consumer acceptance of yogurts were investigated.

The pH of yogurt samples was executed frequently using a pH-meter from the time of inoculation throughout the fermentation process.

2.3. Analyses Methods

2.3.1. Nutritional Composition

The official standard methods of analysis of Association of Official Analytical Chemists (AOAC, 2010) were used for physico-chemical analysis of yoghurts. Total ash, crude protein, crude fiber, and crude fat of the seed grains were determined using the official test methods 923.03, 979.09, 962.09, 4.5.01; respectively. All the minerals except phosphorus were analyzed from triple acid digested samples using atomic absorption spectrophotometer (Hitachi, Model Z-8230, Japan, 2009) according to the method of Isaac and Johnson (1975). Phosphorus content was determined colorimetrically (Dickman & Bray, 1940) using UV/Visible spectrophotometer (Model 6405, Jenway LTD.UK, 1999).

2.3.2. Hundred Seed Weight and Water Absorption Studies

One hundred-seed weight was determined by counting 100-seeds using an electronic seed counter and weighing. Results were expressed as the mean of triplicate determinations. For water absorption studies, samples were soaked in distilled water at 20 ^{o}C. The seeds then removed at regular intervals during soaking, dried by blotting with filter papers and weighed. The water absorbed by the seeds is calculated as a percentage of the fraction of the weight gained by seeds on soaking to the weight before soaking.

2.3.3. pH Measurement

The pH values of yoghurt with cereals and legumes were determined using a pH meter (HANNA Instruments, H301, Portugal), AOAC official method. The viscosity of yoghurt was measured using Vibro Visco-analyser at the Food Process Engineering Laboratory of Addis Ababa University.

2.3.4. Cooking Time for Cereals and Legumes

Cooking time was determined using an automated Mattson cooker as described by Wang and Daun (2005). The automated Mattson cooker consists of a cooking rack and 25 hollow plungers. The weight of each plunger is adjusted to 90 g. A sample (30 g) is soaked in distilled water at room temperature (22±2°C) for 24 h. Soaked seeds were then positioned into each of the 25 saddles of the rack so that the tip of each plunger rests on the surface of the seed. The rack is then placed into a 2 L metal beaker containing 1.2 L of boiling water. When a seed becomes sufficiently tender, the plunger penetrates the seed and drops a short distance through the hole in the saddle. The time taken for each plunger to drop is automatically recorded. Cooking time for a sample is defined as the time required for 80% of the seeds to be penetrated.

2.3.5. Texture Profile

The texture profile of yoghurt samples was measured according to the method described by Malcolm (2002) with a LLOYDЖ, TA plus Ametek, UK, 2007, texture analyzer. The texture profile analyses for yogurt samples were performed using back extrusion test principle with crosshead speed of 1mm sec^{-1} and probe/fixture was performed with probe of 35mm diameter extrusion disk. The maximum force was measured and recorded at a crosshead speed of 1mm sec^{-1}. The firmness of yoghurt was expressed as the maximum force per gram of sample (N g^{-1} sample). All values were reported as the means of triplicate determination.

2.3.6. Microbiological Analysis

Microbiological analyses in yogurt samples were evaluated using a standard method described by Sharma (2006) and Ethiopian standard (2009) reference number ES 3468: 2009. Protocol used for the isolation of microorganism was IS:5887 based on ISO (1993). Mold and yeasts, total coliforms count, faecal coliforms, aerobic bacterial plate count, *E.coli* count, *S.aureus* count and *Salmonella spp* were performed using test methods ES ISO:6611, ES ISO:4832, ES ISO:5541-1, ES ISO:6610, ES ISO:11866, ES ISO: 6611 and ES ISO:6785 of the Ethiopian standard; respectively. AOAC Official Method of Analysis (2010), test method 980.31 was used for the enumeration and identification of *B. cereus*. Food and Drug Administration Bacteriological Analytical Manual (Rhodehamel and Harmon, 2001) was used for the enumeration and identification of *Shigella spp*.

2.3.7. Sensory Quality Evaluation

Sensory quality evaluation of yogurt products was performed to better understand attributes of a product that drive consumer preferences and consequently enable processors to optimize a product's attributes to attract specific target consumers as well as accurately monitor product quality. In view of this a sensory evaluation was carried out by 35 male and female panelists selected from consumers group and people who are familiar with quality attributes of dairy products.

The sensory quality evaluation was conducted using a 5-point hedonic scale adapted from Resurreccion (1998) indicating degree of liking for color, appearance, taste, after taste, flavor (taste + odor), aroma, consistency, acidity and overall acceptability. The test consists of a 5-points hedonic scale ranging from like extremely, through neither like nor dislike, to dislike extremely, with varying number of categories. The panelists were given the processed yogurt samples with cereals and legumes (Figure 5). After providing orientation samples were presented alongside with the hedonic test form, and the panelists were asked to rate each sensory attributes employed in the evaluation of the sensory quality of yogurt.

The 1-5 categories on the evaluation scale were 1 = dislike extremely, 2 = dislike moderately, 3 = neither like nor dislike 4 = like moderately and 5 = like extremely.

Figure 5. Processed yoghurt with cereal and pulse products

2.4. Statistical Analysis

Data were subjected to analysis of variance (ANOVA). Where the ANOVA test indicated significant differences and treatment means were separated using Duncan's multiple range test at 5% probability level.

3. Results and Discussion

3.1. Proximate and mineral composition of yogurt enriched with cereals and legumes

The quality assessment results including nutritional and mineral composition analyses of yoghurt combined with cereals and pulses were presented in Table 1. This research finding on protein content (Table 1) is in agreement with the report of the dairy council (IDF, 2018) which indicates that plain yoghurt consists of 5.7 g/100g protein, 3.0 g/100 g fat and adequate amount of different minerals. Yoghurt with cereals and legumes provided nutrient dense and balanced diet from nutritional point of view. It also increases essential amino-acid composition and other very vital nutrients which were derived from the grain seeds. Incorporation of various cooked grains such as maize, finger millet, haricot bean, wheat, faba bean and sorghum facilitate increment in nutrients composition which are not viable in plain yoghurt alone. Crude fiber composition can also be increased via production of grain-based yogurt which in turn plays an in important role in providing choice to end-users.

The fermentation pathway of set yoghurt is carried-out by the action of specific lactic acid-producing starter culture which consist of *Lactobacillus bulgaricus* and *Streptococcus thermophiles* bacteria coagulates the milk protein, thickening the milk and adding the characteristic sour taste. Yoghurt blended with legumes and cereals reveled improved nutrient composition with dense macro-and-micro nutrient availability. The levels of soluble proteins, non-protein nitrogen and free amino acids can be higher in yogurt as a result of heat treatment to milk and breakdown of casein by starter bacteria (Kim *et al*, 1998; Karagul-Yuceer, *et al*., 2001). Lactic acid bacteria require amino acids for their growth; they break down milk proteins due to their proteolytic activity, and protein in fermented milks is reported to be totally digestible (Alm, 1982a). Fermented milks are more digestible than milk due to proteolytic activity of starter bacteria resulting in higher levels of peptides and amino acids. The mineral content is hardly altered during fermentation; however, reports suggest that the utilization of Ca, P, and Fe in the body is better for fermented milks than that of milk (Ramesh *et al*., 2006).

Table 1. Proximate composition of yoghurt developed with cereals and legumes expressed in g/100g DM and minerals mg/100g.

Product	Protein	Crude fat	Crude fiber	Ash	Ca	Zn	Fe	Cu	P
Yoghurt (Commercial)	5. 62	3.22	0.00	0.81	147.00	0.29	0.49	0.02	118.98
Yoghurt (Plain)	5.70	3.00	0.08	0.76	149.40	0.32	0.57	0.01	115.79
Yoghurt with finger millet	10.83	3.47	2.42	2.36	235.90	2.34	2.24	0.75	129.99
Yoghurt with maize	8.74	3.39	0.86	1.13	187.50	0.42	0.21	0.43	124.74
Yoghurt with Wheat	9.73	3.89	1.40	1.40	191.25	1.06	1.11	0.48	138.03
Yoghurt with sorghum (Meko-1)	8.31	3.96	1.17	1.23	158.40	0.82	1.49	0.45	142.49
Yoghurt with kidney beans (*Roba*)	9.00	4.19	1.99	1.95	209.39	0.80	1.67	0.39	135.21
Yoghurt with haricot beans (*Redwolaita*)	8.73	4.06	1.97	1.97	220.42	1.11	2.19	0.52	139.36
Yoghurt with French beans (*Tabor*)	8.77	3.71	1.84	1.83	206.14	0.79	1.63	0.51	125.94
Yoghurt with navy beans (*Awash*)	9.35	3.75	1.78	1.92	205.05	0.83	1.83	0.53	126.46
Yoghurt with dry beans (*Beshbesh*)	8.97	3.64	1..90	1.73	205.95	1.10	1.26	0.63	122.27
Yoghurt with Faba beans	10.11	3.81	2.53	2.02	200.25	0.79	1.06	0.94	143.49

Note: All values are means of triplicate determination Where DM-Dry matter

Yogurt is highly nutritious healthy food and is an excellent source of protein, calcium and potassium (Mohammed *et al*., 2017). The mineral profile of yogurt prepared from cereals and pulses increased significantly compared to the control sample (plain yogurt) due to the availability of rich amount of minerals both in cereals and pulses. Yoghurt made with cooked finger millet seeds revealed rational amount of calcium compared to other yoghurts made of cereals and pulses. This can be explained due to the high amount of calcium in finger millets (Tadesse variety) which is 248 mg per 100 g of edible portion reported by Shimelis *et al*. (2009). The yoghurt made with beans (Roba variety) also resembles high amount of calcium next to products made from yogurt with finger millet and Redwolaita grains. The yoghurt samples which contained Roba and Redwolita bean varieties consists of 209.39 and 220.42 mg/100g calcium content; respectively. In particular, yoghurt can provide the body with significant amounts of calcium in a bioavailable form. According to the research report by Shimelis and Rakshit (2005) that, the improved Roba was the best variety in terms of food making quality and supplementary bean-based processed foods including fortified products to combat the problem of protein-energy malnutrition in East and Great Lakes Regions of Africa. This nutrient dense yoghurt product enriched with beans (Raba variety) can be used as supplementary food source for lactating mothers and children.

The research findings published by Shimelis *et al* (2009) revealed that the chemical composition of finger millet varieties among which Tadesse variety has rich amount of Ca, Fe, Zn, Cu, Cr, Mg, Mn and P. Hence, using finger millet seeds for yogurt making as ingredient can bring balanced diet for pregnant women, children and elder people in order to maintain healthier lifestyle. Yogurt is a component of the dietary approaches to stop hypertension diet designed to reduce the risk of high blood pressure (Kim *et al.*, 1998). Utilization of nutrients' dense yogurt can enhance nutritional function such as improvement of protein digestibility, alleviation of lactose intolerance, enhancing of mineral absorption. According to Tannock, (1990, 1999), yoghurt has also physiological effects including control of intestinal heath, lowering serum cholesterol, antihypertensive effects, anticancer effects and effect on immunological function. Consumption of fermented milks has been reported to inhibit infection and alleviation of allergies (Mitsuoka, 1978).

The processed products provide an array of nutrients in significant amounts, in relation to its energy and fat content, making it a nutrient-dense food. Furthermore, yoghurt has many health benefits beyond the basic nutrition it provides, such as improved lactose tolerance, a possible role in body weight and fat loss, and a variety of health attributes associated with probiotic bacteria.

Yoghurt with finger millets and faba beans revealed higher in protein, 10.83 mg/100g and 10.11 mg/100g composition; respectively. The calcium concentration is higher in yoghurt with finger millet and yoghurt with haricot beans. It can be concluded that yoghurt manufactured from finger millet, beans and wheat revealed comparatively better nutrient dense yoghurt products. Overall, addition of cereals and legumes in yogurt as dairy products can maximize the nutrients bioavailability and make best use of cereal-legume-based yoghurts which in turn increase the overall nutritional composition of the final product and offer health benefits.

3.2. Physico-chemical Properties

The physico-chemical properties of cereals and legumes such as seed weight, hardness, water absorbed, unhydrated seeds and cooking time of ten cereals and legumes are presented in Table 2.

Table 2. Physico-chemical properties of cereals and legumes used for yoghurt processing.

Grains	Seed weight (g/100 seeds)	Hardness[a] (Ng^{-1})	Water absorbed (%)	Unhydrated seeds[b] (%)	Cooking time (min)
Roba	18.98±0.01	129.64±0.22	167.36±0.02	18.13±0.02	24.03±0.01
Beshbesh	19.35±0.01	136.96±0.96	165.41±0.57	21.76±0.01	26.61±0.06
Awash	16.91±0.02	118.09±0.42	227.29±0.12	1.52±0.01	19.50±0.05
Redwolaita	21.92±0.01	140.98±0.95	154.82±0.06	31.59±0.02	28.55±0.10
Tabor	18.29±0.05	127.55±0.97	167.50±0.03	5.24±0.01	23.60±0.06
Finger millet	15.38±0.21	87.57±0.56	327.23±0.23	0.49±0.04	17.03±0.05
Maize	24.34±0.25	151.34±0.68	138.25±0.34	35.79±0.09	32.09±0.10
Wheat	17.22±0.23	123.27±0.57	192.33±0.45	3.24±0.07	21.31±0.34
Sorghum (Meko-1)	16.06±0.41	116.09±0.38	232.07±0.32	1.48±0.35	19.12±0.05
Faba Bean	54.33±0.92	138.21±0.23	157.77±0.34	29.68±0.48	27.31±0.07

Note: [a]Samples were cooked for their corresponding cooking times determined using the Mattson-cooker.; [b]Calculated as a percentage of number of unhydrated seeds after soaking over night to the total number of seeds which initially has a weight of 100 g.

Unhydrated seeds (hard or non-soakers) percentage among the food grains varied from 1.52 to 35.79, the highest being in maize and the lowest being in finger millet. The number of unhydrated seeds after soaking is also an indication for their respective cooking time. The higher alteration in unhydrated seeds among grains clearly indicates the variation in water absorbed. Based on these results, differences in cooking quality has revealed. Unhydrated seeds are undesirable, and would increase cooking time. They are correlated negatively with water absorbed and positively correlated with cooking time.

Physico-chemical characteristics are important parameters, which ultimately play an important role in cooking cereals and legumes. The results of the present study are consistent with those mentioned by previous workers (Latunda, 1991; Bishnoi and Khetarpaul, 1993; Wang *et al.*, 2010a) for food legumes. Investigators reported that the legumes having the higher water absorbed require less cooking time. The consumers and processors alike prefer grains with low cooking time and low hardness value. A large water absorbed leads to better cooking quality (less cooking time and texture), so is ultimately desirable to the end-user. As cooking of some of the cereals and legumes would provide soft texture with the yoghurt products, less fuel and energy, consumers should be preferred.

Cooking time is one of the main considerations used for evaluating grains cooking quality. Longer cooking times result in a loss of nutrients and could limit end-uses. Hence, consideration of cooking time is of utmost importance. The results obtained for cooking properties of food grains are given in Table 2. Awash and

Maize required the minimum and maximum cooking time of 19.50 and 32.09 min, respectively.

The hardness of the cooked grains is defined, as the maximum force required for 75% deformation of seeds after cooking. The force required for seed deformation was less for finger miler and this also had the smallest cooking time. Hardness ranged from 118.09 to 151.34 N g^{-1}, the highest being in Maize and the lowest being in Awash (Table 2). Hardness values have similar correlation trends in cooking time reported by Shimelis and Sudip (2005). The force required to compress the cooked legumes and cereals increased with increasing cooking time.

Cook-ability has been reported (Salunkhe, 1982) to depend upon such factors as growing conditions, handling and storage, and chemical composition. In general, consumers prefer quicker cooking times. Cooking times may vary based on a number of factors, including storage conditions of the pulses and cereal grains, elevation, agronomic practices and water hardness. Cooking provide tender texture, reduce antinutrients composition, maximize minerals bio-availability and also increase in-vitro protein digestibility (Shimelis and Rakshit, 2005; Emire and Sudip, 2006; Shimelis and Rakshit, 2007, Emire and Rakshit, 2008).

3.3. Microbiological Quality and Texture Profile Analysis of Products

The microbiological analyses result presented in Table 3, shows that the microorganism population in yoghurt samples was 2.3 x 10^5 cfu/g, which is in agreement with the findings reported by Mohammed *et al* (2017) and Karagul-Yuceer (2001). The results for coliform count, mold and yeasts, Aerobic bacteria plate count (APC) and fecal coliform were <1x10^1, < 1x10^1, 2.3x10^2 and < 1x10^1 Cfu g^{-1}; respectively. Coliforms test result indicates the hygienic practices and post-pasteurization contamination. Consequently, the result shows that coliforms do not survive pasteurization process and acceptable food safety management system. Another test, which has a strong bearing on the shelf life of yoghurt, is yeast and mold count. Yeast and mould population levels, fecal coliform, *E-coli* and *S.aureus* were less than the finding of Farinde *et al.*(2009) and Akanbi and Oyediji (2015). The result also comply with the microbiological requirement specified in Ethiopian standard ES 3468:2009 for *E-coli, Salmonella spp, S.aureus*, mold and yeasts.

The result of microbiological analysis, therefore, revealed the absences of photogenic microorganisms which can bring food borne diseases in yoghurt tested samples. Pathogenic microorganism *comprising B.cereus, S.aureus, E.coli, Salmonella* and *Shigella spp* were not detected in yoghurt. This confidence stems from the fact that the severe heat treatment received by the process milk, together with the low pH of the end product, make set yoghurt extremely safe in respect to public health where for none of the recognized pathogens can survive or grow below pH 4.3. In addition, there is good evidence that metabolites such as antibiotics released by the yoghurt organisms can actively depress the viability of any enteric pathogens like *Campylobacter*, *Escherichia* or *Salmonella* spp. (Zourari *et al.*1992).

3.4. Texture Analysis of Yoghurt with Finger Millet

The experimental result on texture analysis displayed in Table 4 and show that yogurt with finger millet has 3398 N g^{-1}. The value for viscosity (2.45m Pa.s) was compared to the research finding of Salvador and Fiszman, (2004) and Shimelis and Worku (2010, 2011), revealed that it is higher than pasteurized milk (1.22 mPa.s) and kefir (1.58 mPa.s); respectively. The Young's Modulus also one of the indictors for texture profile and reveals 1.038 MPa. The youghrt with finger millet has a wonderful smooth texture with a delightful creamy mouth-feel low resistant to flow. The conditions of incubation including temperature-time regimes of fermentation play an important role in controlling the texture of set yoghurt. Additionally, the impact of processing conditions on texture development may help to improve the quality of yogurt with finger millet.

3.5 pH Value and Incubation Time for Yoghurt

The pH value of yoghurt with cereals and legumes after incubation time of three hrs changed from 6.6 to 4.9 (Figure 5). Very importantly, incubation of set yoghurt took place in retail containers (plastic cups) until the required pH (around 4.4-4.7) is reached.

Table 3. Microbiological analysis of yoghurt with cereals and legumes

Types of Microbiological analysis	Load in Cfu/ml
Coliform count	< 1x10^1
Yeasts Mold	< 1x10^1
APC	2.3x10^2
Fecal Coliform	< 1x10^1
E. coli	Absent
S. aureus	Absent
B.cereus	Absent
Salmonella	Absent
Shigella spp	Absent

Note: Cfu-Coliform unit; APC-Aerobic bacteria plate count; *In the count < 1x10^1 is the standard reporting format for plates from all dilution of the sample has no colonies.

Excessive acidity, as a result of continued starter activity during prolonged storage above 5 ^oC, can also be a problem, because the acid-tolerant *Lb. delbrueckii* subsp. *bulgaricus* has the ability to generate lactic acid to levels of 1.7% or above. Such a level is too harsh for the palates of most consumers, and it is this postproduction acidification that, in general, tends to determine the shelf-life of commercial yoghurt (Zourari *et al.*1992). Furthermore, enhanced acidification to pH values below 4 may lead to body and texture defects such as gel shrinkage and syneresis.

Table 4. Texture and viscosity analysis results for yoghurt with finger millet.

Parameters used	Units	Results
Viscosity	mPa.s	2.45
Firmness	N g^{-1}	3398
Young's Modulus	MPa	1.038
Load at maximum load	(N	0.894

3.6 Sensory Quality Evaluation

The sensory quality evaluation of yoghurt was performed approximately 24 hrs after packaging and presented in Table 5. The mean sensory scores of the organoleptic evaluation for all the yoghurt samples are shown in Table 5. The statistical analysis revealed that there were significant ($p < 0.05$) differences in the sensory attributes observed. The lactic acid bacteria and yeast fermentation of milk results in the production of numerous components, including lactic acid, CO_2, a small amount of alcohol, and an array of aromatic molecules, all of which provide yoghurt with its exclusive organoleptic properties.

Based on organoleptic assessment, it was observed that yoghurt with cereals/pulses had very good acceptabilty by gruop of panalists. The sensory evaluation result showed significant differences ($0.05<p$) in all the organoleptic attributes analysed. Thsus, the organoleptic assessment in this study showed that the products had good qualitative characteristics.

Table 5. Sensory properties of yoghurt with cereals and legumes.

Sensory attributes	Mean ± SD
Appearance	3.70 ± 0.97
Taste	4.10 ± 0.81
After taste	4.02 ± 1.04
Flavor	3.82 ± 1.01
Aroma	3.18 ± 0.96
Consistency	3.92 ± 0.99
Color	3.98 ± 0.98
Acidity	3.75 ± 0.96
Overall acceptability	3.86 ± 0.88
Grand mean	3.81 ± 0.96

Note: Mean is calculated using values of 5 (like extremely) and 1 (dislike extremely); Hence, a high mean indicates highly rated attribute; Hedonic rating scale (1 to 5); Where:1=Dislike extremely; 2=Dislike moderately; 3 = Neither like nor dislike 4 = Like moderately; 5 = Like extremely.

According to Tamime and Robinson (1999), the proper quality of fermented milk depends on pasteurization at a temperature of 85-95°C for 5-30 minutes. It is significant because the influence of heat-treatment on the improvement in coagulation and viscosity of the yoghurt is correlated with the degree of denaturation of lactoglobulin-β which, interacting with casein, significantly influences the yoghurt's texture (Dannenberg and Kessler, 1988a). In conformity with literature, the peak degree of interaction takes place at 85°C for 30 minutes and heating milk below 85°C and above 120°C causes a distinct decrease in the clot consistency.

Product development is the lifeblood of the diary food industry. Furthermore, it is very important for food businesses, scientists and policy-makers to understand consumers of food products. This in turn helps to develop successful products and gain/retain consumer confidence. Consumers' requirements and desires are affected by issues such as culture, age and gender while issues that are important to consumers nowadays includes health will not always be so significant. Therefore, food businesses and policy-makers need to understand consumers' attitudes and influences upon them in order to respond effectively (Hal, 2007). In a nutshell, sensory perception towards consumer-led food product development and food acceptance plays an important role for food businesses innovation and process technology.

The technology in processing of yogurt with cereals and legumes is a new concept for Ethiopian consumers. Thus, specific products were tested at laboratory scale and the result was impressive. Accordingly, the dairy processing industry can commercialize this innovative idea via large scale production. Conducting marketing intelligence to select the best suitable cereal/pulse-based or mixtures of cereals-legumes-pulses with yoghurt in the Ethiopian context require further study for the specific and targeted product design and development. The new products posses' complementary effect of cereals and pulses in general. Additionally, production of yoghurt with grains can improve the nutritional status of the young generation in promising Africa and increase farm gate price for small-holder farmers and encourage producing more cereals and legumes in Ethiopia which can be used as an input in yoghurt manufacturing.

4. Conclusions

The potential of producing acceptable yoghurt enriched with cereals and legumes was investigated. The nutritional, physico-chemical, microbial and sensory analyses were implemented to find out the quality attributes of the products. The quality assessment of yogurt enriched with cereals and legumes were executed with the implication for diversification of nutrient dense yoghurt products in order to explore market potential.

It is clear from the obtained research findings that, there was remarkable increase in the nutrient composition of all yoghurt products due to the possessions of complementary effect of cereals and legumes. The nutrient dense yoghurt products were highly acceptable by panelists and the products were also microbiologically safe. Specially, yoghurt with finger millet revealed higher protein concertation, ash content, minerals (Ca, Zn, Fe and Cu) compared to other cereals and legumes mixed yoghurts. Overall, from the nutritional, physicochemical and sensory acceptability points of view, the yoghurt produced with finger millet seeds revealed the best nutrient dense acceptable product.

The adaptive technology in utilization of yogurt with cereals and legumes is a potential concept of yoghurt diversification for Ethiopian consumers and dairy processing industries. Yoghurt products diversification should be taken as focal points in order to uphold better business development and capture the un-meet consumer demand for safe and nutritious products. In a nutshell, the results revealed that yoghurt with cereals and legumes can be processed with the existing technologies in the Ethiopian context and has good nutritional composition and the processing technology provided microbiologically non-hazardous end products.

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