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Review Article

Use of Natural Food Colorants in Kurkufa Food: An Assessment of Nutritional and Sensory Quality in Southern Ethiopia

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Abstract

Staple foods are more common in Africa. Because diversity of nations, Ethiopia is Africa's leading producers of food and highly regarded for cooking traditional foods. In the southern part of Ethiopia, kurkufa food is highly consumed. Sufficient consumption of nutrients, particularly protein and micronutrients, promotes healthy growth in children and reduces their vulnerability to illness. Wheat and maize are essential raw materials for its preparation. It is utilized to supplement a substantial daily energy intake. Kurkufa is important source of macro- and micronutrients, and is a great source of vitamins, proteins, and a variety of carbohydrates and little is known about the nutritional value of Ethiopian Kurkufa foods. The purpose of this study was to ascertain the nutritional makeup and sensory quality of food in southern Ethiopia by using natural food coloring. The Arba Minch Agricultural Research Institute and Bishoftu Agriculture Research Center provided the maize and wheat varieties, while the Burji Soyama markets provided the habesha gomen, chills, tomatoes, and kidney beans. Using the AOAC method, nutritional and sensorial analysis was performed, Kurkufa's composition was found to be between 41.01 - 41.22 moisture content, 12.23 - 12.5 total ash, 4.33 - 4.53 crude fat, 25.21 - 25.61 crude protein, 3.03 - 3.19 crude fiber, 15.95 - 16.64 carbohydrate, and 203.48 - 208.87 kal/100 g energy. Fe, Zn, K, and Ca had respective ranges of 10.90-11.80 mg/100 g, 8.73-9.25 mg/100 g, 147.82-148.12, and 73.58-72.55 mg/100 g in terms of mineral content. The sensory evaluations were within the recognized ranges. The majority of the values fell between FAO, WHO, and EPHI. A noteworthy distinction ($P<0.5$) was noted between them. Therefore, it is best for people of all ages to consume Kurkufa foods. Furthermore, it is better to eat Kurkufa food because of its high nutritional, sensory quality and microbial determination also needed.

Keywords

Kurkufa Food, Minerals, Nutritional Composition, Sensorial Quality

1. Introduction

One of Africa's richest countries in terms of traditional foods is Ethiopia. Ethiopia is distinct from the rest of tropical Africa in a number of ways, including its natural landscape, customs, and cuisine [1]. Every Ethiopian tribe has unique food-related beliefs and attitudes, just like people around the globe. A few of these have to do with diets, illnesses, and food qualities like heavy and light, hot and cold [2].

Various vegetables and staple crops are significant for

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Ethiopia's policies, health, and issues with food security. The crops and vegetables are harvested for use in the processing and preparation of both new and raw food. The majority of these vegetables and crops are grown in the southern Ethiopian zones of Gamo, Gofa, Konso, Burji, Bule Hora, Derashe, and Amaro. Compared to other parts of Ethiopia, they typically consume these crops and vegetables. These areas are better due to their climate, environment, and water availability [2].

The most prevalent types of malnutrition globally are protein energy malnutrition (PEM) and micronutrient deficiencies, which are particularly prevalent in developing nations like Ethiopia, with young children in particular at risk. Various approaches have been used, including school feeding initiatives, nutrition education campaigns, the investigation of underutilized crops, and even initiatives to provide children with large amounts of vitamin A [3]. A variety of tropical staple crops, including sorghum, maize, wheat, finger millet, teff, and beans, along with various vegetables and tree leaves, such as Habesha gomen steam and leaves in the form of Ethiopian dishes, are used to make traditional Kurkufa [4].

Food security, according to FAO (2001), is the state in which all people always have physical, social, and economic access to enough food that satisfies their dietary needs and food preferences and is safe and nutritious for an active and healthy life. The phrase "all people at all times" suggests that there must be stable and equitable food distribution, but it is also becoming understood to include the need for intergenerational equity and, consequently, "sustainability" in food production. "Safe and nutritious food...for a healthy life" suggests that eating too much or unhealthily can lead to food insecurity if the diet is not nutrient-dense, which includes consuming too many calories [5].

Global food system markets may operate effectively under average circumstances, and equilibrium approaches may be able to estimate supply and demand with some degree of confidence. However, in the event of a significant shock, the market may not be able to smoothly link supply and demand through price, and a number of factors may act to magnify the effects of the shock and spread them throughout the world. Food price spikes could be caused by market volatility, which could disrupt the food supply. The food system's [6] dependence on other industries for transportation, energy, water, and other resources increases this potential.

Minerals are necessary for all bodily functions, including growth, development, water balance, and neurological functions, to operate normally. Iron is a necessary component of blood and aids in the oxygenation of different body tissues. Dietary sources include leafy green vegetables, legumes, fish, poultry, and red meat (all of which are readily absorbed). A healthy skeleton depends on calcium, which is also essential for blood clotting and is a major component of teeth and bones. Milk and milk products are the world's main sources of calcium. Additional sources include dark green vegetables (plant sources are not well absorbed) and fish eaten with bones (silver fish mukene, haplochromis species). Children's mental development and thyroid function both benefit from iodine. Iodized salt is the primary dietary source. Zinc is a vital component of skeletal muscle, aids in wound healing, improves and fortifies the immune system, and facilitates digestion. Beef, seafood, liver, nuts, beans, and whole grains are examples of dietary sources. Chromium, copper, fluoride, magnesium, manganese, molybdenum, nickel, potassium, phosphorus, sodium, and selenium are additional minerals that are involved in different bodily functions [7, 8].

A scientific field known as sensory evaluation uses one or more of the five human senses taste, smell, touch, sight, and hearing to analyze and quantify how people react to the ingredients in food and beverages [9].

1.1. Nutritional Composition of Crop Production in Ethiopia

1). Maize

One of the most significant and extensively cultivated crops worldwide is maize. In the world's poorest regions sub-Saharan Africa (SSA), Asia, and Latin America maize provides food, feed, and nutritional security. However, it is also a major source of industrial products and feed in high-income countries. The crop provides at least 30% of the total calories consumed by people in Sub-Saharan Africa (SSA), where it accounts for 40% of cereal production, of which more than 80% is used for food. Daily intake of the crop ranges from 52 to 450 g/person. The consumption of maize per person per day in Latin America ranges from 50 to 267 g [9].

For Ethiopia to have food security, maize is essential. This crop is consumed by over 100 million people as food. The flour is also combined with other flours to make traditional dishes like bread, fosses, and occasionally enjera. High carbohydrate content in maize helps lower disease rates among Ethiopians living in both rural and urban areas [10]. Ethiopian corn variety variations are depicted in Figure 1 below.

Figure 1. *White and yellow corn variety [10].*

2). Wheat (Triticum Aestivum)

Wheat production accounts for the majority of the world's population. Wheat is a raw ingredient in many food products for various food varieties. A self-pollinating annual plant, wheat is a member of the tribe Triticeae, family grasses, and genus Triticum. There are five to 27 species in the genus, depending on various classifications. The two primary sub-

groups of commercial wheats are the 42-chromosome wheats (Triticum aestivum L.) and the 28-chromosome durum wheats (Triticum durum L.). Originating from a hybridization between the wild diploid T. monococcum L, thousands of years ago, was Triticum durum [11].

With 17 percent of all arable land in the world going to wheat, it is the most widely grown cereal grain. More calories and protein are found in the world's diet from wheat than from any other crop, making it the staple diet for thirty-five percent of the global population. In Ethiopian cuisine, the well-known wheat (Triticum Aestivum) variety is combined with maize flour to make breads, cookies, and biscuits (figure 2). Ethiopians in particular rely more on meals based on wheat and maize than on fruits and vegetables [12].

Figure 2. *Wheat staple food for Kurkufa preparation in southern Ethiopia [13].*

3). Fresh Kidney Bean

Phaseolus vulgaris L., commonly known as the common bean, is the most widely grown low-land pulse in Ethiopia. It was first brought to Ethiopia in the 16th C. There has been a consistent rise in the production area, volume, and export market. The crop differs in terms of seed color, size, and growth habit (figure 3). In crop rotation schemes based on maize and sorghum, the crop is one of the suitable grain legume crops that can be grown with minimal agricultural inputs, such as fertilizers. Given that it is the primary pulse crop farmed in the nation's lowlands [13].

Kidney bean is also important in traditional foods like fosses, kitta woti, enjera woti, and mixed with maize, sorghum, wheat and other grain flours to have protein, carbohydrates and vitamins sources in southern Ethiopia. This kidney bean is very essential for digestion systems in human and in reduction of high blood pressure [9].

Figure 3. *Kidney bean suitable grain legume crops in southern Ethiopia.*

1.2. Nutritional Composition of Vegetable Production in Ethiopia

1). Fresh Habesha Gomen

Habesha gomen is a vegetable that grows between 17 and 22 ℃ at elevations between 800 and 2200 meters above sea level. Habesha Gomen (Figure 4) belonged to the Brassicacea family, which also includes radishes, cauliflower, cabbage, and broccoli [14].

Figure 4. *Habesh gomen cultivation in Ethiopia [13].*

A well-liked leafy vegetable primarily grown for home consumption in Ethiopia, rich in iron, a mineral necessary for optimal health, Abundant in vitamin K, which helps shield the body from a variety of cancers, possesses anti-inflammatory qualities that aid in the prevention of autoimmune diseases like arthritis and asthma. There are additional vitamins here, such as riboflavin and niacin. a revenue stream for the majority of smallholder farmers, possesses a cheaper production cost than other horticulture crops [14].

2). Fresh Tomato

Since tomatoes belong to the deadly nightshade family, they were once thought to be toxic and to be the cause of a number of illnesses, including cancer, appendicitis, and "brain fever." They might even have the exact opposite effect. It was not until the eccentric New Jersey gentleman Colonel Robert Gibbon Johnson brought back tomatoes from a trip overseas in the early 1800s that they were even eaten in the United States [15].

As a fruit rather than a vegetable, tomatoes offer a plethora of health advantages for the body. Tomatoes are actually incredibly adaptable health foods, and with so many different ways to prepare them, there's really no excuse to ignore them when planning a balanced diet. The most well-known benefit of eating tomatoes is their high lycopene content. An essential antioxidant, lycopene aids in the prevention of malignant cell formation as well as a host of other ailments and problems. High levels of lycopene can help flush out free radicals in the body; in fact, the tomato's rich red color is derived from the nutrients that are packed with this essential antioxidant [16].

Tomatoes come in round, oval, and "cherry" varieties, but they all share the same nutritional qualities and are a significant source of: - minerals such as potassium, phosphorus,

magnesium, and iron, which are essential for the proper function of muscles and nerves; - vitamins A, B, and C; tomatoes are the third-largest dietary source of vitamin C and the fourth-largest source of vitamin A (Figure 5). due to its pro-vitamin A or beta-carotene content; - phytosterols, which are substances that aid in controlling cholesterol - folic acid, which aids in the removal of homocysteine, an amino acid whose metabolism depends on the B complex vitamins' metabolism, particularly folic acid's [17].

Figure 5. *Tomato natural sources of food colorants and spicy [17].*

3). Fresh Green Onions

The onion (Allium-cepaL.), a major crop for bulb plants cultivated worldwide, is a member of the Alliaceae family and the genus Allium. The main source of onion genetic variability is the eastern Mediterranean countries, where onions are grown for their green and mature bulbs. These regions also exhibit some diversity in onion cultivation practices. Onion plants are typically found in open, sunny, dry areas; however, the majority of species are native to cliffs, waterless foothill slopes, and stony or rocky open areas. Because they are easier to grow, yield more per hectare, and can occasionally increase production due to irrigation, onions are a major economic center in Ethiopia. Inappropriate spacing, inadequate fertilization, and the unavailability of high-quality planting materials arranged in accordance with other cultural practices can all limit onion production [18].

The research center has released five varieties of onions in Ethiopia: Adama Red, Bombay Red, Red Creole, Melkam, and Nasik Red. Ethiopia and the Awash Valley are major growing regions for the varieties, with larger quantities of Bombay Red and Adama Red being grown in the Lake Region. Since green onions are well known for having high levels of vitamins A and K, which are essential for growth. They are used in the production of Kurkufa. Formation and preservation of robust bones. One green onion stalk can supply roughly 16-22% of the daily required amounts of vitamins A, C, K, and folate. As a result, this study suggested preparing Kurkufa with green onions [19].

4). Fresh Green Chili

Chili (Capsicum spp.) is used as a spice in almost every cuisine because of its flavor, color, and pungency. Green chilies are used to make a variety of delectable dishes, including chili chicken, chili paneer, chili sauce, and chili jam. It has additional significance due to its abundance of nutritional and medicinal qualities. Chili is rich in vitamin C as well as other nutrients like Ca, Mg, folate, K, thiamin, Fe, Co, and other vitamins like A, B6, and K, capsaicin, pain relief, anti-arthritic, anti-bacterial, anti-inflammatory, anti-rhinitis, and analgesic effects, as an immune system enhancer in the treatment of obesity, type 2 diabetes, cardiovascular disease, and prostate cancer, lowers the risk of human death. As a result, chili might be a healthy addition to a daily diet [20].

Figure 6. *Samples of green onion ready for uses [20].*

Protein (0.9 g), vitamin A (530 IU), vitamin A 6.4 mcg, carbohydrate (33.4 kJ), fat (1.7 kJ), and food folate (10.4 mcg) are all abundant in fresh green chilies. As a result, this study recommended using a spicy recipe for southern Ethiopian traditional Kurkufa dishes.

Figure 7. *Samples of green chilli ready for uses [20].*

A significant issue with numerous approaches is their reliance on foreign solutions, which are not long-term viable. The program ends quickly, and progress ceases. It is crucial to approach this issue from a more comprehensive, multidisciplinary perspective by carefully choosing affordable, readily available raw food ingredients locally [21]. Determining the impact of Habesha gomen, tomato vegetables, on the macro and micronutrient contents of Kurkufa formulations was, therefore, the goal of this study. This study will investigate whether it can be used as a supplemental food to help older adults meet their overall nutritional needs by bridging the calorie, protein, and micronutrient gaps.

2. Materials and Methods

2.1. Description of the Study Areas and Collection of Food Materials

For the study, kidney beans, tomatoes, wheat, and Habesha

gomen were used along with maize (Zea mays). Between September and October 2023, agro-forestry experimental site of Bule Hora on the Addis Ababa-Moyale highway, 467 kilometers away, was the source of maize and wheat collected from Arba Minch Agricultural Research Institute and Bishoftu Agriculture Research Center, while Habesha gomen, kidney bean, and tomato were gathered from Burji Soyama markets. It is located at 5°35′N, 38°15′E, latitude and longitude, and 1,716 m elevation.

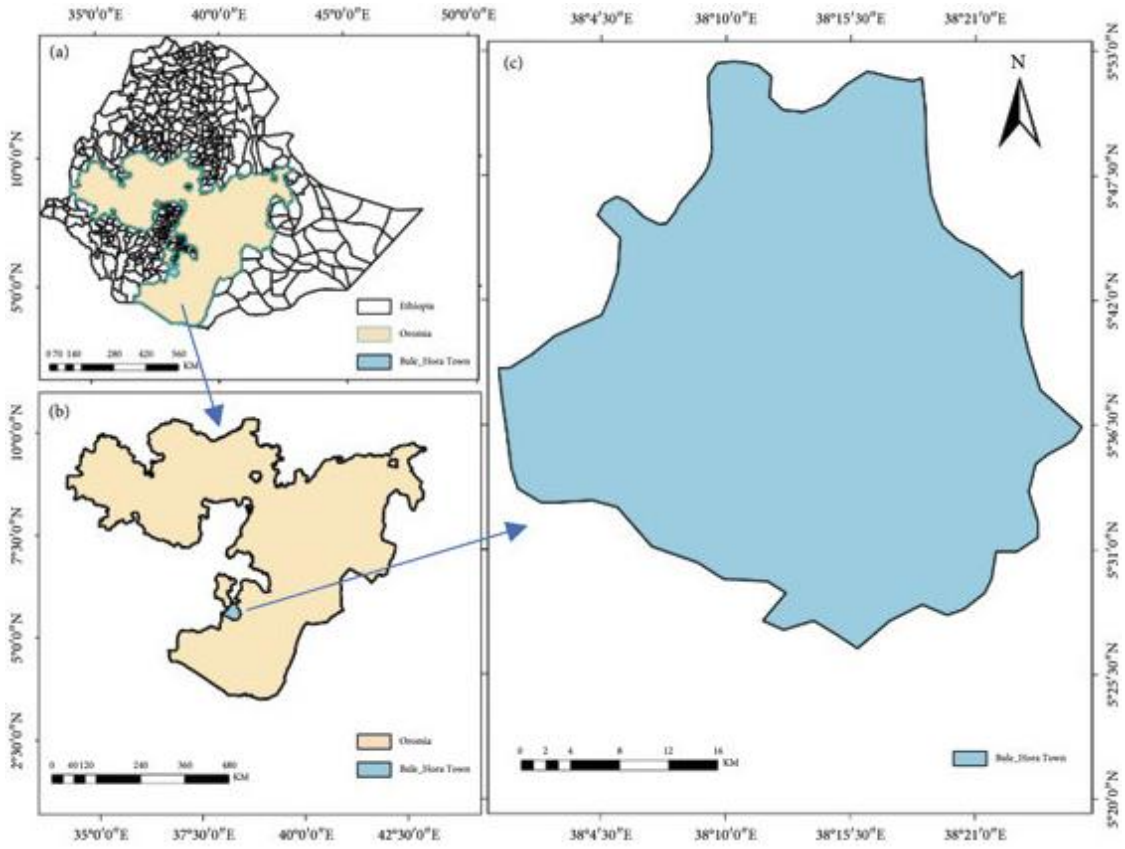

Figure 8. Location map of study area (Source: Google map).

2.2. Processing of Maize and Wheat Flour

Husks, broken grains, stones, dust, light materials, glumes, stalks, undersized and immature grains, and other extraneous materials were removed by hand cleaning the sample materials. Raw grain processing: After being sorted, the wheat and corn were cleaned and dried at 60 ^{o}C in a hot air oven. After that, the grains were ground in an electrical mill and sieved through a 150 µm mesh screen. Prior to formulations and chemical analysis, the powder sample was placed in an airtight plastic container that was sealed and kept at room temperature.

Soaking: For two to three days, the sorted wheat and maize were submerged in water. After being soaked, the grains were decanted and dried at 60 ^{O}C in a hot air oven. After drying, the sample was ground and put through a 150 µm mesh mechanical sieve. Packed into polyethylene bags, the flour with a moisture content of less than 10% was kept at room temperature until it was needed for formulations and chemical analysis.

Roasting: The wheat and corn that had been sorted were cleaned, rinsed, and left in water for a full day. After that, it was oven-dried at 60 ^{O}C in a hot air oven. The sample was first roasted at 120 ^{O}C for up to 10 minutes in order to obtain the desired color after drying. After that, it was ground using an electrical mill, sieved through a 150 µm mesh screen, and packed into an airtight plastic container. It was then kept at room temperature until formulations and chemical analyses could be performed [21].

2.2.1. Kidney Bean

Kurkufa was prepared using both fresh and dried kidney beans. Fresh dried kidney beans were used in this investigation. After washing the kidney beans three times in clean water to get rid of any impurities, boil the water for ten minutes, put the beans in a bowl, and cook for fifteen minutes, or until the beans are the consistency you want (not fully cooked). Remove the aromatics once the beans are soft. The subsequent actions were then carried out swiftly [21].

2.2.2. Habesha Gomene

It was prepared using green natural Habesha Gomene. Fresh wet were used in this investigation. After washing the three times in clean water to get rid of any impurities. The subsequent actions were then carried out swiftly.

2.2.3. Kurkufa Food Preparation

After washing 250 g of habesha gomen three times to get rid of any impurities, chop it with a knife on a cutting board to the desired size, and then add it to the kidney beans that have already been prepared (it's best to cook them separately). Next, add 200 ml of water to boil, add 50 ml of oil from the pods, and add salt to taste. Cook everything together in a sauce pan for three minutes. 500 g Place the hand-rolled dough (a mixture of maize and wheat flour in a 2: 1 ratio) on top of the cooking mix, sifted and wetted, and cook for 10 minutes (Figure 9 below). After washing and chopping two amounts of tomatoes with knives, they were added to the pan and cooked for an additional two minutes. Lastly, wash four chilies, cut them with a knife, and add them to the pan. If necessary, add a little water. Cook, covered, for ten minutes without stirring. Lastly, combine and transfer to a heated plate. Then placed in refrigerators for additional analysis after being sealed in high density polyethylene.

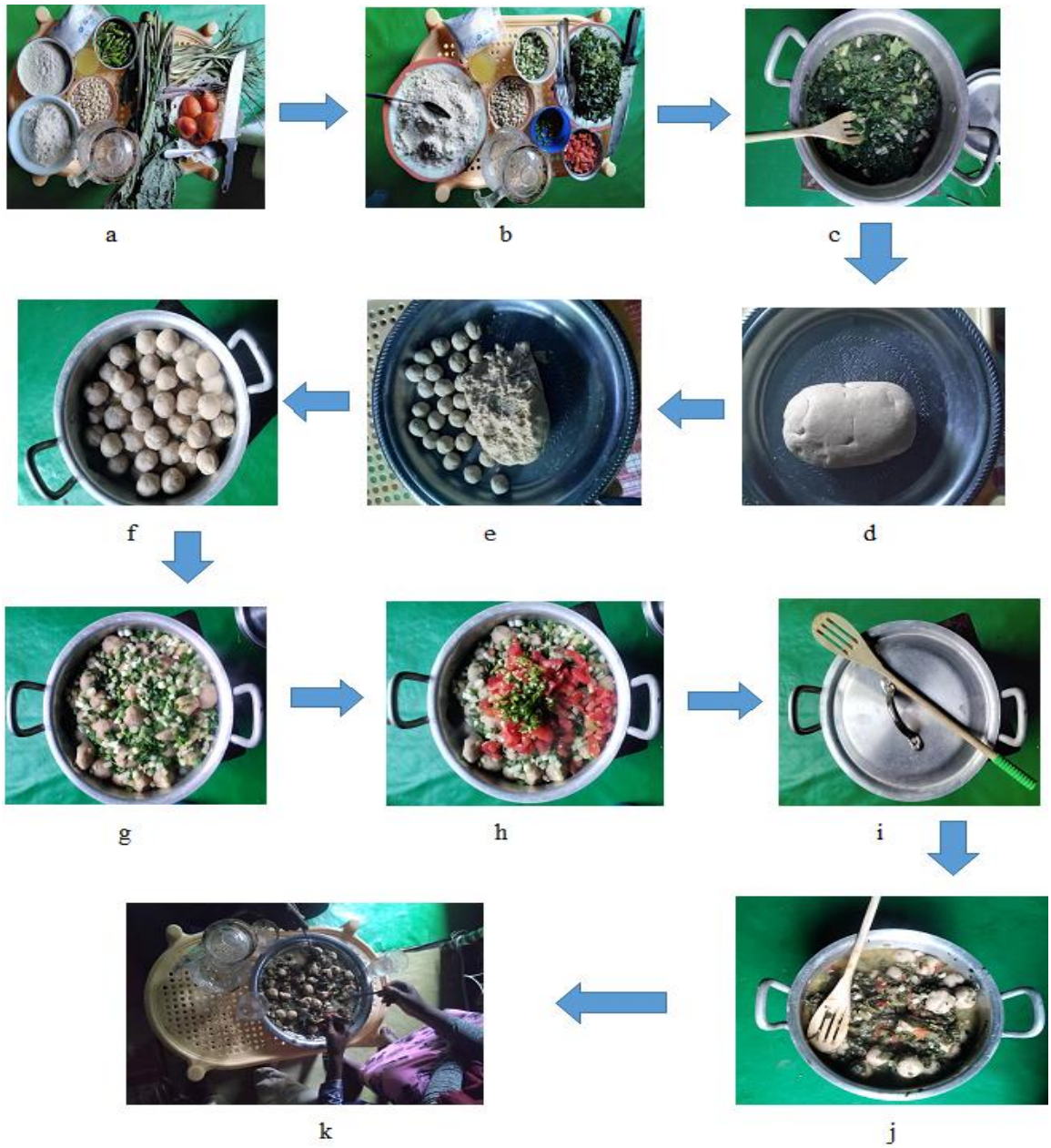

Figure 9. *Preparation of Kurkufa Food with each steps (a). Ingredient preparation b). Mixing flours and size reduction c). Cooking kidney bean and habesha gomen d). Dough making e). rolling in same size f). Adding on step c and cook for 5 min g). Adding onion on f h). Add tomatoes and chilli on g i). Cooking for 35 minutes j). Final mixing k). Eating together and packaged for further study).*

2.3. Experimental Design

Kurkufa samples were created in duplicate using proportions that were similar to each other. The flour used in the formulation recipe was thoroughly mixed until it was visually uniform. Employed a simple mixture design to ascertain the impact of Kurkufa powder blends (wet portion not dried). Kurkufa samples were prepared in duplicate and subjected to nutritional analysis, sensory evaluation, and statistical validity checks.

2.4. Nutritional Analysis

Nutrient composition of the Kurkufa food sample was determined in duplicate using the standard procedures of the Association of Official Analytical Chemists (AOAC, 2005) [22]. A hot-air circulating oven's moisture content was measured using 5 grams of mixed kurkufa foods. The amount of ash was measured by burning two grams of food samples for five hours at 550 ℃ in a muffle furnace. Using a Soxhlet extractor, 2 grams of kurkufa were thoroughly extracted in diethyl ether to determine the crude fat content. Protein was measured using 0.5 grams of kurkufa foods and the Kjeldahl method (Method No. 978.04). After digesting two grams of fat-free kurkufa food samples in refluxing 1.25 percent H_2SO_4 and 1.25 percent NaOH, the amount of crude fiber was measured.

2.4.1. Carbohydrate Determination

The total percentage compositions of moisture, protein, fat, and ash contents were subtracted to find the carbohydrate content [23]. The formula was used to determine the amount of carbs.

[100% - (Moisture% + Protein% + Fat% and Fiber%)].

Where, %M = Moisture content %P = Crude protein content, %F = Crude Fat content %Fb = Fiber content in percent

2.4.2. Gross Energy

Using Atwater's conversion factor, the amount of protein, fat, and carbohydrate was calculated as follows: 4.0 kcal/g for protein, 9.0 kcal/g for fat, and 4.0 kcal/g for carbohydrate [23].

The total energy of Kurkufa food was calculated in kcal/100g = (9 *crude fat + 4 *crude protein + 4 * carbohydrate).

2.4.3. Minerals Determination

To ascertain the mineral composition of the samples, the Association of Official Analytics Chemistry (AOAC) methods were applied [24]. An atomic absorption spectrophotometer (model 7000 Shimadzu, Japan) was equipped with a 50 ml volumetric flask containing the filtrate after one gram of the sample had been ashed, digested, and filtered using HCl. A flame photometer was used to determine the values of sodium, calcium, iron, zinc, and potassium.

2.5. Sensory Evaluation

In a short amount of time, 30 rolled samples of Kurkufa products were chosen for sensory assessment based on the formulation's energy content. Using panelists and willing mothers, the sensory analysis was assessed using acceptability and preference tests with a 5-point hedonic scale (Muhimbula H. S et al 2011) [25]. A panel of judges tasted the Kurkufa food that had been prepared using labels as a guide (the labels for the 15 samples were labeled A through O). A total of thirty people were chosen to serve as panelists, and they included fifteen mothers, five food science instructors from Bule Hora University, five food scientists from Akaki Kality food complex factors in Addis Ababa, and five employees of the Ethiopian Public Health Institute (EPHI) in Addis Ababa, Ethiopia. The primary criteria for selecting panelists were availability during the study period, prior experience with sensory evaluation of products, and willingness to participate. When choosing the panelists, their health was also taken into account (they weren't prone to allergies or colds that could have affected how sensitive they were to the product). In an open kitchen area with plenty of laminate flooring, the panel members were asked to score the paste samples according to color, scent, taste, texture, and general acceptability in Mbela D. E.N et al, 2018 [26].

2.6. Statistical Analysis

Using SPSS software version 24.0, the nutrient values of the Kurkufa food and sensory attribute score were examined. A mean and standard deviation analysis was performed. The experimental results were also subjected to analyses of variance (ANOVA) using the Tukey Test at $P < 0.05$ to identify significant differences between the means.

3. Results and Discussion

Table 1 in this study presents data on the moisture, ash, protein, fat, fiber, carbohydrate, and energy content of Kurkufa food. The protein, fiber, carbohydrate, and energy content of Kurkufa food were significantly different ($P < 0.05$) with average values of 25.41 ±0.23%, 3.11 ±0.06%, 16.29 ± 2.00%, and 206.97± 1.50 Kcal/(100 g) for crude protein, crude fiber, and energy content, respectively. However, the crude protein content was reduced by boiling, roasting, and cooking for longer than one hour. The nutrients involved in body growth, development, and maintenance of nutritional status that allows us to grow healthily and lead happy lives were the main focus of this study.

As shown in Table 1 below, the addition of wheat, kidney

bean, Habesha gomen, green onion, and chilli increased the ash and moisture contents of the composite Kurkufa food by a range of 12.23 - 12.5 and 41.22 - 42.01%. According to Sangronis A et al, 2016), there is a correlation between an increase in moisture content and an increase in fiber content [27]. Because high moisture content promotes microbial proliferation that results in spoiling, it has been linked to a shorter shelf life for composite Kurkufa. The ash content of the cooked rice samples was consistent, ranging from 0.37 to 0.43% [28].

The composite Kurkufa food's protein content increased as well, rising between 25.21% and 25.61%. This increase can be attributed to the replacement of wheat flour with soy flour, as well as the addition of green onions, tomatoes, kidney beans, and Habesha gomen, which have protein contents of 36.40% and 23.90%, respectively, according to [28]. Similar increases in protein content in sorghum-soy composite flours have also been reported by other studies.

When compared to Kurkufa from a prior study that did not include wheat, processing time and heating led to a minor drop in the nutritional values of crude protein and carbohydrates; however, this effect was not statistically significant (P>0.05). Proteolysis was observed in the previous study, and this may have led to an increase in free amino acids and non-protein nitrogen during sprouting [29]. However, the protein calculation process used in this study depended on the measurement of total nitrogen [30]. Therefore, the amount of crude protein is unaffected by the change in nitrogen form caused by the breaking of peptide bonds. The outcome further demonstrated the mixed Kurkufa sample's low fat and high protein content. Compared to the study by Silifat A. S. et al. (2022), which ranged from 1.23 to 1.73% for protein, the crude protein range was higher [30].

The results of this study showed that while the amount of energy consumed per person in Ethiopia has increased significantly over the past 20 years, cereals continue to be the main source of dietary energy and protein. The amount of energy derived from sugars, vegetable oils, and foods derived from animals has only slightly increased. This implies that the nation is still in the early phases of a nutrition transition even though the population is rapidly urbanizing. National surveys conducted in North America and Europe reveal that although public concern over food safety is growing, it is not always well-founded. For instance, although they are more feared than microbes, chemicals actually cause less disease (Eurobarometer, 2010; Petrun et al., 2015) [32].

There aren't many nationally representative surveys on food safety issues in developing nations. Smaller studies, however, reveal high levels of anxiety and that the priorities of people living in developing nations are comparable to those of the United States and Europe. For instance, a compilation of research from seven different nations revealed that consumers' top concern when it came to food was frequently food safety (Tony S, et al., 2019) [33]. In comparison to dough properties obtained without the addition of dietary carbohydrates and fiber, dietary additions generally had pronounced effects on dough properties, yielding higher water absorption, mixing tolerance and tenacity, and smaller extensibility (Gomez et al., 2002) [31].

It is now acknowledged that dietary fiber is important in preventing a number of illnesses, including diverticulosis, diabetes, irritable colon syndrome, cardiovascular disease, and constipation [34]. These findings are supported by numerous well-documented studies. According to FAO/WHO guidelines from 1994, the composite kurkufa's crude fiber content fell between 6 g and other non-absorbable carbohydrates per 100 g of dry matter. When making biscuits, Joel et al. (2009) [34] found that utilizing whole grain raw materials and mixing wheat flour with specific legumes. Pseudo cereals enhanced the final product's functional and nutritional qualities in [35].

It has been proposed that the addition of fiber has detrimental effects on loaf volume and dough structure because it dilutes the gluten network, which hinders gas retention rather than gas production. The increased fiber content may be directly linked to the bread's brownish appearance [35]. The CHO and energy range were found to be higher (15.95 - 16.64 and 203.48 - 208.87) than in the study published in the FAO/WHO ranges of composite breads, which had energy values between 241 and 266 Kcal. As a result, the breads met the minimum energy content recommendation of 1674 kJ/100 g [36] recommended by the FAO/WHO in 1994.

Table 1. *Results of proximate values of Kurkufa food samples.*

Proximate Values		Ash, %	Moisture,%	Crude Fat,%	Crude Protein,%	Crude Fiber, %	Utilizable Carbohydrate,%	Energy, Kcal/(100 g)
Kurkufa food Samples	Sample 1	12.23	41.22	4.53	25.61	3.19	16.64	208.87
	Sample 2	12.5	42.01	4.33	25.21	3.03	15.95	203.48
	Mean	12.40 ±0.08	41.62 ± 0.12	4.43 ± 0.09	25.41 ± 0.23	3.11 ± 0.06	16.29 ±2.00	206.97 ±1.50

Data are mean values of duplicate determination ±standard deviation.

Table 1 demonstrates that in order to support a country's economic, social, and sustainable development, it is necessary to ensure longevity, improve livelihoods, and foster innovation. Based on estimates from the FAO, the five main food and agricultural products produced in Ethiopia in 2004 were cow milk, sorghum and other cereals, maize, and roots and tubers. The primary purpose of all these productions was for local human consumption [5].

Eight million people in Ethiopia have extremely precarious food security due to a combination of socio-political, environmental, and developmental instabilities. Ethiopia's climate is prone to drought, which has disastrous consequences because the country's agriculture is primarily rain-fed. The effects of the drought are even more severe given Ethiopia's precarious situation right now. The daily burdens of those living in the household are disproportionately burdened by food shortages [37].

The results for minerals are shown in table 2 below. Minerals are necessary for all bodily functions, including growth, development, water balance, and neurological functions, to operate normally. Iron, a necessary component of blood that aids in the transfer of oxygen, ranged from 10.9 to 11.08 mg in this investigation. Dietary sources include leafy green vegetables, legumes, fish, poultry, and red meat (all of which are readily absorbed). Its contents were enhanced by the addition of habesha gomen, onion, and chilli. A healthy skeleton depends on calcium, which is also essential for blood clotting and is a major component of teeth and bones. Dark green vegetables, milk and milk products, and fish are the main sources of calcium in the world (plant sources are not well absorbed). Zinc is a vital component of skeletal muscle, aids in wound healing, improves and fortifies the immune system, and facilitates digestion. The zinc content (8.73 - 9.25 mg) in this study is comparable to beef, seafood, liver, nuts, beans, and whole grains are examples of dietary sources. Chromium, copper, fluoride, magnesium, manganese, molybdenum, nickel, potassium, phosphorus, sodium, and selenium are additional minerals that are necessary for different bodily processes [38].

A balanced diet is likely to supply the body with the minerals it needs in relatively large amounts, such as calcium, potassium, sodium, iron, and zinc, which are supplied by a wide variety of foods and increased food production, consumption, and supplementation [39]. Table 2 below contains the data pertaining to the mineral content results of Kurkufa food.

Table 2. *Results of mineral contents of Kurkufa food samples.*

Mineral Contents		Na (mg)	Ca (mg)	K (mg)	Fe (mg)	Zn (mg)
Kurkufa food Samples	Sample 1	12.90	735.78	1470.82	11.80	8.73
	Sample 2	12.70	725.46	1481.20	10.90	9.25
	Mean	12.80 ±1.00	730. 62 ±1.20	1476.01±0.34	11.35 ±1.00	8.99 ±0.12

Mean ± SD in a column with the same letter are not significantly different ($p < 0.05$). Values are duplicate analysis.

As for the micronutrient deficiencies that are referred to as "hidden hunger," FAO reporting indicates that one in three people worldwide may be affected [5]. Over the past few decades, hidden hunger which is assessed using proxies that focus on deficiencies in iron, vitamin A, and zinc has gotten worse in Africa while mostly improving in Asia and the Pacific, according to research published in (Ruel-Bergeron et al. 2015) [37]. In comparison with this study, 613 million women and girls aged 15 to 49 experienced iron deficiency in 2016 [40]; iodine deficiency affected 28.5% of the world's population in 2013; vitamin A deficiency affected 15.3% of pregnant women and 33.3% of children under five in 2005; and zinc deficiency affected 17.3% of the world's population (HLPE 2017) [39].

Ending hunger, food insecurity, and malnutrition in all its forms is becoming increasingly difficult. According to the most recent data available, the number of people worldwide who cannot afford a healthy diet increased by 112 million to nearly 3.1 billion, which is indicative of the effects of growing consumer food prices.

The current study's results showed that there was a statistically significant difference (P < 0: 05) among samples when all sensory attributes were taken into consideration (see Table 3 below). A panel of thirty judges was asked to rate their level of sensory acceptance of the Kurkufa samples with corresponding treatments in the current study. One of the most crucial factors that typically catches customers' attention at first glance is the color of the Kurkufa. People in the Burji, Konso, and Derashe Zones of Southern Ethiopia, where Kurkufa is a staple food, prefer their Kurkufa to be green with a yellowish and white color without the use of natural colorants or supplements.

Table 3. *Results of sensorial evaluation of Kurkufa food compared with EPH, FAO and WHO Standards.*

Sensorial Evaluation		Colors	Flavors	Taste	Texture	Overall acceptability
Kurkufa Food Samples	Sample 1	4.21	4.36	4.08	4.31	4.21
	Sample 2	4.62	4.22	4.08	3.92	4.00
	Mean	4.42 ±0.97	4.29 ±1.11	4.08 ±0.91	4.11±0.89	4.10 ±1.05

Mean ± SD in a column with the same letter are not significantly different ($p < 0.05$). Sensory quality (Hedonic 5 scale) by 30 consumer panelists.

Nonetheless, flavor (4.22 - 4.36) and taste (4.08 observed) were found to be the most valued attributes by customers in the closed system hedonic test. The flavor variable agrees with other research that found it to be a critical component. The most important and pertinent characteristics in the sensory analysis is flavor [41]. According to research, flavor and taste are strongly related and vary depending on the product. Smell intensity was not examined in this instance as Han P, et al. (2019) [42] did, but it was still possible to recognize it as a significant factor in consumers' choices. However, it should be noted that while smell influences appetite, it has no effect on subsequent food intakeit can also point individuals in the direction of healthier choices (Morquecho Campos et al., 2020) [43]. These qualities may occasionally work in favor of traditional foods like casseroles, Kurkufa, fosses, and kitta because they are thought of by customers as being wholesome and nourishing. There isn't a significant difference ($p > 0.05$) between the food samples from Kurkufa.

Taste scores for the Kurkufa food ranged from 4.08 to 4.09; cookie samples scored lowest, while cookies reported in [44] scored between 4.12 and 7.2 because malted barley bran contains tannin. Based on the results, consumers with a mean score of 4.085 could tolerate a kidney bean substitution level of up to 5%. There isn't a discernible difference ($p > 0.05$) between the cookie samples.

Overall acceptability is the culmination of all the characteristics of the product that the panelists assessed. As a result of this experiment, the overall acceptability of the Kurkufa food samples, which varied between 4.00 and 4.21 with all treatments, was found to differ statistically significantly ($P < 0.05$). Less heating and cooking, while a good technology to increase the mold-free shelf life of Kurkufa food, has the crumpling effect [43] that makes it unsuitable for soft bakery products, as this experiment also found. Based on the average mean score of overall acceptability, tomato colored Kurkufa samples got the highest mean scores of 4. 21.

This study demonstrates that even with the same amount of public resources, governments can invest in agro-food systems in an equitable and sustainable manner. But a large amount of this support fails to provide children and others who need it most with healthy diets, distorts market prices, harms small-scale producers, the environment, and Indigenous peoples [45].

As stated in Akinwande B. A et al, 2008, Countries that import food have frequently supported policies more strongly, particularly when it comes to cereals, in an effort to protect their agriculture industry from outside competition. They might have been favoring the production of cereals more than the production of fruits, vegetables, pulses, seeds, and other nutrient-dense foods by doing this. In terms of providing an adequate amount of calories, these policies have improved food security; however, they are ineffective in terms of enhancing nutrition and health outcomes, particularly for children [46].

Based on available data, governments can reduce the cost and increase the affordability of healthy diets for all by reallocating resources to support sustainable food production, supply, and consumption, with a focus on food consumers as stated by Birehanu ZT et al, 2024 [47].

4. Conclusions

This study shows that when examining consumer attitudes and acceptance toward traditional food processing, qualitative consumer testing techniques like focus groups and sensory evaluation can be used effectively. The results of the focus groups demonstrate consumers' preferences for various features of the product (such as price and image), as well as their familiarity with and reasons for consuming Kurkufa food. Preferences for the intrinsic qualities of the products were obtained from the sensory analysis. The target market must always be taken into account when working on flavor modifications because there may be differences in taste preferences, consistency, and smell, among other factors. Similarly, effective association requires that the image align with the expectations of the consumer regarding the product. The target market must unquestionably be taken into account in innovation strategies in order to adjust and improve product positioning. Customs and innovation are complimentary trends that are more likely to be accepted if they are combined with information about nutrition and health. This is also becoming more of a viable option for small producers to investigate. The amount of time available for preparing and eating Kurkufa food is influenced by the demands of modern life. Simultaneously, prevailing market conditions and heightened competition prompt the development of innova-

tive strategies that help businesses stay in business. Trends show an increased interest in natural foods, natural colorants, reduced fat and sugar, and products that guarantee more and better health benefits.

5. Recommendation

The authors recommend continuous nutrition education in consumption of diversified foods that include vegetables, pulse and other legumes in order to enhance daily protein supplies. Further research is also necessary to document effectiveness of this type of fortified food complement formulation by improving the following;

Food safety system in Ethiopia is not always as organized and developed as in other developed countries. Moreover, problems of growing population, urbanization, lack of resources to deal with pre-and postharvest losses in food, and environment and food hygiene issues mean that food systems in the country continue to be stressed, adversely affecting the quality and safety of food supplies. Therefore**,** process any food in modern system is better.

Initiate the establishment of National Food Safety Policy as well as Safety Council and upgrade the capacity of existing public health laboratory, personnel, food-borne diseases surveillance system and legal and policy frame work.

Approach embassies, agencies and others to support the national food safety programmes through fund mobilization of FAO/WHO.

Disseminate food hygiene information through mass media and awareness would be needed.

Finally it would have been good to improve established food safety authority at national level. This will change unorganized efforts of the different ministries into organized way and also avoid redundancy activities.

Abbreviations

AAOC	Association of Official Analytical Chemists
ANOVA	Analysis of Variance
CHO	Carbohydrate
EPHI	Ethiopian Public Health Institute
FAO	Food and Agriculture Organization
HCl	Hydrochloric Acid
ORCiD	Open Researcher and Contributor ID
PEM	Protein Energy Malnutrition
SSA	Sub-Saharan Africa
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

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Author Contributions

Hirbo Geremew Hirbo is the author. The author read and approved the final manuscript as present form.

Declaration

The authors of this research article titled " Use of Natural Food Colorants in Kurkufa Food: An Assessment of Nutritional and Sensory Quality in Southern Ethiopia", hereby declare that the study was conducted in adherence to ethical research standards. The data presented in this manuscript is original and has not been published elsewhere nor is it under consideration in any other journal. All sources and references used in the research have been appropriately cited. There are no conflicts of interest or competing financial relationships that could have influenced the findings of this study. Ethical approval was obtained from the relevant institutional review boards, and necessary permissions were secured from respective authorities. The study was conducted with transparency, integrity, and in compliance with academic and scientific research guidelines.

Ethics Approval

Ethical approval clearance was obtained by the institutional review boards. Permission was also sought from each zone during field work. The author requested and officially received approval to use exact information’s.

Consent to Participate

Not Applicable. Informed consent was obtained from all subjects involved in the study and this manuscript has not been published elsewhere and not under considerations on the other journals.

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Conflicts of Interest

There are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Mogessei A. (2002). The microbiology of Ethiopian Foods and beverages: A Review. Ethiopian Journal of Science, 25(1), 3-27. https://doi.org/10.314/sinet.v25i1.18076

[2] Kidist H. D. (2018). Nutritional Quality Evaluation of Seven Maize Varieties Grown in Ethiopia, Journals of Biochemistry and Molecular Biology, 3(2), 45-48. https://doi.org/10.11648/j.bmb.20180302.11

[3] Belay A., Awoke T., Woldeyohannes M. and Debella A. 2022. Evaluation Of The Nutritional Quality Of Complementary Food Formulated From Locally Available Grains And Moringa Stenopetala In Southern Ethiopia, African Journal of Food, Agriculture, Nutrition and Development; 22(7): 20849-20870. https://doi.org//10.18697/ajfand.112.21865

[4] Dagne T. T., Adamu Z. (2023). Industrialization of Indigenous Food (Kurkufa and Qitta) Preparation. J. Nutrition and Food Processing, 6(5). https://doi.org/10.31579/2637-8914/188

[5] FAO. Food Insecurity in the World 2001. http://www.fao.org/3/a-y1500e.pdf (Accessed December 6, 2017)

[6] Hummel, D., (2015). Climate change, environment and migration in the Sahel. Rural 21, 40 - 43.

[7] Marianela, F., and Coauthors. Past and present biophysical redundancy of countries as a buffer to changes in food supply. Environ. Res. Lett., 11, 55008, 2016. https:doi.org/10.1088/1748-9326/11/5/055008

[8] Lemi Y., Debela D. (2023). Nutritional and Specialty Maize Production, Consumption, and Promising Impact on Ethiopia's Food and Nutrition Security: A Review. EAS Journal of Nutrition and Food Sciences, 5(5), 142 - 158. https://doi.org/10.36349/easjnfs.2023.v05i05.003

[9] Michiel V. D., Tomas M, Marloes V. L. Pytrik R. Kindie T. and Martin K. I. (2020). Reducing the Maize Yields Gap in Ethiopia. Decomposition and Policy Simulation, 183, 102828. https://doi.org/10.16/j.agsy.2020.102828

[10] Afework L. and Admikew G. (2021). Wheat Breeding Research and Major Achievements in Ethiopia: A Review. International Journal of Current Research and Academic Review; 9(06): 17-27. https://doi.org/10.1155/2021/8817278

[11] Wuletaw T., Habte Z., Tolesa D., Daniel K., Wondwosen S., Tafesse S., Tamrat N., Negash G., Zewdie B., Solomon A. (2022). Wheat Production and Breeding in Ethiopia: Retrospect and Prospects. Journals of Crop Gentics, breeding and Genomics, 4(3), 8 - 22. https://doi.org/20.500.11766/67542

[12] Fitsum A. (2022). Progress of common bean breeding and research achievements in Southern Ethiopia. Net Journal of Agricultural Science, 10(3): 59-65. https://doi.org/10.20431/2454-6224.0805002

[13] Kale Production, First version was published by SHEP (Kenya) in 2009, revised by Ethio-SHEP in 2019 (Ver.1) https://farmerstrend.co.ke/complete-guide-plant-best-sukuma-wiki-kales-ethiopia/

[14] Debjit B., Sampath K. P., Shravan P., Shweta S. (2020). Tomato-A Natural Medicine and Its Health Benefits. Journal of Pharmacognosy and Phytochemistry, 1(1), 33 - 43.

[15] Gomez R., Varon R., Amo M., Tardaguila J.,' and Pardo J E. (2000). Differences in the Rate Of Coloration In Tomato Fruit. Journal Of Food Quality 21, 329-339.

[16] Jafer D. (2016). The Role of Tomato Products for Human Health (Solanum lycopersicum) - A Review. Journal of Health, Medicine and Nursing, 33, 66 - 74.

[17] Diribsa A., Chala K., Weyessa G., Leta TJ., Venkatesh S., Abel S. & Krishnaraj R. (2022). Growth, yield, and yield variables of onion (Allium Cepa L.) Varieties as infuenced by plantspacing at Dambi Dollo, Western Ethiopia, 12 (3), 9 - 23. https://doi.org/10.1038/s41598-022-24993-x

[18] Mahadeen, A. Y. (2018). Effect of planting date and plant spacing on onion (Allium cepa. L) Yield under rain fed in Semi-Arid conditions of Jordan", Bull Faci. Agricultural, 59: 237-241. https://doi.org/10.3844/ajabeep.2008.202.207

[19] Swapan C., Mominu A. K. I. and Aminul K. M. I. (2017). Nutritional Benefits and Pharmaceutical Potentialities of Chili: A Review. Journal of Fundamental and Applied Agriculture, 2(2): 227-232. https://doi.org/10.5455/faa

[20] Engelund, E. H., Breum G., and Friis J J. O. (2019.). Optimization of large - scale food production using Lean Manufacturing principles. J. of Eur. Research C, 20(1): 4-14. https://doi.org/10.1111/j.1748-0159.2008.00109.x

[21] Saravacos, G. D. and Kostaropoulos A. E., Handbook of food processing equipment. Vol. 2012. 2002: Springer.

[22] AOAC, (American Official Chemist Method, Washington, USA. 2005.

[23] Shrestha A. K and Noomhorm A. (2022). Comparison of physico-chemical properties of biscuits supplemented with soy and kinema flours. Int J. Food Sci. Technol, 37: 361 - 368. https://doi.org/10.1046/j.1365-2621.2002.00574.x

[24] Asma M. A, Fadil E. B. and Tinay E A. H. (2016). Development of weaning food from sorghum supplemented with legumes and oil seeds. Food Nutr. Bull, 27: 26-34. https://doi.org/10.1177/156482650602700104

[25] Muhimbula H. S., Abdulsudi Z, Joyce K. (2011). Formulation and sensory evaluation of complementary foods from local, cheap and readily available cereals and legumes in Iringa. Tanzania. African Journal of Food Science, 5(1): 26-31. Available online https://www.academicjournals.org/ajfs

[26] Mbela D. E. N., Kinabo J., Mwanri A. W. and Ekesa B. (2018). Sensory evaluation of improved and local recipes for children aged 6 to 23 months in Bukoba, Tanzania. African Journal of Food Science, 12(11) pp. 297-308. https://doi.org/10.5897/AJFS2018.1738

[27] Sangronis A, Rodr guez E., M., Cava R. and Torres A. (2016). Food Alternatives in Africa. Eur. Food Res. Tech. 222(1-2): 144-148.

[28] AOAC. (2000). Official methods of analysis. (Vol. ii 17th ed.), of AOAC International Assn. of Official Analytical Chemists, Washington, DC, USA, Official Methods 925.09, 923.03, 979.09, 962.09, 4.5.01.

[29] Torres, A., J. Frias, M. Granito and Valverde C., V. (2007). Germinated Cajanus cajan seeds as ingredient in pasta products: chemical biological and sensory evaluation. Food Chem. 101: 202-211. https://doi.org/10.15835/nsb.7.1.9428

[30] Silifat A. S., Clara R. B. O., and Lateef O. S., (2022). Chemical and Nutritional Composition of Some Common Foods in Abeokuta, Nigeria, 23(5), 56 - 59. https://doi.org/10.1590/S1516-891319990003000010

[31] Gomez M., Ronda F., Caballero P and Apesteguía A. (2003). Effect of dietary fibre on dough rheology and bread quality, Eur. Food Res. Technol., 216: 51-56. https://doi.org/10.1007/s00217-002-0632-9

[32] Eurobarometer, 2010. Special Eurobarometer 354 Food-related risks, TNS Opinion & Social, Brussels, Belgium. Retrieverd from http://www.efsa.europa.eu/en/factsheet/docs/reporten.pdf

[33] Tony S., Emma C., Sangita S. and Sibhatu B. (2019). Trends in energy and nutrient supply in Ethiopia: a perspective from FAO food balance sheets", Nutritional Journal, 18, 34 - 46. https://doi.org/10.1186/S12937-019-04711-1

[34] Joel N., Abdulraheem L. O., and Zakari U., M., (2011). Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends, African Journal of Food Science, 5(8): 466 - 472. available online https://www.academicjournals.org/ajfs.

[35] FAO. 2004. Human energy requirements. Report of a Joint FAO/WHO/UNU Expert Consultation, Rome, 17-24 October 2001. FAO Food and Nutrition Technical Report Series No. 1. Food and Agriculture Organization of the United Nations. Rome http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/007/y5686e/y5686e00.htm

[36] Dorit N. K, Einat O. and Tilahun A. (2001). Food security and nutrition the Ethiopian case for action. Public Health Nutrition: 5(3), 373-381. https://doi.org/10.1079/PHN2001313

[37] Ruel-Bergeron, J. C., Stevens G. A., Sugimoto J. D., Roos F. F., Ezzati M., Black R. E., and Kraemer K.. "Global update and trends of hidden hunger, 1995-2011: The hidden hunger 15 Index. PLoS One, 10, 1-13, https://doi.org/10.1371/journal.pone.0143497 2015

[38] Development Initiatives, 2017: Global Nutrition Report 2017: Nourishing the SDGs. Bristol, UK, 115 pp. https://www.globalnutritionreport.org/files/2017/11/Report_2017.pdf (Accessed January 11, 2018)

[39] HLPE, 2012: Food security and climate change. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, 102 pp. http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report

[40] D áz R, Pr ás R, Mera C. Caracterizaci ón sensorial de una hamburguesa precocida-congelada, usando carne caprina, perejil (Petroselinumcrispum) yalbahaca (Ocimumbasilicum)' Revista Cumbres 3: 09-16. 2017. https://doi.org/10.48190/cumbres.v3n2a4

[41] AO, UNDP (United Nations Development Programme) & UNEP (United Nations Environment Programme). 2021. https://doi.org/10.18356/30053307-26

[42] Han P., Fark T., Wijk R., Roudnitzky N., Iannilli E., Seo H, Hummel T., (2019). Modulation of sensory perception of cheese attributes intensity and texture liking via ortho- and retro-nasal odors. Food Quality and Preference 73: 1-7. https://doi.org/10.1016/j. foodqual.2018.11.019

[43] Morquecho-C., Graaf K., Boesveldt S., (2020). Smelling our appetite? The influence of food odors on congruent appetite, food preferences and intake. Food Quality and Preference, 2023 • VOL. 48 Nº 3 153 85: 1-7. https://doi.org/10.1016/j.foodqual.2020.103959

[44] Ikuomola D. S., Otutu O. L. & Oluniran D. D. (2017). Quality assessment of cookies produced from wheat flour and malted barley (Hordeum vulgare) bran blends. Cogent Food & Agriculture 2(7): 2-13., https://doi.org/10.1080/23311932.2017.1293471

[45] Abinet T., Shimelis A. E., Habtamu F. G., and Ashagrie Z. W. (2022). Improvement of Injera Shelf Life and Staling through Vacuum and Non vacuum Polyethylene Packaging: Their Synergistic Effect with Chemical Preservative. J of Food Quality, 12 (2), 12 -23. https://doi.org/10.1155/2022/897

[46] Akinwande B. A., Ade Omowaye B. I. O. & Akintaro O. O. (2008). Quality evaluation or ginger flavored soy-cassava biscuit. Nutritional and Food Science Journal 38: 473 - 48. https://doi.org/10.1108/00346650810906994

[47] Birhanu ZT, HIrbo G, & Kasahun TM. (2024). Proportional Study on the Nutritional Values and Physicochemical Properties of Processed and Raw Juice Consumption in Arba Minch Town, Ethiopia. International Journal of Nutrition Research and Health, BioRes Scientia Publishers. 3(1): 1-11. https://doi.org/10.59657/2871-6021.brs.24.030