Production of local complementary foods from sprouted legumes and wheat germ

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Abstract

Therefore, this study was conducted in the College of Agriculture / Tikrit University 2024-2025. The study aimed to use the embryo of the adab, sprouted mung bean, and sprouted cowpea, with three mixtures, as a material that supports it in producing children and studying the effect of adding to the current formula and acids, in addition to noting that there is a percentage of here, carbohydrates, ash, and calories in the sprouted mung bean They reached 3.54, 19.11,, 65.567, 3.03, 3.75 and 383.51% respectively. Regarding the estimation of the fatty acids of the product, we note that wheat germ for all acids gave the highest percentage amounting to (143.14 - 817.38 - 197.74 - 41.3 - 8.89 - 496.61).

Key words: Complementary foods, sprouted legumes, wheat germ.

1. Introduction

Complementary foods play a pivotal role in reducing malnutrition rates globally, especially among vulnerable groups such as children and the elderly. Accordingly, this study aims to develop complementary foods using wheat germ and sprouted legumes, focusing on evaluating the nutritional properties of these products and analyzing their sensory quality to ensure their acceptance by consumers. This study is expected to contribute to providing innovative food alternatives that support individual health and meet the aspirations of modern food markets.[1]

Baby foods prepared from sprouted and fermented grains and legumes are among the most popular foods, as the sprouting and fermentation processes increase the efficiency of grains and legumes and reduce some anti-nutritional substances such as trypsin inhibitor, phytic acid, tannins, gas-causing agents, and others [2].

2.Materials and Methods

2.1 Sample sources

2.1.1 Wheat germ

Obtained from Tikrit Silo, local seed type

2.1.2 Sprouted beans

Obtained from the local markets of Tikrit city

2.1.3 Sprouted mung bean

Obtained from the local markets of Tikrit city

2.1.4 vanilla

It was obtained from the local markets of Tikrit city.

2.1.5 Nonfat dry Milk

It was obtained from the local markets of Tikrit city and bears the brand Sunny baby Regilait. Origin: France.

2.2 Preparing mixtures

The mixtures were prepared according to the following table (1):

Table 1Mixture preparation

Mixture number	Mixture components	Mixing ratios/g
1	**Wheat germ + sprouted mung beans + milk**	**3.192+12.57+14.248**
2	**Wheat germ + sprouted beans + milk**	**3.174+12.91+14.762**
3	**Wheat germ + sprouted mung beans + sprouted beans + milk**	**3.151+9.205+8.45+9.621**

2.3 Soaking and germination

The beans and mung beans were cleaned, then the mung beans were soaked in water for 12 hours. The beans were soaked in water for 24 hours at a ratio of 1:3 (weight:volume), with the soaking water replaced twice. They were then placed in plastic trays containing pieces of cloth and placed in an incubator at a temperature of 31°C. Away from light for 72 hours, while the beans were germinated for 24 hours, and the grains were moistened every 6 hours per day. After germination, the grains were washed and boiled in a pressure cooker by adding a water ratio of 4:1 (weight: volume) for 20 minutes, based on what was .

This was the best percentage of water addition and the best time required for cooking. Then, it was dried in the oven at a temperature of 70°C for 10-12 hours until the weight stabilized and complete drying was achieved. After that, the grains were roasted on a low heat with continuous stirring for 3-5 minutes in order to get rid of the remaining germination smell and give a flavor. Then, they were ground using a Sanyo home grinder and the flour was passed through a sieve It was then packed in glass jars and stored at room temperature until use.

2.4 How to prepare the mixtures

Three food mixtures were prepared with a protein percentage of no less than 20%. The first mixture contained sprouted legumes and wheat germ, the second mixture contained sprouted beans and wheat germ, and the third mixture contained sprouted legumes, sprouted beans, wheat germ, and milk at a rate of 11% for each. After that, vanilla was added to all mixtures as shown in Table (1).

2.5 Chemical evaluation of prepared food mixtures

2.5.1 determination of fat percentage

The percentage of fat was estimated using the Soxhlet apparatus, using petroleum ether solvent at 40-60°C. 5 g of the sample was weighed, placed, and well-wrapped in filter paper. It was placed in the designated part of the apparatus. 250 ml of petroleum ether was added to the apparatus. The temperature of the apparatus was set at 50°C for 6 hours. Then, the solvent was evaporated from the sample using a rotary evaporator. After that, the weight of the oil was calculated as follows:

$$\text{Oil ratio\%}=\frac{\text{Oil weight}}{\text{Oil Sample ratioratio}}\ 100$$

2.5.2 Protein determination

The percentage of nitrogen was estimated by the Micro-Kjeldahl method for the mixtures, by weighing 0.2 g of the sample, then placing each sample in a digestion tube, and adding to each tube 5 ml of 95% concentrated sulfuric acid and two drops of 70% perchloric acid ($HClO_4$), then gradually heating the mixture until the solution became clear. Then it was distilled

after adding 10 ml of sodium hydroxide (10 molar) and the liberated ammonia was collected in a 50 ml flask containing 25 ml of 2% boric acid with two drops of Bromocresol Green indicator and Methyl red indicator, then it was sieved with 0.05 molar hydrochloric acid HCL and the amount of acid was calculated by changing the color of the indicator from green to red .

2.5.3 Ash determination

The ash percentage was estimated by weighing 2 g of the studied samples and placing them in a pre-dried ceramic bowl with a fixed weight. Then, they were dried using an electric oven at a temperature of 100 °C to get rid of moisture. After that, the bowl was transferred to the incineration oven at a temperature of 600 °C until the weight was fixed and a white or gray powder was obtained. The ash percentage was calculated.

2.5.4 Total carbohydrates

It was estimated by calculating the difference between the components as stated by (4) using the following equation:

Total carbohydrates = moisture + protein + fat + ash – 100

2.5.5 Calories

It was estimated according to the method followed by (3), who found that the calorific value (kcal/100g of substance) = (P x 4) + (F x 9) + (C x 4).

P = percentage of protein

F = percentage of fat

C = percentage of carbohydrates

2.6 Saturated fatty acid analysis

Fatty acids were estimated according to the Agelint method of where a weight of (2g) was taken from the sample after grinding it and mixed with (6 ml) of n.Hexan and placed in a shaking water bath for an hour at a temperature of 60°C. After that, the sample was dried for the purpose of concentration on a rotary device and a size of 2 microns was taken from the sample and 2 ml of KOH (4M) was added. The mixture was placed in the water bath again at a temperature of 50°C for half an hour Then leave it to reach the laboratory temperature and add 1 ml of distilled water, then put it on the shaker for one minute and add 1 ml of n.Hexan, then clarify the mixture on the centrifuge at the highest rotation for 10 minutes. The supernatant is taken using a 0.4 syringe filter and incubated in the (GC) device according to the statistical program that works according to the following steps:

Column/DN 10

Flow Rate/1 ml/min

Temperature/150 c

Pressure / 4 psi

3.Results and discussion

3.1Chemical evaluation of prepared food mixtures

Table (2) shows that the percentage of protein, fat, carbohydrates, ash and calories in wheat germ amounted to 3.03, 20.981, 69.1, 5.319, 1.57 and 408.195% respectively, and was close to what he found when analysing wheat germ for the aforementioned components. In close relation to what was mentioned by [4] when analyzing wheat germ, protein, fats, carbohydrates and ash, 19.90%, 4.27%, 70.63% and 2.1% respectively. The reason is attributed to the activity of the phytase enzyme which breaks down phytate and releases mineral elements, as [5] it was concluded that the ash percentage in wheat germ reached 1.8%.

The percentage of protein, fat, carbohydrates, ash and calories in sprouted beans reached 7.55, 21.881, 63.665, 3.43,

3.474 and 373.45% respectively compared to uncooked beans, which gave percentages of 0.67, 17.23, 65.69, 3.78, 2.63 and 365.7% respectively. In its analysis, the percentage of protein, fat, carbohydrates, ash and calories reached 22.15%, 4.86%, 66.49%, 2.68% and 3.70% respectively. When analysing its components, the percentages of moisture, protein, fat, fibre and ash were 9.8%, 20.50%, 3.8%, 3.90% and 2.90% respectively.

We also note that the percentage of protein, fat, carbohydrates, ash and calories in sprouted mung beans was 4.16, 23.493, 65.567, 3.03, 3.75 and 383.51% respectively, compared to the unsprouted mung beans, which gave percentages of 8.85, 19.11, 63.65, 3.54, 4.85 and 362. The results were close to what was mentioned by [7], as its results were 22.15% protein, 4.86% fat, 66.49% carbohydrates and 2.68% ash. [3] found in its analysis that the percentage of protein, fat, carbohydrates, ash and calories reached 22.15%, 4.86%, 66.49%, 2.68% and 3.70% respectively.

While sprouted beans gave the highest percentage of calories, reaching 412.13, compared to wheat germ, which gave the lowest percentage, reaching 378.59, and close to what is found in Super Amin food, which ranged between 373 and 418 kilocalories/100 grams of mixture, and it was found [8] and less than what was obtained [9], which ranged between 517.83 and 530.12 kilocalories/100 grams of mixture. The reason for this increase is due to the addition of a high amount of fat, which leads to an increase in the amount of calories in therapeutic baby foods prepared by Al-Mayahy.

The percentage of protein, fat, carbohydrates, ash and calories in infant formula were respectively 4.34, 16.52, 55.13, 18.63, 5.38 and 454.27%. The milk percentages were within the range specified by [10] the U.S. Dairy Export Council (USDEC), which confirmed that the moisture percentage should be 2.00-4.50%, protein 15.50-27.00%, fat 26.00-28.50%, carbohydrates 36.00-38.50% and ash 5.50-6.50%.

Table 2 Chemical estimation of prepared food mixtures

Basic Ingredients	Humidity%	Protein (%)	Carbohydrates (%)	Fat(%)	Ash(%)	Calories (kcal/100g)
Wheat Germ	**3.03 def**	**20.98 bc**	**69.10 a**	**5.31 d**	**1.57 e**	**408.19 c**
Sprouted Black-eyed Beans	**7.55 b**	**21.88 ab**	**63.66 cd**	**3.47 ef**	**3.43 cd**	**373.45 cd**
Sprouted Mung Beans	**4.16 cde**	**23.49 a**	**65.56 bc**	**3.03 f**	**3.75 cd**	**383.51 cd**
First Mix	**2.125 f**	**21.49 b**	**de60.73**	**11.95 bc**	**3.67 cd**	**ab510.86**
Second Mix	**def3.03**	**20.85 bc**	**e59.08**	**13.75 ab**	**5.05 a**	**540.43 a**
Third Mix	**ef2.74**	**21.43 b**	**e58.22**	**13.75 ab**	**3.85 cd**	**539.61 a**
Black-eyed	**10.67 a**	**de17.23**	**65.69 bc**	**de3.78**	**2.63 d**	**365.70 d**

Beans						
Mung Beans	**ab 8.85**	**19.11 cd**	**cd63.65**	**def3.54**	**4.85 b**	**362.90 d**
Infant Milk	**4.34 cde**	**16.52 e**	**55.13 f**	**18.63 a**	**5.38 a**	**454.27 b**
Cerelac	**cde3.58**	**15.24 e**	**cd63.88**	**ab14.45**	**d2.85**	**446.53 bc**

As for the mixtures, the first mixture was superior in the protein percentage, reaching 21.49%, compared to the second mixture, which gave the lowest percentage, reaching 20.85%. These results agreed with many researchers,. (17) when they germinated some legume grains. (18) also found an increase in the protein percentage in non-germinated wheat (19) for fava bean seeds, in which the protein percentage rose to 27.2% in the germinated seeds, after it was 25.6% in the non-germinated seeds.

3.2 Estimation of the percentage of unsaturated fatty acids It can be Table (3) shows that wheat germ for all acids gave the lowest percentage of (143.14 - 817.38 - 197.74 - 41.3 - 8.89 - 496.61). This superiority may be the result of the interactions of amino acids with other proteins in the sample, as these acids may be linked to proteins differently in germinated mung beans, which affects their presence.

Regarding the mixtures, the second mixture outperformed all acids with a percentage of (41.68 - 141.75 - 60.19 - 34.67 - 3.41 - 155.64). Compared to the third mixture, which gave the lowest percentage of all acids with percentages of (33.77 - 103.89 - 51.19 - 20.34 - 2.76 - 115.87), respectively. This is consistent with what was mentioned by [6].

Table (3) Unsaturated fatty acids

Palmitic	**Palmitoleic**	**Stearic**	**Oleic**	**Linoleic**	**Linolenic**	**Acids / Materials**
mg	**mg**	**mg**	**mg**	**mg**	**mg**	
496.61	**8.89**	**41.3**	**197.74**	**817.38**	**143.14**	**Wheat Germ**
64.2	**5.62**	**21.95**	**42.53**	**124.03**	**78.25**	**Sprouted mung beans**
72.28	**3.19**	**24.07**	**36.53**	**108.3**	**56.98**	**Unsprouted mung beans**
77.33	**6.45**	**26.12**	**54.81**	**156.42**	**89.78**	**Sprouted beans**
86.05	**4.23**	**31.04**	**47.16**	**133.85**	**63.24**	**Unsprouted beans**
121.45	**2.93**	**25.53**	**57.82**	**133.90**	**37.95**	**First mix**
155.64	**3.41**	**34.67**	**60.19**	**141.75**	**41.68**	**Second mix**
115.87	**2.76**	**20.34**	**51.19**	**103.89**	**33.77**	**Third mix**
213.13	**12.92**	**89.25**	**242.59**	**324.13**	**31.61**	**Comparison mix**

3.3 Estimation of Mineral Elements

Table (3-3) shows that the percentages of iron, potassium, calcium, zinc, and phosphorus in wheat germ were 1.687975%, 109.040081%, 4.835821%, 1.7177%, and 116.000%, respectively. This was close to what [9].concluded when analyzing wheat germ for the aforementioned components.

We also note that the percentage of iron, potassium, calcium, zinc and phosphorus in sprouted beans reached 2.167675%, 123.27497%, 17.23881%, 0.471325% and 40.02047% respectively. The results of this study agreed with what was mentioned by[12].who mentioned that some minerals .

increase during the germination process and agreed with [11].who found that there is an increase in some minerals: such as iron, magnesium, sodium and potassium and a decrease in the calcium content.

The percentage of iron, potassium, calcium, zinc and phosphorus in the sprouted mung beans reached 0.712611%, 133.534579%, 13.28647%, 0.393414% and 29.250195% respectively. These results were close to what [6].reached when she analyzed one of the local lentil varieties, as the percentage of calcium, iron and phosphorus reached respectively

Table (3-3) Contents of basic materials and selected mixtures

Po4 (ppm)	Zn (ppm)	Ca (ppm)	K (ppm)	Fe (ppm)	Metals / Materials
116.000	1.7177	4.835821	109.040081	1.687975	Wheat Germ
40.020407	0.471325	17.23881	123.27497	2.167675	Sprouted mung beans
29.250195	0.393414	13.28647	133.534579	0.712611	Sprouted beans
202.0443	2.9419	23.5912	323.2133	3.3150	First mix
223.4219	3.1441	29.3939	320.1130	5.3050	Second mix
173.5270	2.4189	31.7479	331.2188	4.2311	Third mix

As for the nutritional mixtures, the second mixture gave the highest percentage of iron, zinc and phosphorus, with percentages ranging respectively (5.3050, 3.1441, 223.4219) compared to the other mixtures that gave the lowest percentage of these elements. The reason for this is The ingredients of this mixture are a rich source of important minerals, including iron, zinc, and other important nutrients that contribute to meeting daily needs through eating foods to which the ingredients of this mixture are added in varying proportions. [13].

3.4 Estimating the vitamin content of the materials and mixtures used in the study

Table (3-4) shows that wheat germ provided percentages of the following vitamins (Vitamin B2, Vitamin B1, Vitamin C, Vitamin K, Vitamin E, Vitamin D3, and Vitamin A) at levels of (3.383, 0.117, 0.051, 0.183, 0.555, 0.0488, and 0.657), respectively.

From Table (3-4) it is clear that sprouted beans gave percentages of the following vitamins (Vitamin B2 - Vitamin B1 - Vitamin C - Vitamin K - Vitamin E - Vitamin D3 - Vitamin A) with percentages reaching (5.222 - 0.168 - 0.063 - 0.131 - 0.902 - 0.058 - 0.742 -) respectively.

From Table (3-4) it is clear that the sprouted mung beans gave percentages of the following vitamins (Vitamin B2 Vitamin B1 - Vitamin C Vitamin K - Vitamin E - Vitamin D3 - Vitamin A) with percentages reaching (7.020- 0.244- 0.076- 1.223- 1.409- 0.314- 1.580) respectively.

. [14]. also pointed out that sprouted mung beans have higher antioxidant content than wheat and bean seeds, which enhances their nutritional value. Sprouting also increases the availability of water-soluble vitamins, such as folic acid and niacin, making them more easily accessible to the body compared to unsprouted forms [14].

Regarding the mixtures, the first mixture was superior in the following vitamins (B2, B1, C, K, E) with percentages reaching (0.48, 0.365, 1.7, 2.56, 180) respectively, and the second mixture for vitamin D3 with a percentage reaching 373.33 and vitamin A with a percentage reaching 588.3 compared to the second mixture for the following vitamins (B2, B1, C, K, E, A) which gave the lowest percentage reaching (0.39, 0.147, 1.6, 44, 1.98, 428.46) respectively, and the first mixture for vitamin D3 with a percentage reaching 368

Table (3-4) Vitamins Estimation

Vitamin A	Vitamin D3	Vitamin E	Vitamin K	Vitamin C	Vitamin B1	Vitamin B2	Vitamins / Materials
mg	mg	mg	mg	mg	mg	mg	
0.657	0.0488	0.555	0.183	0.051	0.117	3.383	Wheat Germ
0.742	0.058	0.902	0.131	0.063	0.168	5.222	Sprouted mung beans
1.580	0.314	1.409	1.223	0.076	0.244	7.020	Sprouted beans
488.15	368	2.56	180	1.7	0.365	0.48	First mix
428.46	373.33	1.98	44	1.6	0.174	0.39	Second mix
588.3	370	2.55	133	1.7	0.4	0.47	Third

							mix

3.5 Sensory Evaluation

Table (3-5) shows the average sensory evaluation scores for the prepared nutritional blends. It is clear that there were no significant differences between the therapeutic blends (first and third). The third blend yielded the highest consistency and aroma, with scores of 32.857 and 8.28, respectively. The first blend yielded taste and general acceptability scores of 30.625 and 77.125, respectively. The second blend yielded the highest color score, with scores of 8.

Table (3-5) Sensory evaluation scores for food mixture

General acceptance100	The smell 10	the color 10	The taste 40	Texture 40	Food mixtures%
77.125	7.5	6.875	30.625	32.125	First mix
73.985	6.875	8	28.36	30.75	Second mix
76.875	8.28	6	29.75	32.857	Third mix

3.6 Microbial tests

3.6.1 Total count of aerobic bacteria

Table (3-6) shows the logarithm of the total number of aerobic bacteria, colony forming unit/g, for the selected therapeutic food mixtures and standard F-100 food during a storage period of (28) days at a refrigerator temperature of (4-5) °C.

It is noted that the logarithm of the total number of bacteria in the selected food mixtures decreased during the storage period, as the first, second and third mixtures did not contain 2.31, 2.13 and 3.23 colony forming units/g at the beginning of storage until the third week, and they contained 2.31, 2.13 and 3.23 colony forming units/g, and at the end of storage they became 2.54, 2.35 and 3.45 colony forming units/g. This may be due to the addition of sugar, in addition to the fact that the manufacturing method used in preparing the food is manual and the possibility of contamination occurring at that time. In addition to room temperature being a factor that helps microbial growth, the results of the study agree with what [8].indicated, that adding sugar, skimmed milk and other additives to baby food prepared from grains and legumes is an important source of microbial contamination. The results of the increase in the total number of aerobic bacteria in baby food stored at room temperature agree with Mohsen [9].in their study of the microbial content of infant food mixtures prepared from cereals.

Table (3-6) Logarithm of the total number of aerobic bacteria, colony forming unit/g, for the selected therapeutic food mixtures and standard F-100 food during a storage period of (28) days at a temperature of (4-5) °C.

28	21	14	7	0	days / Mixtures
2.54	2.31	ND	ND	ND	First mix
2.35	2.13	ND	ND	ND	Second mix
3.42	3.23	ND	ND	ND	Third mix

4.Conclusions

1-The results of this study demonstrated the potential of using sprouted and unsprouted bean seeds, sprouted and unsprouted mung beans, and wheat germ in preparing foods for infants with gluten sensitivity, aged six months and older, as a nutritional supplement to breast milk or formula.

2- The sprouting process was shown to have an effect in reducing some types of antinutrients and improving nutritional value.

3- The germination process led to an increase in protein, carbohydrates and calories, in addition to an increase in iron and phosphorus.

5.Recommendations

1. Use other types of grains and legumes to prepare baby food blends that meet their basic needs.

2. Use other methods to prepare baby food to improve its nutritional value and eliminate harmful nutrients.

3. Use other ingredients to create different and delicious flavors.

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