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Evaluation of Nutritional Value for Several Types of Vegetarian Kofta

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ABSTRACT

Global warming is the main factor causing climate change. The worldwide food system is responsible for about 25% of greenhouse gases (GHG) emissions, with livestock production accounting for the majority of these emissions. So, the goal of the current study was to use legumes (particularly lentil, chickpea, and white bean) as a replace for animal protein in the preparation of a nutritious vegetarian kofta. The physical, chemical, sensory properties and amino acids composition were evaluated. The results showed a significant difference between treatments for WHC, cooking yield as the replacement of beef meat with the investigated legume decreased the cooking loss and increased cooking yield for vegetarian sample compared to control. The amount of phytic acid, tannin, and trypsin inhibitor significantly decreased throughout the cooking of brown lentil, chickpea, and white bean. Also, the crude fibre content of cooked vegetarian kofta significantly enhanced its nutritional value. Additionally, consumers appeared to prefer the vegetarian kofta that was evaluated in terms of sensory evaluation. Finally, because of its high nutritional value and affordable price, it is advised to prepare nutritious vegetarian kofta that can be used to make commercial items and be used to feed students in schools, university cities, vegetarians, and Christian brothers. By substituting lentil, chickpea, and white bean for beef meat, these three legumes reduced the final coasts by 79.189, 68.103, and 72.854%, respectively.

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INTRODUCTION

Approximately 25–30% of the world's greenhouse gas (GHG) emissions are attributed to agriculture and food production, with the livestock industry accounting for an estimated 14.5% of these emissions globally. **(Goodland and Anhang, 2009and IPCC, 2014).** Because there is a high correlation between economic growth and meat consumption, according to **Fiala (2008)** and **Wellesley *et al.* (2015)** indicate that by 2050, worldwide meat consumption will have increased by 75–80%. In general, animal-based goods have more intense GHG emissions than food products made from plants.

Consumption of meat increases the risk of chronic diseases, especially cardiovascular disease, stroke and several types of cancer, which are referred to as “non-communicable diseases” **(Walker *et al.*, 2005)**. It has been demonstrated that adding even a modest amount of meat to the diets of low-income households can improve their nutritional status and decrease signs of severe malnutrition, such as childhood stunting **(Rivera *et al.*, 2003)**. Moreover, globally there is a shortage of protein supplies from natural resources. Also, **Joshi *et al.* (2016)** concluded that production of meat will be unsustainable by 2050 at current and projected consumption rates. Because they share some visual and chemical features (such as texture, flavour, and appearance) with some meat products, meat replacements (also known as "meat analogues" or "meat-free alternatives") are a source option to satisfy the need for red meat **(Joshi and Kumar, 2016)**. Due in large part to greater knowledge of the alleged environmental and health benefits of reducing meat consumption, the market for meat substitutes has experienced rapid growth in recent years **(MINTEL, 2014)**.

According to **Joo *et al.* (2021)**, meat substitutes are primarily vegetable-centric dietary items made with proteins from pulses, cereal, microbes, and other fillers and flavoring mediators. Additionally, meat substitutes made from texturized pulses are an excellent alternative to animal proteins since they have similar health benefits as animal proteins, including higher protein, low fat, and agents that promote pleasant taste and texture. On the other hand, these products are perfectly suitable and can be used to feed Christians Brothers who keep away from meat products during their fasting period. Plant proteins are a vital part of meat substitutes, especially legumes, which play an essential role in human nutrition as their protein is considered a poor meat in many regions of the world particularly in the developing world as reported by **Riascos *et al.* (2010). Malav *et al.* (2015)** showed that there has been an exponential increase in legume-based meat products especially in terms of texture, quality and other functional properties and the main reason could be economic values. Pulses are promising for increasing environmental sustainability by replacing meat consumption as concluded by **Melendrez-Ruiz *et al.* (2019).**

Pulses are generally dried seeds from leguminous crops belonging to the family *Leguminosae* (with the exception of plants utilized for oil extraction like soybean) and are next to cereal as a source for food especially in developing countries as reported by **Asif *et al.* (2013).** Pulses consumption is rising worldwide due to its great nutritional content, as it is low in calories and has glycemic index (GI). Furthermore, their proteins are easily available as observed by **Mansoor and Yusuf (2002)** *in vitro* digestibility which scored between (69-90%). In addition, the fat has a polyunsaturated structure. Moreover, it contains folic acid, vitamins of group B, mineral substances (potassium, phosphorus, calcium and iron and phenolic compounds **(Sahin, 2016)**. Other benefits of legumes include their low cost and long shelf life, pulses such as lentils and chickpeas are seen as staple foods and they are nutritious and improve health.

Lentil (*Lens Culinaris Medik*) a plant in the *leguminoceae* family, is one of the winter season pulse crops grown in many parts of the world as reported by **Erskine *et al.* (2011)**

which can be used as a meat substitute in vegetarian diets and is often referred to as "poor man's meat" because it is popular with people from all socioeconomic backgrounds, according to **Iqbal *et al.* (2016)**. The nutritional value for humans found in its seeds, which comprise roughly 21-31% protein, 43.4-69.9% total carbohydrate, 0.7-4.3% fat, 5.0-26% fibre, and 2.2-4.2% ash, has also demonstrated a number of health benefits as reported by **Joshi *et al*. (2017).**

One of the most popular and historically used legumes, particularly in tropical and subtropical regions, is the chickpea (*Cicer arietinum L.*). It is regarded as a functional food or nutraceutical due to its high levels of protein (21.75-24.73%), total hydrolysable carbohydrates (45-53.88%), moisture (8.08-8.69%), and ash (2.68-3.84%). In addition**, Abd EL-Rahim *et al.* (2004)** discovered that it is abundant in fibre and minerals (phosphorus, calcium, magnesium, iron, and zinc). With respect to their high protein, fibre, prebiotic, vitamin B, and chemically varied micronutrient content, dry white beans (*Phaseolus vulgaris L.*), occasionally known as common beans, have been described as a virtually perfect diet by **Geil *et al*. (1994)**. As a result, according to **Nciri *et al*. (2014)**, 50% of the grain legumes utilized as a source of human sustenance are dry beans. One of the minced meat products is meat kofta, and the meat processors are interested in it as a commercial possibility due to its appeal to all social classes in Egyptian culture. It is produced from minced beef that has been combined with binders, spices, and sauces. The meat emulsion is then manually formed into circular koftas. Since there has been a huge increase in demand for restructured beef products over the past 20 years, this procedure presents the food industry with numerous prospects. **(Resurreccion, 2004)**. Therefore, this study aimed to utilize plant-based protein sources such as brown lentil, chickpea and white bean in preparation new healthy and economic kofta rich in protein, minerals and essential amino acids as a sustainable approach for combating the environmental effects of climate change.

Materials and Methods

2. Materials

Chickpea ***(Cicer arietinum)*** seeds, white beans (***Phaseolus vulgaris***) and brown lentil_***(Lens culinaris L.)*** seeds were obtained from Legumes Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Fresh onion, garlic, parsley, corn starch, wheat flour, spices mixtures and sunflower oil were purchased from the local market at Tanta. All reagents and chemicals used in this study were analytical grades.

(a) (b) (c)

Fig. 1: Seeds of chickpea (a), white bean (b) and brown lentil (c)

Methods

Technological Methods

Preparation of raw materials: Whole brown lentil, whole chickpea and white bean seeds were soaked in enough water to make them tender, boiled in that same quantity of water until thoroughly cooked, and then all of them were ground using a kitchen machine**.**

Preparation of kofta product: Minced main materials were mixed with chopped fresh onion, chopped fresh garlic, parsley, salt and spices mixture. Four different formulations of kofta were prepared according to Egyptian general method: beef meat kofta as a control sample consists of beef meat **(T_1),** lentil kofta prepared by replacing of beef meat with soaked-boiled lentil **(T_2)**, chickpea kofta prepared by replacing of beef meat with soaked-boiled chickpea **(T_3)** and white bean kofta product prepared by replacing of beef meat with soaked-boiled white bean **(T_4)** as shown in **Table (1).** Each formula was well mixed with other ingredients, shaped as finger with approximately 10 g (with 7cm length)and placed at 4ºC for 24h before cooking. The kofta was then deep fried in pan at 180℃ for 4min. Cooked kofta were cooled then placed on a foam plate, packed inside polyethylene bags, stored at −18℃ until use.

Table (1): Formulas for the prepared kofta as (g/100g)

Ingredients	T_1	T_2	T_3	T_4
Minced beef meat	60	-	-	-
Soaked-boiled lentil seeds	-	60	-	-
Soaked-boiled chickpea seeds	-	-	60	
Soaked-boiled White Bean Seeds	-	-	-	60
Rice powder	10	10	10	10
Fresh onion	6.5	6.5	6.5	6.5
Fresh garlic	1	1	1	1
Fresh green Coriander	2.5	2.5	2.5	2.5
Mesh potato	10	10	10	10
Spices mixture	2.5	2.5	2.5	2.5
Oil	-	5.5	5.5	5.5

T_1= beef meat kofta as Control sample, T_2= lentil kofta, T_3= chickpea kofta, T_4= white bean kofta

2.2.2. Analytical Methods

2.2.2.1. Anti-nutritional factors (Phytic acid, tannins and trypsin inhibitor)

Phytic acid content was extracted and determined based on the **Gao *et al.* (2007)** methodology. The trypsin inhibitor content was measured using the **Hamerstrand *et al.* (1981)** technique. The quantitative determination of tannins was carried out in accordance with **Price *et al.* (1978)** instructions, which modified by **Osman (2004)**.

2.2.2.2. Physical properties `

a) Cooking loss and cooking yield: The difference in the mass of the prepared kofta before and after frying was used to calculate cooking loss. The measurements were made three times, and the results are reported as averages **(Niamnuy et al., 2008).**

% cooking loss = sample weight before frying – sample weight after frying/sample weight before frying × 100.

% cooking yield = 100 – % cooking loss

b) Water holding capacity (%): Water holding capacity in samples was measured according to the method described by **Soloviev (1966). Bound water % of moisture content was calculated as follows: -**

$$\frac{\boldsymbol{moisture}\,\% - \dfrac{\boldsymbol{cm^2 \times 8.4 \times 100}}{\boldsymbol{0.3 \times 1000}}}{\boldsymbol{moisture}\,\%} \times \mathbf{100}$$

Where:

Cm^2 = area resembling the W.H.C. in cm^2.

8.4 = mg free water per each / cm^2 of the W.H.C. area.

c) pH value determination:

In 100 ml of distilled water, 10 gm of material were homogenized. According to **A.O.A.C. (2010)**, the pH was determined using a pH-meter (model JENCO, 608, USA).

2.2.2.2. Chemical analysis:

a) Proximate composition: Moisture, protein, ether extract, ash and crude fiber contents were evaluated according to **A.O.A.C. (2010),** available Carbohydrate was calculated by difference.

b) Determination of minerals content

Ashing samples were digested by concentrated nitric acid. Minerals content (Ca, Mg, Na, K, Zn and Fe) were measured as described in the **A.O.A.C. (2010)** using atomic absorption spectrophotometer (Perkin Elemr Model 4100 ZL).

c) Determination of amino acids composition and protein quality

1. Amino acids composition

According to **ZWEIG (1958)**, amino acid composition was measured by acid hydrolysis using an amino acid analyzer (Beckman amino acid analyzer, Model 119 CL). In a sealed tube at 110°C for 24 hours, the dried, ground material (100 mg) was hydrolyzed with 10 ml of 6N hydrochloric acid and 0.1% mercaptoethanol. The hydrolyzed samples were filtered through Whatman No. 1 filter paper after cooling at room temperature, and the filtrate was diluted with distilled water to 25 ml in a volumetric flask. A vacuum desiccator was used to dry 5 ml of diluted filtrate while potassium hydroxide was present. The dry residue that resulted from this process was dissolved in 1 ml of sodium citrate buffer (pH 2.2) and kept at 4 °C until amino acid analysis.

2. Computation of chemical score

The chemical score is defined according to **Bhanu *et al.*, (1991)** as follows:

$$\frac{Mg\ of\ essential\ amino\ acid\ in\ 1g\ test\ protein}{Mg\ of\ essential\ amino\ acid\ in\ 1g\ reference\ protein} \times 100$$

According to **FAO/WHO/UNU (1993)**, the amino acid that shows the lowest score was taken as the first limiting amino acid.

3. Computation of protein efficiency ratio (C-PER)

C-PER was calculated using the equation suggested by **Alsmeyer *et al.* (1974)** as follows:

C-PER = - 0.468 + 0.454 (Leucine) – 0.105 (tyrosine)

4. Computation of biological value (BV)

Biological value (BV) of protein samples was calculated as described by **Farag *et al.* (1996)** following the next equation:

BV = 49.09 + 10.53 (C-PER)

Where:

BV = Biological value.

C-PER = Computed protein efficiency ratio

2.2.2.4. Sensory Evaluation:

Ten panelists from Department of Food Science and Technology, Faculty of Home Economic, Al-Azhar University evaluated the cooked kofta's sensory quality. The panellists were asked to rate the colour, taste, texture, aroma, and general acceptability. A score of 1 indicates extreme dislike, whereas a score of 10 indicates intense like. It was calculated how acceptable it was overall. The ratings of each panellist were statistically examined.

2.2.2.5. Final coast:

According to the local market prices of the components used, the total costs of the prepared kofta samples were determined in Egyptian pounds.

2.2.2.6. Statistical Analysis:

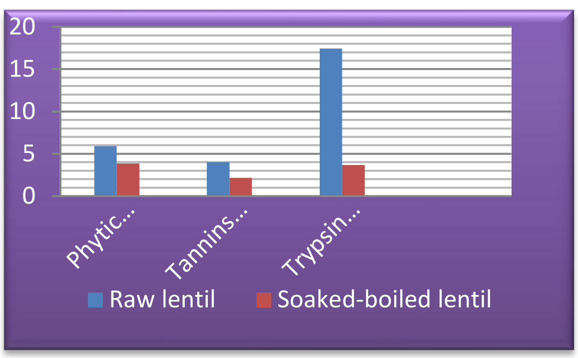
Using SPSS analysis of variances, the results were statistically assessed **(Coakes, 1997)**. The statistically significant variations between individual means were examined using Duncan's multiple range tests **(Duncan, 1995).**

Results and discussions

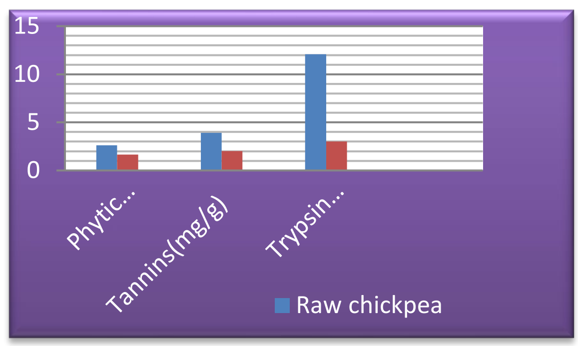
Anti-nutritional factors of studied pulses

Conforming to the results shown in **Fig. (2)**, soaked-boiled lentil, chickpea, and white bean seeds had much less phytic acid, tannins, and trypsin inhibitor than raw seeds of the same species. From the obtained data, it could be noticed that raw brown lentil, chickpea and white bean contain (5.92, 2.60 and 6.01 mg/g phytic acid which reduced with rate ranged between (34.9 and 36.9%) after soaking and boiling. The present result has been confirmed by **Bessar and El-Sayed (1997)**, who found that decreases in phytic acid during soaking may be caused by the activation of the phytase enzyme, which catalyses the conversion of phytic acid into inositol phosphate and orthophosphate as well as the migration of soluble phosphate from the legume into the steeping medium. Furthermore, the temperature of cooking completely inhibited phytase action. Also, tannin value recorded 4.01, 3.92 and 2,85 mg/g for raw lentil, chickpea and white bean, respectively which decreased by 46 and 48% after soaking and boiling. The decrease may be attributed to the heat labile and water-soluble nature of tannins as observed by **El-Akhras *et al*. (2016)** who found that Tannin value of raw chickpea decreased to 48% after soaking for 12 hours and cooking treatments.

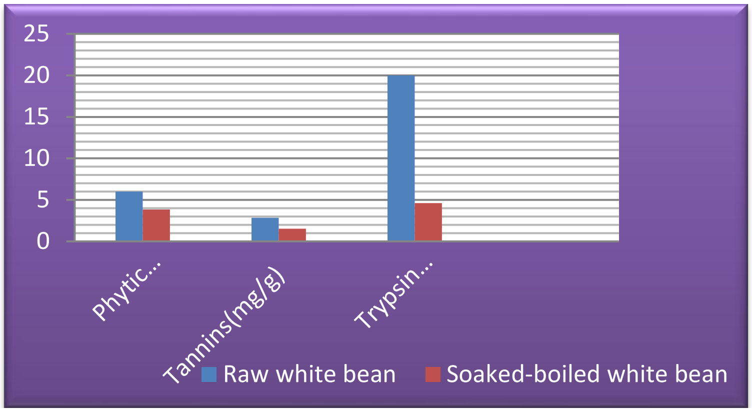
Furthermore, soaking and boiling treatment caused elimination of trypsin inhibitor content from 17.43, 12.09 and 20 TIU/mg to 3.66, 3.02 and 4.60 TIU/mg for lentil, chickpea and white bean, respectively with rates ranging between 75 and 79%. Cooking may have reduced the amount of trypsin inhibitor by causing it to denaturate and coagulate, which inhibited its function. **Hefnawy (2011)** reported the same result, suggesting that heating procedures reduced the trypsin inhibitor activity in lentil seeds. The results presented here agreed with those reported by **Khattab and Arntfield (2009)**, who found that different thermal treatments considerably reduced tannins, phytic acid, and trypsin inhibitor activity (TIA) in black gram, red kidney beans, and white kidney beans. From the previously mentioned data, it can be shown that cooking and soaking are the greatest methods for improving nutritional value and digestibility because they respectively reduce around 36.9%, 48%, and 79% of phytic acid, tannins, and trypsin inhibitors.



a) Effect of preparation method on anti-nutritional factors of brown lentil seeds



(b) Effect of preparation method on anti-nutritional factors of chickpea seeds



(c) Effect of preparation method on anti-nutritional factors of White bean seeds

Fig. (2) Effect of preparation method on anti-nutritional factors of (a) brown lentil seeds, (b) chickpea seeds and (c) white bean seeds

3.2. Proximate chemical composition of main ingredients included in the studied formulas.

The proximate chemical composition of main ingredients (beef meat, raw and cooked pulses included in the studied product) was determined and the results were listed in **Table (2).** In all studied samples except beef meat sample, it could be noticed that available carbohydrates was the predominant component followed by protein as the second major component which recorded the highest value in beef meat sample compared to other studied samples. From the tabulated data, it could be concluded that all studied pulses were affected by soaking and boiling processes as these treatments significantly decreased ash, ether extract and protein contents. These decreases might be attributed to their diffusion into soaking and boiling water.

The obtained results corresponded with those made by **Xu *et al.* (2014)** regarding the chemical composition of three Kabuli chickpeas as influenced by various cooking techniques. Meanwhile, crude fiber content for all investigation pulses was significantly increased by soaking and boiling processes, according to **Bressani (1993)**, this rise may have resulted from the protein-fiber complexes that formed after probable chemical alteration caused by the soaking and boiling of dry pulses. These results are similar to those obtained by **EL-Akhras *et al.* (2016) and Abusin *et al.* (2009)** who reported that there is a significant reduction in some parameters composition expect moisture as a result of soaking and cooking.

Table (2): Gross chemical composition of the main ingredients included in the studied formulas (%on dry weight basis)

Parameters	Samples						
	Raw beef meat	Brown Lentil		Chickpea		White bean	
		Raw	Soaked-boiled	Raw	Soaked-boiled	Raw	Soaked-boiled
Moisture	74.15±0.03[a]	11.56±0.01[g]	55.69±0.01[d]	13.57±0.05[e]	60.73±0.02[b]	12.03±0.03[f]	58.25±0.05[c]
Crude protein	77.63±0.03[a]	26.04±0.04[d]	25.85±0.05[e]	28.59±0.03[b]	27.68±0.01[c]	25.47±0.04[f]	24.53±0.01[g]
Crude ash	3.30±0.01[d,e]	4.03±0.03[b]	3.24±0.04[f]	3.83±0.01[c]	3.27±0.04[e,f]	4.49±0.03[a]	3.33±0.02[d]
Ether extract	11.03±0.04[a]	2.50±0.01[f]	2.03±0.03[g]	6.71±0.05[b]	5.61±0.01[c]	3.80±0.05d	3.15±0.06[e]
Crude fiber	0.16±0.01[f]	7.05±0.05[c]	7.86±0.023[a]	5.09±0.04[e]	7.01±0.04[c]	6.17±0.05d	7.57±0.02[b]
Available Carbohydrates	7.88±0.03[g]	60.38±0.03[c]	61.02±0.05[b]	55.78±0.04[f]	56.43±0.01[e]	60.07±0.04[d]	61.42±0.03[a]
Energy(Kcal/100 g)	441.31±0.05[a]	368.18±0.03[d]	365.75±0.01[e]	397.87±0.01[b]	386.93±0.06[c]	376.36±0.02[d]	372.15±0.02[d,e]

Each value is expressed as mean of triplicates ± standard deviations, Different letters in the same row means significantly differences ($p<0.05$).

3.3. Physical properties of the suggested kofta formulas

The effect of replacing beef meat with lentil, chickpea and white bean on physical characteristics of prepared kofta is presented in **Table (3).** Cooking loss and cooking yield as observed by **Pietrasik and Li-chan (2002)** are the most important influence factors for meat processing in predicting the behavior of products during cooking conditions due to the non-meat ingredients or other factors. The available data indicated that using pulses as a substitute for beef meat improved significantly physical properties of investigated formulas; this is due to the high fiber content in these pulses. It could be noticed that the cooking loss of the studied pulses kofta was low compared to the control sample. This may be due to the denaturation of meat protein and the loss of moisture content contributing to the shrinkage process. As a consequence of decreasing cooking loss, the cooking yield and W.H.C. were increased by replacing meat with studied pulses, this is confirmed by **Kodous *et al.* (2019)** who observed that there is an inverse relationship between W.H.C. and cooking loss. These obtained results were similar to those concluded by **Serdaroglu *et al.* (2005)** who found that cooking yield for meatballs using legume (lentil and chickpea flour) as extenders were 93.2 and 85.2%, respectively. Additionally, **Table 3** illustrates pH values in the investigated treatments. It may demonstrate that there are not actually noticeable pH differences amongst them.

Table (3): Physical properties of different cooked kofta formula

Sample	Parameters			
	Cooking loss (%)	Cooking yield	W.H.C.	pH
T_1	20.13±0.02[a]	79.87±0.02[d]	32.97±0.03[d]	6.41±0.04[a]
T_2	8.10±0.02[d]	91.88±0.05[a]	35.04±0.05[a]	6.35±0.02[a,b]
T_3	13.65±0.03[b]	86.34±0.05[c]	34.31±0.04[b]	6.30±0.05[b]
T_4	10.45±0.01[c]	89.55±0.06[b]	33.68±0.05[c]	6.32±0.03[b]

Each value is expressed as mean of triplicates ± standard deviations, Different letters in the same row means significantly differences (p<0.05).
T1= beef meat kofta as control sample, T2= Lentil kofta, T3= chickpea kofta, T4= white bean kofta

3.4. Proximate chemical composition of prepared kofta

Table (4) reveals an approximate chemical profile of the prepared kofta. According to the results, the control sample T1 had the highest levels of moisture and protein (measured on a dry weight basis). Although there was a high meat content in this sample and the water quantity decreased, nutrients became more concentrated after drying, increasing the protein content. Additionally, because fresh meat has a higher moisture content (74.15%) than the various examined pulses, the calculations performed on dry weight showed that the control sample had the highest protein level. The aforementioned results in **Table (4)** declared that substitution of white bean, chickpea, and lentil for the beef meat markedly increased the content of crude fiber significantly from 0.98 in control sample to 9.18, 8.38 and 9.03% in T2, T3 and T4 respectively. Increasing consumption of dietary fibers as is known can help lose weight and keep it off while also reducing constipation. Additionally, it may reduce cholesterol levels, diabetes and heart disease risks, as well as blood pressure. Although T1, T2 and T3 had the higher content of carbohydrates compared to T1 these blends recorded the lowest caloric value compared to T1. This is mainly due to the fact that the kofta produced from the several investigated pulses (T1, T2 and T3) had the lowest possible fat and protein content. These results are confirmed by those of **Owon *et al.* (2014).**

Table (4): Gross chemical composition (% On dry weight basis) and energy of studied formulas

Sample	Parameters						
	Moisture	Crude Protein	Crude Ash	Ether extract	Crude fiber	Available carbohydrates	Energy (Kcal/100g)
T1	41.05±0.02[a]	38.31±0.04[a]	5.78±0.01[b]	19.15±0.03[a]	0.98±0.05[a]	35.78±0.01[c]	468.71±0.01[a]
T_2	34.73±0.06[b]	15.51±0.01[c]	5.59±0.07[c]	14.93±0.03[d]	9.18±0.03[d]	54.79±0.06[a]	415.57±0.04[d]
T_3	32.39±0.01[d]	16.78±0.02[b]	5.61±0.05[c]	17.54±0.04[b]	8.38±0.05[c]	51.69±0.03[b]	431.74±0.02[b]
T_4	33.42±0.04 c	14.69±0.05[d]	5.99±0.01[a]	15.44±0.01[c]	9.03±0.03[b]	54.85±0.04[a]	417.12±0.035[c]

Each value is expressed as mean of triplicates ± standard deviations, Different letters in the same row means significantly differences ($p<0.05$).
T1= beef meat kofta as control sample, T2= Lentil kofta, T3= chickpea kofta, T4= white bean kofta

3.5. Mineral composition of prepared kofta

Minerals are essential for maintaining human health. As reported by **Nadeem *et al.* (2010)** legumes are abundant in minerals, but due to the presence of anti-nutritional substances including phytate, trypsin inhibitors, and polyphenols, their bioavailability is often low. **Table (5)** shows the macro and micro- elements composition (mg/100g) such as calcium (Ca), sodium (Na), potassium (K) and magnesium (Mg) of different kofta samples. These data revealed that all pulses kofta treatments had high macro-minerals content compared with control sample.

Also, potassium (K) recorded the highest value in all treatments followed by calcium (Ca) content which, according to **Beto (2015)**, the most prevalent cation in the body, is essential for muscular contraction and vasodilation as well as neuronal and intracellular communication. These results are in agreement with **Abd –Elhak (2021)** who indicated that Meat and meat products aren't perceived nearly as good sources of calcium. On the other hand, from tabulated data, it could be observed that control sample recorded high content of Zn and Fe compared with other studied treatments, which was confirmed by **Yang *et al.* (2016)** who noted that the majority of the zinc in the typical individual's food intake (20–40%) comes from meat and meat products.

Table (5): Mineral composition (mg/100g) of the studied kofta formulas

Sample	Macro mineral				Micro minerals	
	Ca	Na	K	Mg	Zn	Fe
T_1	68.56	55.10	223.51	39.02	47.43	10.56
T_2	114.57	70.67	323.73	73.80	37.90	6.57
T_3	135.22	105.92	298.89	105.80	36.55	7.33
T_4	164.82	80.11	300.50	103.40	38.89	7.06

T1= beef meat kofta as control sample, T2= Lentil kofta, T3= chickpea kofta, T4= white bean kofta

3.6. Amino acid composition of prepared kofta

The protein quality supported by essential amino acid content is that the better of any grain with such a point of view, amino acid composition (%) including (EAAs) of investigated kofta protein is shown in **Table (6)** along with the provisional pattern recommended by the **FAO/WHO (2007).** From the results given in **Table (6)**, it could be noticed that the lowest value of total essential amino acids was recorded in kofta prepared from chickpea with value (32.20%). Also, leucine and lysine were the most predominant among all the essential amino acids in all examined kofta samples.

On the other side, (T1) had the highest value of TNEAA compared to other examined samples. Furthermore, from results which registered in **Table (6)**, it could be observed that the major non-essential amino acid in all examined kofta samples was Glutamic acid and the highest value of it was recorded (17.80) in formula (T2). **Deutz *et al*., (1992)** reported that in critical illnesses, muscles glutamic acid is also essential for cell proliferation**.** In this study, the proportion of essential amino acid to non-essential amino acid for kofta samples showed a slight difference ranging between (0.529-0.563).

It could be observed that all essential amino acids expect methionine occurred at higher levels in all vegetarian kofta blends than those of the control sample (T1) and FAO/WHO reference protein. This indicates that, the vegetarian studied formulas have high nutritional value. In this respect, this thorough explanation of necessary amino acids demonstrates how, as suggested by **Hirdyani (2014)**, pulses can partially replace animal proteins in a vegetarian diet.

Table (6): Amino acids composition (%) of the studied formulas

Amino acids	Kofta Formulas				FAO/WHO (2007)	
	T1	T2	T3	T4	School children	Adult
Essential Amino Acids (EAA)						
Methionine	1.30	0.80	1.10	0.87	2.30	1.60
Leucine	6.40	7.20	7.00	7.30	6.00	5.90
Isoleucine	3.10	3.40	3.40	3.70	3.00	3.00
Lysine	6.40	6.50	5.60	6.60	4.80	4.50
Phenylalanine	4.40	3.70	3.90	3.80	4.10	3.80
Theronine	3.90	4.30	4.00	4.08	2.50	2.30
Histidine	3.40	3.30	3.30	3.50	1.60	1.50
Valine	4.00	4.20	3.90	4.10	2.90	3.90
TEAA	32.90	33.40	32.20	33.95	27.20	26.50
Non-Essential Amino Acids (NEAA)						
Glutamic acid	16.20	17.80	17.00	17.60	-	-
Aspartic acid	9.20	11.30	11.00	11.50	-	-
Arginine	6.50	7.60	7.40	7.50	-	-
Tyrosine	2.30	2.10	1.90	2.00	-	-
Alanine	5.10	4.20	4.20	4.40	-	-
Glycine	7.60	4.60	4.50	4.40	-	-
Serine	3.80	4.80	4.40	4.60	-	-
Proline	11.40	7.90	10.30	8.30	-	-
TNEAA	62.10	60.30	60.70	60.30	-	-
TAA	95.00	93.70	92.90	94.25	-	-
E/N ratio	0.529	0.554	0.530	0.563	-	-
Ammonia	5.10	6.30	6.90	5.75	-	-

T1= beef meat kofta as control sample, T2= Lentil kofta, T3= chickpea kofta, T4= white bean kofta

3.7. Amino acid scores (%), Computed protein efficiency ratio (C-PER) and biological value (BV) of prepared kofta

The effectiveness of a protein in satisfying a person's amino acid requirements can be predicted using amino acid scoring. According to this concept, the ability to synthesise tissue proteins has limitations unless all necessary amino acids are present at the same time and in appropriate quantities at the exact site of tissue protein synthesis **(Oluwaniyi *et al*., 2017).** The limiting amino acid is the one with the lowest percentage value, and the resultant ratio is the score. The amino acid score of suggested kofta formulas was calculated and tabulated in **Table (7)** along with the amino acid score pattern for the **FAO/WHO (2007)**.

Data showed that methionine is the first limiting amino acid in all kofta blends. As mentioned in **Table (7),** the calculated protein efficiency ratio (PER) of T1, T2, T3 and T4 recorded 2.059, 2.580, 2.510 and 2.636, respectively. This variation in PER might be attributed to the variation of essential amino acids in tested samples. From the results given in **Table (7),** it could be noticed that biological values (BV) in all samples ranged from 70.781 to 76.849%. It's documented scientifically that a protein-based food is known to have superior nutritional quality when its biological values (BV) are high (between 70 and 100%). Therefore, it could be concluded that legume protein can utilize as a cheaper source of human diet in Egyptian markets and as a good food source because it showed a good amino acid profile, (C-PER) and B.V.

Table (7): Amino acid scores (%), Computed protein efficiency ratio (C-PER) and biological value (BV) of the studied kofta formulas

EAA	Kofta formula							
	T1		T2		T3		T4	
	School children	Adult	School children	Adult	School children	Adult	School children	Adult
Methionine	56.52(1)	81.25(1)	34.78(1)	50.00(1)	47.83(1)	68.75(1)	37.83(1)	54.38(1)
Leucine	106.67	108.47	120.00	122.03	116.67	118.64	121.67	123.73
Isoleucine	103.33	103.33	113.33	113.33	113.33	113.33	123.33	123.33
Lysine	133.33	142.22	135.42	144.44	116.67	124.44	137.50	146.67
Phenylalanine	107.32	115.79	90.24	97.37	95.12	102.63	92.68	100.00
Therionine	156.00	169.56	172.00	186.96	106.00	173.91	163.20	177.39
Histidine	212.50	226.67	206.25	220.00	206.25	220.00	218.75	233.33
Valine	137.93	102.56	144.83	107.69	134.48	100.00	141.38	105.13
C-PER	2.059		2.580		2.510		2.636	
BV (%)	70.781		76.260		75.525		76.849	

FAO/WHO (2007), (1) First limiting amino acid, T1= beef meat kofta as control sample, T2= Lentil kofta, T3= chickpea kofta, T4= white bean kofta

3.8. Sensory evaluation of the prepared kofta

Results of the sensory evaluation for prepared kofta are found in **Table (8).** It confirmed that there were no significant differences in taste, odor, color and overall acceptability between the control sample (T1) and the other prepared kofta formulas. According to the means given by the panelists of fried samples textures score was varied and significantly affected by replacement beef meat with lentil, chickpea and white bean which recorded the highest score for meat kofta compared with other processed kofta. In general, it seems like the tested pulses kofta formulations were better. Legumes have demonstrated nutritional advantages and are advised for sustainable diets. They actually contain a lot of fibre and protein, as well as varying amounts of minerals. However, legumes also include bioactive substances including phytates, polyphenols, and tannins that, depending on the amount consumed, might have contradictory nutritional effects **(Georgé *et al*., 2018).**

Table (8): Sensory evaluation of the studied kofta formulas

Sample	Characteristics				
	Taste (10)	Odour (10)	Texture (10)	Color (10)	Overall acceptability (10)
T1	9.65±0.53a	9.37±0.74a	9.74±0.53a	9.50±0.53a	9.56±0.61a
T2	9.44±0.46a	9.25±0.46a	8.60±0.53b	9.47±0.83a	9.19±0.53a
T3	9.38±0.53a	9.20±0.46a	8.61±0.53b	9.20±0.75a	9.09±0.35a
T4	9.41±0.74a	9.30±0.46a	8.58±0.64b	9.35±0.71a	9.16±0.23a

Each value is expressed as mean ± standard deviations, Different liters in the same row means significantly differences ($p<0.05$).
T1= beef meat kofta as control sample, T2= Lentil kofta, T3= chickpea kofta, T4= white bean kofta

3.9. Total cost calculations:

Using lentil, chickpea, and white bean in the preparation of kofta decreased the final coasts by 79.189%, 68.103%, and 72.854% respectively, according to data obtained in **Table 9**.

Table (9): Total cost of the prepared kofta (Egyptian pound / 1Kg)

Formula ingredients	T1		T2		T3		T4	
	gm	Cost (EP)	gm	Cost (EP)	gm	Cost (EP)	gm	Cost (EP)
Beef meat	600	174	-	-	-	-	-	-
Lentil	-	-	600	24	-	-	-	-
Chickpea	-	-	-	-	600	45	-	-
White bean	-	-	-	-	-	-	600	36
Rice powder	100	3	100	3	100	3	100	3
Fresh onion	65	0.65	65	0.65	65	0.65	65	0.65
Fresh garlic	10	0.35	10	0.35	10	0.35	10	0.35
Fresh green Coriander	25	0.50	25	0.50	25	0.50	25	0.50
Mesh potato	100	1.50	100	1.50	100	1.50	100	1.50
Spices mixture+ salt	25	3.50	25	3.50	25	3.50	25	3.50
Oil	55	5.92	55	5.92	55	5.92	55	5.92
Final cost	-	189.42	-	39.42	-	60.42	-	51.42
% of reduction	-	-	-	79.189	-	68.103	-	72.854

T1= beef meat kofta as control sample, T2= Lentil kofta, T3= chickpea kofta, T4= white bean kofta, EP= Egyptian pound

Conclusions

Aforementioned could lead to the conclusion that the investigation's results sufficiently demonstrated the value of whole lentil, chickpea, and white bean ingredients in creating affordable, high-quality vegetarian kofta as at home or in the marketplace. They contain a respectable amount of protein and minerals and had acceptable sensory qualities. Furthermore, it could be observed that legume kofta as meat product substitutes hold significant potential to address the Sustainable Development Goals as zero hunger and malnutrition.

Besides having a lower carbon intensity than the majority of meat products, clean water and sanitation can also provide important nutritional benefits. Moreover, using lentil, chickpeas and white bean in preparing kofta reduced the final coasts by 79.189, 68.103 and 72.854% respectively.

Abbreviations

(EAA) = Essential Amino Acids
NEAA = Non-Essential Amino Acids
T1= beef meat kofta as control sample
T2= Lentil kofta
T3= chickpea kofta
T4= white bean kofta
EP= Egyptian pound
C-PER= Computed protein efficiency ratio
BV=biological value
W.H.C.= Water holding capacity

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