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RESEARCH ARTICLE

OPTIMAL FORMULATIONS OF LOCAL FOODS TO ACHIEVE NUTRITIONAL ADEQUACY FOR 6-23-MONTH-OLD YEMENI CHILDREN

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Abstract

Nearly 4.5 million children under the age of five in Yemen suffer from acute malnutrition due to the high prices of imported baby food. Therefore, there is an urgent need to prepare and manufacture local foods of nutritious quality, cheap and available locally, to allow Yemeni families to feed their children and achieve public health. Six food mixtures (F1-F6) were prepared and manufactured from local field crops based on teff flour, rice, sorghum, wheat, sweet potatoes and lentils.

The formations (Mixers) were roasted to improve the nutritive nutritional value and sensory attribute of formulated recipes. The protein level was calculated, fat, carbohydrates and mineral in all mixers using of Percentages. All the formulations were evaluated for their acceptability by trained panelists using a five point hedonic scale. Although, many formulations were found to be organoleptically acceptable recording moderately to extremely like scores, generally formulations F3 (Teff (15%), lentils (6.5%), sweet potatoes (18.5%), white corn (10%), wheat (30%) and rice (20%).) and F4 (Teff (30%), lentils (10%), sweet potatoes (10%), white corn (25%), wheat (13%) and rice (12%) were highly acceptable by panelists and scored significantly ($P < 0.05$) higher than the other formulated complementary foods. Their mean score ranged between 4.2 to 4.35 in terms of taste and general acceptability.

Keywords: Sensory evaluation, Nutritional mixers, Yemen children, Local foods.

1. Introduction

The level of under nutrition among children remains unacceptable throughout the world, with large number of children living in developing world. Among developing countries, Yemen is highly affected, having large numbers of malnourished children [1]. Because of the rapid rate of growth and development during the first two years of life, nutrient needs per unit body weight of infants and young children are very high [2]. However, in low-income communities of the developing countries, like those in the Sub-Saharan Africa, millions of infants and children cannot afford these nutrient needs and hence are affected by under nutrition [3]. This is because most foods fed to infants usually lack the recommended densities of the essential macro- and micro-nutrients such as energy, protein, vitamin A, iron and zinc. For example, according to a report by Ferguson and Darmon [4], when the nutrient densities of complementary foods fed to 6-11-month-old infants in many developing countries are compared with WHO recommended levels, less than 15% of the 115 foods examined achieved the recommended nutrient density levels for calcium, iron and zinc. Deficiency of energy and essential nutrients during the complementary feeding period (the age range of 6–24 months) can have serious consequences on the health and wellbeing of infants at a later age in life, some of which are long lasting/irreversible [5]. The issue is even worse during the second six months of life as the challenge for meeting nutrient needs, especially those of micronutrients, is the greatest at this time [6]. Therefore, infants should be provided with energy and nutrient-dense foods during the complementary feeding period, along with appropriate feeding practices and continued breastfeeding so as to ensure long-term optimal growth and development during the infancy period [7]. The energy density of a food refers to the amount of calories per unit of volume or weight of the food and is very crucial in infant feeding [8]. However, in the developing world, energy intake of infants and very young children of low-income groups, is considerably below the recommended daily amount [9]. Therefore, fulfilling this energy requirement is critical [10]. Similarly, nutrient density which refers to the amount of a nutrient per 100 kcal, is very vital in complementary feeding as infants need more of the macro- and micro-nutrients because of their rapid growth and development [11]. The period of infancy in one’s life is referred to as the window of opportunity for preventing under nutrition and its long-term adverse consequences and thereby improve health and development [12] Thus, foods given to infants during this period, formally referred to as complementary foods, are required to adequately provide enough of the required energy, macro- and micro-nutrients including minerals and trace elements, especially iron and zinc [12] so that they will grow and develop to the best level. Therefore, interventions in complementary feeding that are effective at reducing malnutrition during this vulnerable period should be of a high priority [10].It has been widely recommended that a food-based, comprehensive approach is more effective and sustainable than programs targeting individual nutrient deficiencies in order to tackle the problem of infant malnutrition [12].The period of infancy in one’s life is referred to as the window of opportunity one of the major reasons for the wide-spread problems of malnutrition among infants and children in low-income communities is the use of cereal-based foods that are characterized by low energy and nutrient density [1]. However, despite being low in most vitamins and minerals, cereal-based complementary foods are still the crucial sources of nutrients for the majority of infants in low-income countries as access to animal-origin foods or commercially fortified complementary foods is highly limited for a number of reasons [3].Therefore, there are global recommendations to help improve the nutrient density of such cereal-based complementary foods in a cost effective manner. One important approach is compositing cereals with legumes and tubers that are rich in either of the important macro- and/or micro-nutrients and this food-based strategy is referred to as food-to-food fortification [6]. Moreover, the raw materials should be appropriately processed using recommended techniques that can enhance energy and nutrient densities [2]. In this study, complementary foods were developed from a composite of Taif flour, sweet potatoes, local lentils, rice, maize ,wheat using household- and industrial-level approaches. The macro- and micronutrient densities of the complementary foods were analyzed. The respective nutrient densities were then determined and compared with recommended levels (average desired nutrient densities) for 6-24 months. This research will be study of some Yemeni agricultural crops that are not consumed permanently and use it as complementary foods for children.

2. Material and Method

2.1. The Sample collection

During the months of January and February 2021, Teff, Lentils, Sweet potatoes, rice, White corn, and Wheat were collected from local markets in Aden, Yemen, expectation of teff seeds were purchased from the Agricultural Research Station in Mukalla, Hadramout Governorate, Yemen **(Fig 1)**

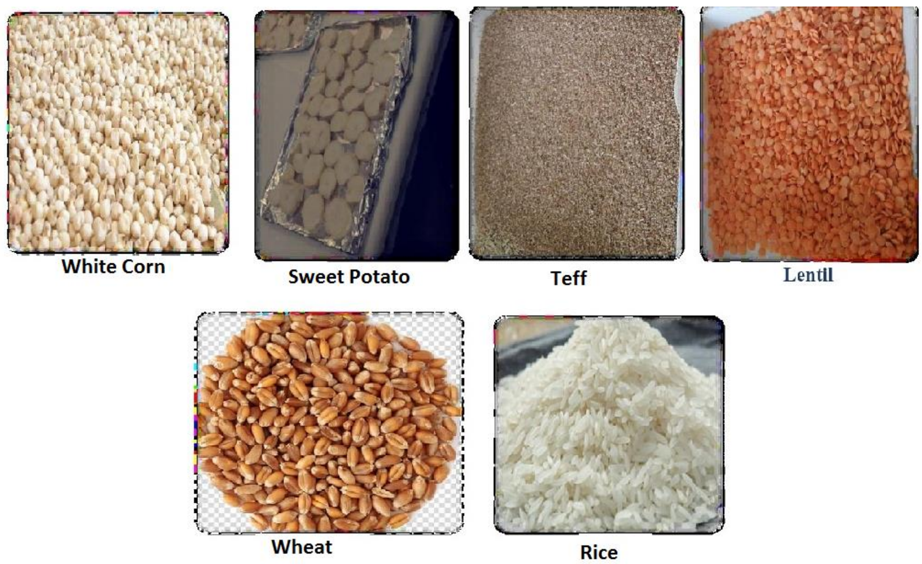

Fig. 1: Yemeni local crops used in study

2.2. Preparation of the samples (Formulas)

2.2.1. Preparation of Teff flour

Half a kilo of the seeds are taken and roasted with a household roaster for five minutes to be grinded later by the home mill and the resulting flour is passed on a sieve with holes of 250 microns to obtain a homogeneous fine flour to be packed in plastic bags and kept in the refrigerator at a temperature of 4 degrees Celsius until used [13].

2.2.2. Preparation of lentils flour

One kilo of lentil seeds was taken and they were immersed for eight hours in water in a ratio of 3: 1 of the seeds and water. After finishing the immersion period, the water and the manually outer layer of the seeds are removed. Boiling process begins for 30 minutes (until the seeds are smooth when pressed with the finger). The seeds are dried in a pneumatic oven at a temperature of 50-55 ° C for 12 hours. Dried seeds are ground by the home mill and the resulting flour is passed on a sieve with holes of 250 microns to obtain homogeneous fine flour to be packed in plastic bags and kept in the refrigerator at 4 ° C until used.

2.2.3. Preparation of sweet potatoes flour

Sweet Potato washed to get rid of the stuck soil then peel and slice 1 mm thick and dried in a pneumatic oven at a temperature of 50-55 ° C for 7-8 hours to obtain dry slides with a humidity of 7-8%. Dried slices are ground by the home grinder and the resulting flour is passed on a sieve with holes of 250 microns to obtain homogeneous fine flour to be packed in plastic bags and kept in the refrigerator at 4 ° C until use [13].

2.2.4. Preparation of rice flour

The rice was purified from impurities, then one kilo of rice was taken. Dried seeds are ground by the home mill and the resulting flour is passed on a sieve with holes of 250 microns to obtain homogeneous fine flour to be packed in plastic bags and kept in the refrigerator at 4 ° C until use.

2.2.5. Prepare white corn and wheat

They were purchased and Prepared from local market Sheikh Othman in Aden Governorate Yemen.

From the six cereals prepared four recipes where named each recipes F1, F2, F3, F4, F5 and F6. All samples formulated to provide equal amount of energy and protein were percentage composition of Nutritional Formula in Table 1.

Table 1: Percentage of complementary nutritional formulation.

Main Ingredients	Formulation name	Mixing ratios (in gram and percentage)
Teff, lentils, Sweet potatoes, White corn, Wheat and Rice	F1	Teff (35%), lentils (15%), sweet potatoes (20%), white corn (10%), wheat (15%) and rice (5%).
	F2	Teff (50%), lentils (5%), sweet potatoes (20%), white corn (5%), wheat (10%) and rice (10%).
	F3	Teff (15%), lentils (6.5%), sweet potatoes (18.5%), white corn (10%), wheat (30%) and rice (20%).
	F4	Teff (30%), lentils (10%), sweet potatoes (10%), white corn (25%), wheat (13%) and rice (12%).

2.3. Chemical analyses

All of methods were used in chemical analysis for moisture, protein, fat, fibers, carbohydrates and minerals content according to described method [13].

2.3.1. Moisture

Use oven drying temperature of 105 ° C according to (1/106) ICC method of 2006.

2.3.2. Protein

Digestion unit (kieldahl - type TR Germany) and the Vapodest-type distillation unit (VAP30) were used. After nitrogen determination by titration, factor 6.25 was used to quantify the protein according to the described method [13].

2.3.3. Fat

Fats were estimated using a Soxhlet device according to the described method [13].

2.3.4. Fibers

The fibers were estimated by the Worn method, which depends on the morphology of carbohydrates and digestible proteins, and the extraction of fats by a dilute acid solution, then a dilute base solution, then the non-digestible materials were collected after the filtration process. The fibers were estimated by weight according to the method described in [13].

2.3.5. Carbohydrates

calculated as the difference of 100- (moisture% protein% fat% fiber).

2.4. Mineral content

The minerals content of the samples were determined by atomic absorption spectrophotometer (AAS) (Agilent FS240 AA, USA) following [13]. Three grams of composite flour samples were carbonized on a heating plate and ashed in a muffle furnace (Sx2-4-10, Zhejiang, China) at 550 _C until ashing was completed. The white ash was dissolved using 5 mL of 6N HCl, dried on a hot plate, followed by the addition of seven mL of 3N HCl heating on a hot plate and then finally, the solution was diluted to the mark (50 mL) with de-ionized water.

The Fe, Zn and Ca contents were determined by AAS using airacetylene as a source of flame energy for atomization. The absorbance for Fe was measured at 248.3 nm, and the Fe content was estimated from a standard calibration curve (0, 0.5, 1.0, 2.0, 3.0 and 4.0 µg/mL) prepared from analytical grade iron wire. The absorbance for Zn was measured at 213.9 nm, and the Zn content was estimated from a standard calibration curve (0.000, 0.125, 0.250, 0.500, 0.750 and 1.000 µg/mL) prepared from ZnO. The absorbance of Ca was measured at 422.7 nm after adding 2.5 mL of LaCl3 to sample solutions. The Ca content was then estimated from the standard solution (0.0, 0.5, 1, 1.5, 2.0 and 2.5 µg/mL) prepared from CaCO3.

The Na,, Cu, P and K contents were determined using a flame photometer (ELICO CL 378, India) by measuring their emission at 589 and 767 nm, respectively. The Na content was estimated from standard solution (0.0, 0.5, 1.0, 1.5, 2.0 and 2.5 µg/mL) prepared from NaCl. The K content was estimated from a standard solution (0, 2, 4, 6, 8, 10 and 12 µg/mL) prepared from KCl.

The mineral element content was calculated using **Eq. (1):**

Element (mg /100g) = (µg/mL)*DF_

[(Sample mass, db)10]

where: DF ¼ dilution factor (50 mL for Ca, Fe, Zn, K and Na), and db is sample mass on a dry matter basis

2.5. The Sensory evaluation

Sensory evaluation of the gruel samples was conducted at Aden city districts, Yemen. A total of 53 trained panelists of mothers who have children aged between 6-24 months with experience of preparing infant foods were randomly selected from a list of mothers in the selected districts. After orientation, coded products were given randomly to the panelists to evaluate sensory attributes, namely taste, appearance, smell, Consistency, mouth feel and overall acceptability. A five-point hedonic scale using smile emojis (5 = Like extremely, 4 = Like slightly, 3 = Neither like nor dislike, 2 = Dislike slightly, and 1 = Dislike extremely) was used [14]. .

2.6. Statistical analysis

The present study used a descriptive design to determine the nutritional content and quality of proteins, Carbohydrates, Fats, Ash, moisture and Dietary fiber. Each sample group will analyze in duplicate with using the statistical package for social science (SPSS, 13.0 software, 2009), values of P<0.05 will considered to be significant.

3. Results

Table 2: The Nutritional content of baby food from Teef and other crops for F1, F2, F3 and F4 per 100 gram.

Formula	Moisture	Protein	Ash	Fat	Fibers	Carb.	Con. rate of the nutrient content
	Con.	Con.	Con.	Con.	Con.	Con.	Con.
F1	5.8	13	2.1	6.7	1.8	71.23	70.82
F2	5.2	14	2.4	11.4	0.81	65.15	74.67
F3	5.3	14.8	2.3	16	0.6	61.61	78.39
F4	6.2	15	1.7	10.9	0.07	64.50	75.79
Mean	5.75	15.42	2.0	10.33	0.85	65.04	67.395
St.d	0.481	2.012	0.310	3.286	0.562	3.264	5.064

Carb.=Carbohydrates
Con. = Concentration

Compositions of the nutritional formulas are given in **Table 1**. The amounts of various staples (cereals) and supplements (legumes) were calculated to provide 292 kcal (from energy) and raise the protein level to 8% NPE as one third infants energy and protein requirement per day [14]. The protein level was obtained on the basis of the most limiting amino acid in each mixture, using amino acid score since protein quality in plant-based products is constrained by amino acid composition. To combat the problem of under-nutrition, the mixing ratios were formulated to contain enough energy and protein to meet the daily requirements of infant from 6 month to 24 months.

Table 2 showed that moisture of baby food results from Taff flour and other crops which that were locally produced ranged from 5.8- 6.2%, respectively, which acceptable proportions are for baby food, when it is kept in suitable storage conditions (cold and dry). The results was completely identical to the Indian Standard, which specifies the moisture content of 10% in baby foods and Yemeni Organization for Standardization, Metrology and Quality Control no. 22/2003, which specifies the moisture content of 5% in baby foods on the basis of the dry weight.

The infant needs protein from the seventh month [14]., in **Table 2**, we note that the protein content in all food mixtures (Formula) range between 13 -15% respectively.

The ash is known to be a component of food. It is made of mineral or organic materials. This component consists of minerals such as potassium, phosphorous, sodium and copper.

The results in **Table 2** showed that ash content ranges from (1.7-2.4%). mixture F2 achieved the best concentration in ash as this Formula, it gave a concentration of 2.4%. In spite of this, mixture F2 was not different from the rest of the mixtures, which gave close concentrations to it in ash.

The fat content in **Table 2** ranged from (6-7-16 %), mixture F3 achieved the best concentrations (16%) according to the Yemeni Organization for Standardization, Metrology and Quality Control no 22/2003 [14] for infant and child food mainly made from grains and pulses specified that the fat content should be no more than 9%.

in addition to the results in **Table. 2** for fat in mixture F1 was best as the was 6.7%.

Observed in **Table 2** that the fiber concentration content ranged between 1.8 – 0.07%, the results shown that mixture F1 achieved the best concentration in the fibers, as this mixture gave a concentration of 1.8%.

Table 2. showed the carbohydrate content in baby food mixes per 100 grams, as the carbohydrates in blends yield between 71.23 - 64.50%. Where mixture F1 achieved the best concentration of carbohydrates, as this mixture gave a concentration of 71.23% and natural high-carbohydrate ratios in mixes, as they are mainly based on grains and legumes that are rich in carbohydrates.

Table 3: Content of mineral in formulas mg \ 100 grams

Elements	Maximum	Minimum
Calcium	140 mg	50 mg
Potassium	180 mg	60 mg
Phosphor	100 mg	25 mg
Sodium	60 mg	20 mg
Iron	undefined	0.45 mg
Zink	1.5 mg	0.5 mg
Copper	129 µg	25 µg

Table 3. shows the content of mineral, calcium, potassium, phosphorus, sodium, iron, zinc, copper, in baby food formulations for every 100 calories of Teff flour and other locally produced cereals.

Table 4: Energy element in child food in formulations (Mixers) of teff flour and other cereals g \ 100 kcal.

Mixers	Protein content	Fat content	Carb. content	Energy Element Concentration Rate
	concentration	concentration	concentration	concentration
F1	3.2	1.5	16.7	7.13
F2	3.2	2.2	16.6	7.33
F3	3.3	3.5	14.5	7.1
F4	3.6	2.4	16.2	7.4
F5	4.4	2.1	17	7.83
F6	2.2	1.1	13	5.43
Mean	3.32	2.13	15.67	7.04
St. d	0.71	0.83	1.58	0.83

Table 4. The nutritional content of baby food gram per 100 kcal for Taff, Lentils, Rice, Wheat, White corn and Sweat potatoes give the numbering 1, 2, 3, 4, 5 and 6 respectively. Also**,** Table 4. Shows the content of energy elements in child food formulations of Teff and other cereals per 100 kcal, also indicates the minimum and maximum limits for energy elements per 100kcal**,** according to the specifications of the codex committee [15].

Table 5: Mean scores of sensory evaluation of porridge prepared from samples formulated as tested by trained panelists.

	Taste	Appearance	Smell	Mouth feel	Consistency	General acceptability
F1	2.40^{c}	3.30^{c}	3.35^{c}	2.85^{c}	2.90^{d}	2.85^{d}
F2	3.60^{b}	3.85_{b}	3.80^{b}	3.60^{b}	3.20^{c}	2.10^{c}
F3	4.35^{a}	4.35^{a}	4.00^{a}	4.05^{a}	3.40^{b}	4.20^{b}
F4	4.00^{a}	4.40^{a}	3.95^{a}	4.05^{a}	4.20^{a}	4.35^{a}

Means bearing different superscripts on the same column are significantly different ($p < 0.05$). F1-4 are the complementary nutritional formulation names as detailed in **Table 1**.

The results of sensory evaluation by trained and are presented in **Tables 5**. The data shows average likeness of the formulated complementary foods with respect smell, consistency**,** appearance, mouth feel and general acceptability. Mean scores ranges of attributes evaluated were: taste (2.40 to 4.00), appearance (3.30 to 4.40), smell (3.35 to 3.95), mouth feel (2.85 to 4.05), consistency (2.90 to 4.20) and general acceptability (2.85 to 4.35) for trained panelists).

Table 6: Evaluation of preference for complementary nutritional formulations for target age groups**,** April 2021**.**

Age (month)	N.	Child's intake Mix. F1	Child's intake Mix. F2	Child's intake Mix.F3	Child's intake Mix. F4
4-11	200	3.83 ± 0.06^{a}	3.44 ± 0.08^{a}	16.22 ± 1.26a	6.12 ± 0.36a
12-23	100	4.03 ± 0.07^{ab}	3.80 ± 0.13^{ab}	22.26 ± 1.52a	6.88 ± 0.35a
24-35	100	4.01 ± 0.12^{ab}	3.72 ± 0.13^{ab}	44.92 ± 4.78b	7.90 ± 0.52ab
36-47	50	4.41 ± 0.12^{bc}	3.98 ± 0.14^{ab}	69.31 ± 8.21c	10.29 ± 1.03c
48-59	50	4.66 ± 0.12^{c}	4.30 ± 0.22^{b}	73.75 ± 15.93c	9.67 ± 2.13c
Total	500	4.02 ± 0.03	3.67 ± 0.06	29.26 ± 1.57	7.11 ± 0.23

[a-c] Any two means in the same column not followed by the same letter are significantly different.

Table 6 shows the mean value of Child's intake formula 1, Child's intake formula 2, Child's intake formula 3 and Child's intake formula 4 by the age category. Mean value of age group 6-11 months based on response by the mother/caregivers' was statistically significantly different from 48-59 months and 36-47 months age group.

Taste is an important parameter when evaluating sensory attribute of food. The product might be appealing and having high energy density but without good taste, such a product is likely to be unacceptable. With exception of formulation F3 significantly higher ($P < 0.05$) than the rest of tested formulations in terms of their taste.

Appearance is important attribute in food choice and acceptance. Outcome of sensory evaluation indicated that some samples were similar in appearance while others differed significantly. With exception of formulation F3 and significantly higher ($P > 0.05$) than the rest of tested recipes.

Smell is an integral part of taste and general acceptance of the food before it is put in the mouth. It is therefore an important parameter when testing acceptability of formulated foods. Results of sensory evaluation indicated that smell of certain samples varied significantly ($P < 0.05$) from others. Generally, F3 and F4 scored significantly higher (4.00 to 3.95) ($P < 0.05$) in terms of smell than the rest of formulations by trained panelists.

The results revealed that no significant differences ($P > 0.05$) were observed by trained panelist between F3 and F4 in terms of mouth feel and both were highly liked as indicated by higher scores of 4.05.

Further, this study aimed at assessing maternal preferences for consistency of formulated complementary foods. In present study, trained panelists showed significantly higher preference ($P < 0.05$) for formulation F4 (mean score 4.2) compared to the rest of other formulated complementary foods.

Generally, formulated complementary foods F3 and F4 were highly acceptable by both groups of panelist with mean scores (4.35, 4.20) and (4.33, 4.28) for trained.

4. Discussion

For **Table 2**. There is previous study [15], they produced baby foods based on legumes and grains (Durra, Durra, Peanuts, and Soybeans) in different proportions where all mixtures were characterized by moisture ratios ranging from 4 to 9%, also there is another study [15], they produced baby food from grains and legumes (wheat, rice, pork, and lentils), the moisture content of the mixtures was characterized by rates ranging from 5-7%.

A study conducted [16] aiming to produce baby food from rice, wheat, corn, lentils and spectrum, the mixtures were characterized by moisture levels ranging between 6.6-7.7%, and this humidity is higher than the humidity. Our study indicated that the most appropriate moisture for baby food mainly produced from grains and legumes is no more than 10% in order to maintain good product quality and these results are similar with [17], as high humidity leads to exposure product to microbial harm.

When back to the Yemeni standard and the International Codex Alimentarius Commission on baby foods produced from grains and legumes, the results in the above table show similar in the proportions of protein in (Mix F3 and Mix F4), and this result is the according to the Yemeni standard specifications No. 22/2003 [14]. which suggested that the percentage of protein in baby foods produced from grains and legumes should not be less than 15% on the basis of dry weight, in addition to protein content in Mix F1 is less as specified by the Indian Standard for Baby Food produced from grains, which is 14%, and this is indicated by [18]. In general, the results of our current study on protein ratios in all food mixtures referred to in **Table 2** showed that Mix F4 is the best nutritious for children from the seventh month, according to what was determined by the Yemeni standard and the Codex Alimentarius International Committee [14, 15] **(Table 2).**

The back to the Yemeni Standard No 22/2003 [14] suggested that the proportion of total ash in baby foods produced from grains and legumes should not increase than 3.5%.

In a previous study [16], where they prepared the nutritional mixture for the overall growth of children (dried wheat, nuts, rice), mixtures are characterized by levels ranging from 3.30 - 2.16 g / 100 g, as it is higher than our study and the reason is the difference in the agricultural environment**.** Another study [16], they prepared biscuits with soybean flour. The materials were purchased for a counter which are soybeans, evaporated milk, granulated sugar, salt, and baking powder. The ash content was 1.39 - 2.25 mg / 100 g higher than our study. The reason is the high ash content of the product could be a source of minerals.

In general, the results of our current study on ash ratios in Table 2 was according to the Yemeni standard specifications No. 22/2003 [14], and the Codex Alimentarius International Committee [15].

Eating a lot of fats is linked to various health disorders such as obesity, cancer, high blood cholesterol, and coronary heart disease [7]. It is this awareness that has prompted consumers to have the amount of fats in their diet [8] for this reason, despite the importance played by fats, a variety of ingredients such as fat substitutes are used to take advantage of the unique properties [9].

Previous study [19] where they produced complementary baby food using (bulgur, lentils, chickpeas) in different proportions, where the mixture is characterized by a fat content ranging between 1.83 - 3.38 mg / 100 grams, as it is a lower percentage than our study, and this is attributed to this Reduction to effective removal of husks after drying of sprouted beans.

Another study [20] produced nutritional foods for weaning Acceptable and affordable for low-income residents (corn, beans, peanuts and soybeans) as the mixture features a ratio between 6.16 8.61g / 100g as it is a higher percentage than our study and the reason is that the product was visibly greasy when it was launched.

The fiber is effective in lowering total cholesterol in the blood and promoting satiety. Insoluble fiber helps treat constipation and reduce the risk of colon cancer [9].

A researcher study [21] when they produced baby biscuits using soybean flour mixing with other baking ingredients such as baking powder, salt, fat, sugar and milk 1.04-0.47%, the fiber content was lower compared to the fiber in our diet, ranging between 1.04 - 0.47 mg / 100 grams.

Another study [11], in which baby biscuits were produced using (wheat flour and other baking ingredients such as butter, sugar powder, sodium bicarbonate, whole milk powder, salt, and orange peel powder) where the fiber content was higher compared to The fiber in our diet ranged from 9.5-10.9 mg / 100g.

Carbohydrates in complementary foods are beneficial for infants, as the sugars produced can transfer them sweeter to supplemental porridge, thus enabling the baby to eat more food per meal and reduce the addition of table sugar. Preparation of porridge, but sugar may be added [8]. A previous study [22], they produced baby biscuits using (white wheat flour and other ingredients such as sugar, salt, fat, sodium bicarbonate and whole milk), the carbohydrate content was lower compared to the carbohydrates present in our diet, ranging between 70.08 69.56 mg / 100 g. Another study [22] in which baby biscuits were produced using (wheat flour and other baking ingredients such as butter, powdered sugar, sodium bicarbonate, whole milk powder, salt, and orange peel powder) where the carbohydrate content was lower. Compared to carbohydrates. In our diet this was between (61.61-71.23) mg / 100 grams **(Table 2).**

Table 3. showed mineral salts content (calcium, Potassium, Phosphor, Sodium, Iron, Zink and copper) under study in baby food mixes in each (mg 100 grams) and (for any formulations) and comparing them to the maximum levels of these elements according to the specifications of the Codex Alimentarius Commission [15], which notes that most of the mineral salts content values in each 100 kcal were within the minimum and maximum limits except for the phosphorus component, which increased slightly in all mixtures Except the mixture number three where he remained within the limits required**.**

Table 3. showed the calcium content in baby food mixes per mg/ 100 grams, where the results for calcium range from (50 - 140) mg / 100 g. Table No. 3 shows that the (Mix F3) was the highest in the proportion of calcium. When referring to the Yemeni standard specifications No. 22/2003 [14], that determined the percentage of calcium in infant and child foods manufactured mainly from grains and pulses 250 mg per 100 grams of the product on the basis of dry weight and this percentage does not match the results of our research and this may be due to the difference of the materials introduced in the mixtures, but there were Previous study [22] Whereas, they produced breakfast cereals using (wheat flour, mango and soy flour) in different proportions, as the two mixtures are characterized by a percentage of calcium ranging between 350 - 540 mg / 100 g, and these results were higher than our results in **Table 3.** Another study [20] where they prepared complementary baby food from corn, cowpea, peeled peanuts, soybeans and soybean oil in varying proportions, as they were characterized by a calcium ratio ranging between 69-33 mg / 100 g, which is less than the percentage of calcium in our mixtures.

The potassium is very necessary in blood clotting and muscle contraction [12] Sodium with potassium is useful for maintaining body fluids [17], it also has the role of regulating osmotic pressure in cells and aiding in the synthesis of protein and glycogen in the body [13]. **Table 3** shows the iron content in baby food mixes per 100 grams, where the results for potassium range from (311 - 484) mg / 100 g. It is noticed that the mixture F1 was the best in terms of potassium. Previous study [23] where they prepared complementary baby foods from bulgur, lentils and chickpeas in varying proportions, as they were characterized by a potassium ratio ranging between 590-610 mg / 100 g, which is higher than the percentage of potassium in our mixtures and this may be due to differences in the genetic characteristics of the varieties and plant maturity, another study [23] Whereas, they produced breakfast cereals using (wheat flour, mango, milk, soy flour) in different proportions, as the mixtures are characterized by potassium (450 - 510) mg / 100 gm, which are close to our study. When referring to the Yemeni Standard Specifications No. 22/2003 [14], which determined the percentage of potassium, in infant and child foods, mainly made from grains and pulses, **400 -**1000 mg per 100 g of the product on the basis of dry weight, and this percentage is identical with the results of our research.

Table 3 shows the phosphorous content in baby food mixes per 100 grams, where the results range from (25-100) mg / 100 grams, the mixtures were the highest in the proportion of phosphorus. Previous study [17]**,** where they prepared complementary baby foods from corn, cowpeas, peeled peanuts, soybeans and soybean oil in varying proportions, as they were characterized by phosphorus ratio ranging between 353 - 410 mg / 100 g, which is less than the percentage of phosphorus in our mixtures, another study [24] where they prepared complementary baby foods from bulgur, lentils and chickpeas in varying proportions as they were distinguished by phosphorus ranging from 252 to 366 mg / 100 g, which is less than the percentage of phosphorus in our mixtures. When referring to the Yemeni Standard Specifications No. 22/2003, which determined the percentage of phosphorus in infant and child foods that are mainly manufactured from grains and pulses, as a minimum of 125 mg per 100 grams of the product on the basis of dry weight, and this percentage is identical with the results of our research.

The sodium has a role in regulating osmotic pressure in cells, transferring nerve cells and muscle contraction, and also has a role in helping the absorption of some fluids such as vitamins and glucose through the intestinal wall [19]. **Table 3** shows the sodium content in baby food mixes per 100 grams, where the sodium results range from (180-252) mg / 100 grams.

Previous study [20] whereas, they produced breakfast cereals using (wheat flour, mango, milk, soy flour) in different proportions, as the mixes are characterized by a ratio of Sodium (100-120) mg / 100g, which is less than the percentage of sodium in our mixtures. When referring to Yemeni Standard Specifications No. 22/2003[14], which determined the percentage of sodium in infant and child foods that are mainly made from grains and pulses, 100 mg for the ready-to-eat product, and 300 mg for the non-ready-to-eat product (maximum), and this percentage is identical with the results of our study.

The iron is important in the formation of hemoglobin, oxygen and electron transport in the human body [25]. Iron deficiency is the most common cause of anemia [26] and it is the most common nutritional problem among humans, threatening more than 60% of women and children in most non-industrialized countries, and more than half These suffer from pernicious anemia [27]. **Table 3** Shows the iron content in baby food mixes per 100 grams, where the results were 0.45 mg / 100 grams (minimum). In another study [28, 29], whereas, they produced breakfast cereals using (wheat flour, mango, milk, soy flour) and the iron content in both mixtures was 7.5 mg, which is highest than of our study. When referring to Yemeni Standard Specifications no. 22/2003 [14], which determined the percentage of iron in infant and child foods that are mainly made from grains and pulses, as a minimum of 10 mg per 100 grams of the product on the basis of dry weight, and this percentage is not identical with the results of our research.

The zinc is an essential mineral and a component of a variety of different enzymes in which it participates in catalytic, structural and regulatory roles [20] This tiny mineral acts as a stimulant for many enzyme systems in humans [16] Zinc makes up about 33 parts per million of adult body weight and is essential for many Enzymes involved in a number of physiological functions, such as protein synthesis and energy metabolism [3]. Low zinc levels in children have been associated with retarded growth, poor appetite and poor taste [18] The World Health Organization recommended an allowable limit of zinc in foods such as 60 mg / kg [17]. Ministry of Health standard specifications that the zinc content of children's biscuits should be 2.5-3 mg / 100 g [11]. **Table 3** shows the zinc content in baby food mixes per 100 grams, where the results for zinc range from (0.5 - 1.5 mg / 100 grams. In a previous study [30]**,** as they produced baby biscuits using wheat flour and other baking ingredients such as margarine, skimmed milk powder, sugar and yolks, the zinc content was lower compared to the zinc in our diet, as it ranged between 0.075 - 0.109 mg / 100 grams. When referring to the international specifications for baby food, we noted that the mixtures are identical to what was determined by the international standards (Codex Committee on Nutrition and Foods for Special Dietary (USES), which determined the proportion of zinc in baby food (9%) [31].

The copper is important in the synthesis of collagen and phospholipids, which are necessary for the formation of melanin surrounding nerve fibers, and it also acts as a system activator (Tyrosinase, Ascorbic acid oxidayoin, such as enzyme, it is also an essential component of some metallic enzymes and is required in hemoglobin synthesis and in metabolic growth promoters [22]. **Table 3** Shows the copper content in baby food mixes per 100 grams, where the copper results range from (129 -25) µg / 100 grams. Earlier study [30], where they prepared complementary baby food from corn, cowpeas, peeled peanuts, soybeans and soybean oil in varying proportions, as they were distinguished by the copper ratio between 0.001 - 0.49 µg / 100 g**,** which is less than the percentage of copper in our mixtures **(Table 3)**.

Babies Need Supplementary food, also breast milk, especially at the age of six months and more because of the increased nutritional requirements to Carbohydrates, Protein, fat and vitamins for the growing Body **(Table 4).**

Table 4 shows that all the mixtures under study were characterized by a decrease in the level of fats, except for mixture F3, which decreased slightly in its fat content and slightly in its protein content according to rates of the rates of codex alimentarius commission for the minimum and the upper limit of the two components, but it matched in its carbohydrate content, and this means that this mixture needs to a slight modification of its components to suit the content of its components with the specifications of codex alimentarius commission , which can be adopted as an international body , whose specifications are taken from all countries of the world. We would like to point out that the CODEX STAN 074-1981, REV. 1-2006 for baby food made from grains and fortified with any source of protein has recommended that the protein content does not exceed 5.5g/100kcal, and this means that all the mixtures under study are in conformity with the CODEX standard in the case of this element. The same specification recommended that the fat content not exceed 4.5g/100kcal .it is clear from the results that all the mixtures under study have conformed to the specification, since the fat content in all of their mixtures did not exceed 4.5g/100 kilocalories, also carbohydrate content not exceed 17g per 100 kilocalories **(Table4).**

Fig. 2: F1: formulation 1; F2: Formulation 2; F3: formulation 3; F4: Formulation 4. Formulation 1 = Teff (35%) , lentils (15%), sweet potatoes (20%), white corn (10%), wheat (15%) and rice (5%), Formulation 2= Teff (50%) , lentils (5%), sweet potatoes (20%), white corn (5%), wheat (10%) and rice (10%), Formulation 3= Teff (15%) , lentils (6.5%), sweet potatoes (18.5%), white corn (10%), wheat (30%) and rice (20%) and Formulation 4= Teff (30%) , lentils (10%), sweet potatoes (10%), white corn (25%), wheat (13%) and rice (12%).

Table 5. Showed sensory characteristics of formulated complementary foods were only assessed by a single approach that is commonly employed in developing countries; the sensory evaluation or consumer studies with mothers. This approach has some limitation as its implementation in the field is often complicated because of mothers' illiteracy and the difficulty for them to understand some sensory testing methods [32]. In addition, it only gives information on the mothers 'preferences but none on the true preferences of children or on the gruel acceptability by children. Consumer studies with mothers can be used to know their acceptance to give a kind of gruel to their child but the validity of this approach is limited by the reliability of their answers [33]. A second approach that involves measuring food intake is often difficult and expensive as the consumption surveys have to be carried out in free living conditions following standardized protocols which require numerous surveyors and laboratory facilities for some necessary analysis [34, 35]. Consequently, the present study and most of the studies carried out in developing countries still adopt the first approach with fairly good results **(Table 5).**

Table 6. shows that as the age increases, the amount of food formula consumed by the child also increases. Similar trend was observed for the child's intake formula 4 with the Child's intake formula 1. These results were similar to the results of [34]. With respect to the mothers' response based on their perception about the products, where they rated the products where they rated the products as having high quality have in terms of appearance, smell, taste, texture and overall acceptability.

In present study, the more preference recorded for the F3 and F4 samples are probably contributed by the panelist innate behavior with common local products of %), Formulation 3= Teff (15%), lentils (6.5%), sweet potatoes (18.5%), white corn (10%), wheat (30%) and rice (20%) and Formulation 4= Teff (30%), lentils (10%), sweet potatoes (10%), white corn (25%), wheat (13%) and rice (12%) **(Figure 2)**. A similar result was reported by [36], which stated that the most preferred porridge was the whitest than processed by the use of sorghum grains.

5. Conclusion

The complementary food formulations in the present study were based on locally available low-cost food materials commonly consumed in Yemen. The mixing ratios constituted formulations that had enough energy and protein to meet the energy and protein requirements for children as recommended for complementary foods. Therefore, the formulated food mixes are potentially suitable for use as complementary foods in Yemen.

Sensory evaluation done on all the recipes revealed that F3 and F4 samples have high acceptance. The fact that these recipes are inexpensive, locally available and nutritious makes them potentially effective in solving some of the nutrition problems facing infants and children in Yemen and other countries. Further studies to explore the possibility of improving locally formulated complementary foods for other age groups are needed to help combat the rampant malnutrition in Yemen and other developing countries.

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References

[1] N. Q. Al-Hajj, A. H. A. Ahmed, T. Naji, M. Alabyadh, and S. A. Al-Hashedi, “Assessment Of The Nutritional Status Of Under-Five Years (6–59 Months) Children Attending Friendship Teaching Hospital, Aden Province, Yemen”, *World J. Pharm. Res.* vol. 10, no. 5, pp. 47-59, Feb. 2021. DOI: 10.20959/wjpr20215-20291

[2] G. Kathryn, Dewey, H. Kenneth, Brown, “Update on Technical Issues Concerning Complementary Feeding of Young Children in Developing Countries and Implications for Intervention Programs”, *Food Nutr Bull*, vol. 24 no.1, pp. 5-28, Jan. 2003. doi.org/10.1177/156482650302400102

[3] I. Egli, “Traditional Food Processing Methods to Increase Mineral Bioavailability from Cereal and Legume Based Weaning Foods”, PhD diss., *ETH Zurich*, 2001. https://doi.org/10.3929/ethz-a-004132286

[4] M. Omwamba, and S. M. Mahungu, "Development of a protein-rich ready-to-eat extruded snack from a composite blend of rice, sorghum and soybean flour”, *Food Sci. Nutr*., Vol.5 No.14, pp. 1309-1317, Aug. 2014. DOI: 10.4236/fns.2014.514142

[5] M.H. Helland*, T. Wicklund and J.A. Narvhus, "Effect of germination time on alpha-amylase production and viscosity of maize porridge", Food Res. Int., vol. 35, no. 2-3, pp. 315-321, Aug. 2002. DOI: 10.1016/S0963-9969(01)00202-2

[6] C. U. Inyang, U. M. .Zakari , "Effect of Germination and Fermentation of Pearl Millet on Proximate, Chemical and Sensory Properties of Instant “Fura- A Nigerian Cereal Food”, *Pak. J. Nutr*., vol. 7 no.1, pp. 9-12, 2008. DOI: 10.3923/pjn.2008.9.12

[7] H. Martin, H. Laswai and K. Kulwa, "Nutrient content and acceptability of soybean based complementary food”, *African J. Food, Agric. Nutr. Dev.* Vol. 10, no. 1, pp. 2040-2049, Jan. 2010. DOI: 10.4314/ajfand.v10i1.51482

[8] D. Shiriki, M. A. Michael and D .I. Gernah, "Nutritional evaluation of complementary food formulations from maize, soybean and peanut fortified with Moringa oleifera leaf powder", *Food Sci. Nutr*., vol. 6, no. 5, pp. 494, April 2015. DOI: 10.4236/fns.2015.65051

[9] M. E. Mohamed, B.H. Amro, A.S. Mashier and E. B. Elfadil, "Effect of Processing Followed by Fermentation on Antinutritional Factors Content of Pearl Millet (Pennisetum glaucum L.) Cultivars", *Pak. J. Nutr*., vol. 6, no. 5, pp. 463-467, 2007. DOI: 10.3923/pjn.2007.463.467

[10] G. H. Pelto, E. Levitt, L. Thairu, "Improving feeding practices: current patterns, common constraints, and the design of interventions", *Food Nutr Bull*, vol. 24, no. 1, pp. 24-82, 2003. DOI: 10.1177/156482650302400104

[11] M.R. Shadan, K. Waghray, and F. Khoushabi, "Formulation, preparation and evaluation of low-cost extrude products based on cereals and pulses", *Food Sci. Nutr*, Vol. 5 no.14, July 2014. DOI: 10.4236/fns.2014.514145

[12] D.J. Barker, "Maternal nutrition, fetal nutrition, and disease in later life", *Nutrition*, vol. 13 no. 9, pp. 807-813, Feb. 1997. DOI: 10.1016/S0899-9007(97)00193-7

[13] AOAC (2020). Association of official analytical Chemists, Official Methods of Analysis, seventeenth ed., II. AOAC International, Washington, DC, USA. Method No: 920..39, 920.87, 923.03, 925.10, 962.09, 974.24, 985.35 and 965.17. https://doi.org/10.1093/jaoac/50.5.997

[14] المواصفة القياسية اليمنية رقم ٢٠٠٣/٢٢ أغذية الأطفال والرضع المصنعة اساسا من الحبوب والبقول. الهيئة اليمنية للمواصفات والمقاييس وضبط الجودة. الجمهورية اليمنية. صنعاء http://ysmo.org/stands.php?page=5 .

[15] J. R. MacLean C. William, P. Van Dael, R. Clemens, J. Davies, E. Underwood, L. O’Risky and J. Schrijver,."Upper levels of nutrients in infant formulas: comparison of analytical data with the revised Codex infant formula standard", *J. Food Compos. Anal*., vol. 23, no. 1 pp. 44-53, 2010. DOI: 10.1016/j.jfca.2009.07.008

[16] World Health Organization (2001). Global strategy for infant and young child feeding. World Health Organization, 1-5. DOI: https://apps.who.int/iris/handle/10665/78801

[17] S. O. Ijarotimi, and O. O. Keshinro, "Determination of nutrient composition and protein quality of potential complementary foods formulated from the combination of fermented popcorn, African locust and bambara groundnut seed flour", *Pol. J. Food Nutr. Sci*., vol. 63, no. 3, pp. 155-166, 2013. DOI: https://doi.org/10.2478/v10222-012-0079-z

[18] T. G. Yohannes, Makokha, A. O. Okoth, J. K. and M. W. Tenagashaw, "Developing and nutritional quality evaluation of complementary diets produced from selected cereals and legumes cultivated in

Gondar province, Ethiopia", *Current Research in Nutrition and Food Science Journal*, Vol. 8, no.1, pp. 291-302, April 2020. **DOI:** 10.12944/CRNFSJ.8.1.27

[19] K.H. Brown, S. E. Wuehler and J. M. Peerson,. "The importance of zinc in human nutrition and estimation of the global prevalence of zinc deficiency", *Food Nutr Bull.* vol. 22, no.2, pp. 54-67. Jan. 2001..DOI: https://doi.org/10.1177/156482650102200201

[20] O. Bruyeron, M. Denizeau, J. Berger and S. Trèche, "Marketing complementary foods and supplements in Burkina Faso, Madagascar, and Vietnam: Lessons learned from the Nutridev program", *Food Nutr Bull.* Vol. 31, no.2, pp. 54-67. Mar. 2010. DOI: 10.1177/15648265100312S208

[21] C. Vidal-Valverde, J. Frias C. Sotomayor C. Diaz-Pollan M. Fernandez and G. Urbano G. "Nutrients and antinutritional factors in faba beans as affected by processing", *Z. Lebensm. Unters. Forsch. A*, vol. 207, no.2, pp. 140–145. Aug. 1998. DOI: 10.1007/s002170050308

[22] N.M. Nnam, "Comparison of the protein nutritional value of food blends based on sorghum, bambara groundnut and sweet potatoes", *Int. J. Food Sci. Nutr.*, vol. 52, no.1, pp. 25-29, Jul. 2009. DOI: 10.1080/09637480020027246

[23] A.F. Walker, F. Pavitt "Energy density of Third World weaning foods", *Nutr Bull*., vol. 14, no. 2, pp. 88-101, May 1989. DOI: 10.1111/j.1467-3010.1989.tb00315.x

[24] R.S. Gibson, K. B. Bailey, M. Gibbs and E. L. Ferguson, "A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability", *Food Nutr. Bull*., vol. 31, no. 2, pp. 134–46, Jun. 2010. DOI: 10.1177/15648265100312S206

[25] P.J. Van Jaarsveld M. Faber, S.A. Tanumihardjo P. Nestel, C.J. Lombard and A.J.S. Benade, "β-Carotene–rich orangefleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative- dose-response test", *Am J Clin Nutr;* vol. 81, no. 5, pp. 1080–1087, May 2005. DOI: 10.1093/ajcn/81.5.1080

[26] J.W. Low, M. Arimond, N. Osman, B. Cunguara, F. Zano and D. Tschirley, "A food-based approach introducing orangefleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique ", *J Nutr*, vol. 137, no.5, pp. 1320–1327, May 2007. DOI: 10.1093/jn/137.5.1320

[27] A.H. Mahmoud, and A. M. E. Anany, "Nutritional and sensory evaluation of a complementary food formulated from rice, faba beans, sweet potato flour, and peanut oil", *Food Nutr Bull.*, vol. 35, no. 4, pp. 403-413, Dec. 2014. DOI:10.1177/156482651403500402

[28] Van Hal MV. "Quality of sweet potato flour during processing and storage", Food Rev Int; vol. 2, no. 16, pp. :1–37, Sep. 2000. DOI: 10.1081/FRI-100100280

[29] I. Hoxha, N. Macedonia, R. Deliu and F. Industry, "The Impact of Flour from White Bean (Phaseolus vulgaris) on Rheological, Qualitative and Nutritional Properties of the Bread", *OALib Journal*, vol. 7, no. 2, pp.1, Feb. 2020. DOI: 10.4236/oalib.1106059

[30] Mensha,Y.,Wilmot ,R.D.,Philips,J &R.R,Eitenmiller (2003). "Formulation and evaluation of cereal / legumes based weaning food supplements", Plant Foods Hum. Nutr., vol., 58, no. 3, pp. 1-14, Sep. 2003. DOI:10.1023/B:QUAL.0000040324.04977.DD

[31] Y. Hofvander, and B.A. Underwood, "Nutrition and Health: Processed Supplementary Foods for Older Infants and Young Children, with Special Reference to Developing Countries" . Food Nutr. Bull, vol. 9, no.1, pp. 1-6, Mar. 1987. DOI: doi.org/10.1177/156482658700900105

[32] E.O. Keyata, Y.B. Tola, G. Bultosa, and S.F. Forsido "Optimization of nutritional and sensory qualities of complementary foods prepared from sorghum, soybean, karkade and premix in Benishangul-Gumuz region, Ethiopia", *Heliyon*, vol.7, no.9, pp. e07955. doi.org/10.1016/j.heliyon.2021.e07955

[33] J.R. Stokes, M. W. Boehm and S.K. Baier "Oral processing, texture and mouth feel: from rheology to tribology and beyond", *Curr. Opin. Colloid Interface Sci*, vol. 14, no. 4, pp. 349–359, Aug. 2013. DoI: 1016/j.cocis.2013.04.010

[34] C. O. Syeunda, J. O. Anyango, A. K. Faraj, "Effect of compositing precooked cowpea with improved malted finger millet on antinutrients content and sensory attributes of complementary porridge", *Food Nutr. Sci*,. vol. 10 no. 9, pp. 1157-1178. Sep. 2019. DOI: 10.4236/fns.2019.109084

[35] Y. A. Tadesse, M. A. Ibrahim, F. S. Forsido and T. H. Duguma, "Nutritional and sensory quality of complementary foods developed from bulla, pumpkin and germinated amaranth flours", *Nutr. Food Sci*., vol. 6, no. 3, pp. 418–431, Sep. 2018. DOI: 10.1108/NFS-01-2018-0001

[36] S. Tizazu, K. Urga, C. Abuye and N. Retta "Improvement of energy and nutrient density of sorghum based complementary foods using germination", *Afr. J. Food Nutr. Sci*, vol. 10, no. 8, pp. 2927–2942, Aug. 2010. DOI: 10.4314/ajfand.v10i8.60875

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مقالة بحثية

تركيبات مثالية من الأغذية المحلية لتحقيق الكفاية الغذائية لأطفال اليمن الذين تتراوح أعمارهم بين 6 إلى 23 شهرًا

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المُلخّص

يعاني ما يقرب من 4.5 مليون طفل تحت سن الخامسة في اليمن من سوء التغذية الحاد بسبب ارتفاع اسعار أغذية الأطفال المستوردة، لذلك هناك حاجة ملحة إلى تحضير وتصنيع أغذية محلية ذات جودة مغذية ورخيصة الثمن ومتاحة محليا لإتاحة الفرصة للأسر اليمنية لإطعام أطفالهم وتحقيق الصحة العامة.

تم تحضير وتصنيع ستة خلطات غذائية (F1-F6) بالاعتماد على دقيق التيف والأرز والذرة البيضاء والقمح والبطاطا الحلوة والعدس، وتم تحميص التكوينات (الخلاطات) لتحسين القيمة الغذائية والسمة الحسية للوصفات المعدة.

تم تقييم جميع الخلطات الغذائية من أجل قبولها من قبل كل من أعضاء اللجنة المدربين باستخدام مقياس المتعة من خمس نقاط. على الرغم من أن العديد من التركيبات كانت مقبولة من الناحية الحسية وتسجيل درجات متشابهة إلى حد كبير. بشكل عام التركيبات الخلطة الغذائية (F3) التيف (15%)، العدس (6.5%)، البطاطا الحلوة (18.5%)، الذرة البيضاء (10%)، القمح (30%) والأرز (20%). والخلطة الغذائية (F4) التيف (30%) والعدس (10%) والبطاطا الحلوة (10%) والذرة البيضاء (25%) والقمح (13%) والأرز (12%) كانت مقبولة للغاية من قبل أعضاء اللجنة وحصلت على درجات أعلى معنويًا (P <0.05) من الأطعمة التكميلية المصنعة الأخرى، وتراوح متوسط درجاتهم بين 4.2 إلى 4.35 من حيث التذوق.

الكلمات المفتاحية: التقييم الحسي، الخلطات الغذائية، أطفال اليمن، أغذية محلية.

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