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Quality evaluation of untraditional instant stock powder from some legumes

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ABSTRACT

The consumption of stock powder as a seasoning and condiment is increasing due to its ease of use and relatively low cost. This study aimed to develop a healthy stock supplemented with legume powder and compare its nutritional components with commercially available stock powder (instant vegetable stock). Therefore, eight instant stock powder formulas were developed from soaked and soaked-steamed legumes such as lentil, sweet lupine, and chickpea. Physiochemical, phytochemical characteristics, sensory evaluation, and microbial analysis during the storage period for six months were estimated. The results of all legume stock formulas revealed that the moisture content and water activity were within permissible limits and below the growth level of microorganisms. The soaked stock formulas (F1, F3, F5, and F7) exhibited higher lightness (L*) and lower redness (a*) values compared to the soaked-steamed formulas (F2, F4, F6, and F8). Also, they have higher solubility values than those of the soaked-steamed stock formulas. The highest content of protein, ash, crude fiber, and fat was found in sweet lupine stock. Minerals content (K, Mg, Ca, Mn, Zn, and Fe) significantly ($p \leq 0.05$) increased in all instant legume stock powder formulas in contrast to commercial stock control, which increased in Na content. Furthermore, soaked-steamed stock formulas reduced the total phenols, carotenoids content, and antioxidant activity compared to the soaked stock formulas. No significant differences ($p \leq 0.05$) were observed in appearance and aroma scores between commercial stock control and all developed stock formulas. Regarding overall acceptability, commercial stock control and mixture of soaked-steamed legumes stock (F8) had the highest scores, followed by soaked-steamed chickpea (F6) and mixture of soaked legumes stock (F7). The total bacterial count as well as the mold and yeast were increased by increasing the storage period in all stock powders, but within the permitted limits. Instant legume stock powder is competitively priced and cheaper than local commercial options in the Egyptian market. So, this study can help manufacturers develop stock products by enhancing nutritional value and improving consumer acceptance.

Keywords: Stock powder, legumes, physiochemical properties, sensory evaluation, microbiological quality.

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INTRODUCTION

For many years, stock cubes and powder have been used as cooking seasonings **(Ajayi *et al.*, 2013)**. Within a variety of economic circumstances, most consumers utilize stock cubes or instant powder in appropriate amounts during food preparation. So, stock may be a suitable way to provide micronutrients to many people without significantly changing their regular diets **(Chen and Oldewage-Theron, 2004)**. According to **Korea Agro-Fisheries and Food Trade Corporation (2015)**, the seasoning market has been expanding annually, indicating the growing demands of customers. Globally, various stock products are available in the market for convenience and time-saving purposes **(Fatima, 2013 and Lee *et al.*, 2000)**. There are many types of stocks, such as dried powder, liquid, and cube forms. Stock can be frequently utilized as a flavor enhancer in instant noodles, soups, and sauces (**Ilansuriyan *et al.*, 2015 and Tian *et al.*, 2014)**.

The dried powder is stable at room temperature and resistant to oxidative spoilage due to its low moisture content; consequently, it has a longer shelf life and can be kept and stored safely. Stocks of vegetables, beef, chicken, and seafood are commercial products in markets **(Intipunya and Bhandari, 2010)**. Chicken and beef stocks are the most popular and extensively used around the world **(Kohno *et al.*, 2005)**. The powdered seasoning stock usually contains salt, any powdered protein source, and some natural and functional ingredients, such as herbs and spices, that can be easily incorporated into the powders to enhance their nutritional value and promote health benefits that help to prevent acute and chronic disorders **(Ravindran and Matia-Merino, 2009)**.

Commercially, the stock in the local market contains allergy-causing ingredients such as soybean and some unhealthy ingredients like sulfur dioxide and monosodium glutamate (MSG) **(El-Sherif and El-Hadidy, 2018)**.

Legumes are important crops in human nutrition for ensuring nutritional security and sustainability **(Pratap *et al.*, 2018)**. Leguminous is a cheap and good source of protein, starch, dietary fiber content, and minerals **(Banti and Bajo, 2020)**. Moreover, it can be used as a protein source at a relatively lower price than animal products for low-income populations. Legumes also contain bioactive compounds (phytochemicals) that may have beneficial health effects to treat or prevent several chronic health diseases including cardiovascular diseases, obesity, type 2- diabetes, inflammatory diseases, and cancer **(Clemente and Olias, 2017 and Keskin *et al.*, 2021)**. Legumes can potentially improve sensory quality, nutritional value, and techno-functional properties, so it should be recommended to incorporate them into diets **(Clemente and Jimenez- Lopez, 2020 and Foschia *et al.*, 2017)**. Lentil is regarded as a healthy food that may be used in different food applications; hence, it could be incorporated either in snacks or while preparing household, school, or hospital meals, mainly in developing countries to eliminate malnutrition, and it is used as a meat alternative in plant-based diets **(Kaale *et al.*, 2023 and Sharma *et al.*, 2022)**. Chickpea is an ancient pulse crop widely consumed because of its high nutritional value, so it can be used as a high-energy and protein source in human diets and has highly bioavailability **(Gao *et al.*, 2015 and Zhang *et al.*, 2023)**. Lupine, a sustainable non-starchy legume, holds promise as a beneficial source of plant protein **(Devkota *et al.*, 2024)**. It has unique nutrients among legumes and may have beneficial health effects when included in the diet (**Bryant *et al.*, 2022**). The addition of lupine in many food industries on a large scale, such as bakery products, meat, and dairy substitutes, can enhance their nutritional value by improving protein content (**Abreu *et al.*, 2023**).

Various pretreatment techniques including soaking, boiling, cooking, extrusion, autoclaving, and sprouting are frequently used on legumes prior to consumption. These methods are effective in legumes digestibility and nutritional profile and lower anti-nutritional factors, which are known to inhibit either digestion or absorption of nutrients in the human body **(Abbas and Ahmad, 2018 and Amoah *et al.*, 2023)**. So, the present work has been aimed to prepare a rapidly, easily, and healthy instant legume stock from soaked-steamed lentil, sweet lupine, and chickpea powders supplemented with various spices. In addition, evaluate their physiochemical, sensorial, and microbiological characteristics in comparison to commercially instant stock control.

MATERIALS AND METHODS

Materials

Legumes such as lentil (*Lens culinaris* L.), sweet lupine *(Lupinus albus* L.), and chickpea (*Cicer arietinum* L.) were used to prepare the instant stock; different spices (coriander, curcuma, paprika, onion, and garlic powders), salt, and commercial instant stock (as a control) were purchased from the local markets, Giza, Egypt. All chemicals used in this study were analytical grade and purchased from Sigma Company.

Methods

Preparation of legume powder

Each legume was cleaned separately from impurities and washed with water, then the lentil was soaked for two hours, and the sweet lupine and chickpea for 24 hours at room temperature, by changing the soaking water. After soaking, the husks were manually removed, and the legumes were milled using a grinder. The legumes were divided into two parts: the first part was soaked legumes, while the second part was pre-soaked legumes that were cooked by steaming in a covered cooking pot to produce soaked-steamed legumes. The most appropriate steaming time was about 15-25 min, at which the legumes became soft enough to be crushed by pressing between fingers. All parts were then dried with hot air flow in the oven at 50ºC until complete drying. The dried legumes were ground using an electric grinder (Moulinex®) and sieved into fine powder to pass through a sieve (250 microns), then packed into polyethylene bags and kept in a deep freezer until use.

Preparation of instant legume stock powder

Eight formulas of soaked and soaked-steamed legume powders were prepared after a preliminary experiment to identify the best percentage of addition as shown in Figure (1). Salt and a mixture of spice powders (coriander, paprika, curcuma, garlic, and onion powder) were added to the formulas as shown in Table 1. The formulas were kept in polyethylene bags and stored at room temperature for six months.

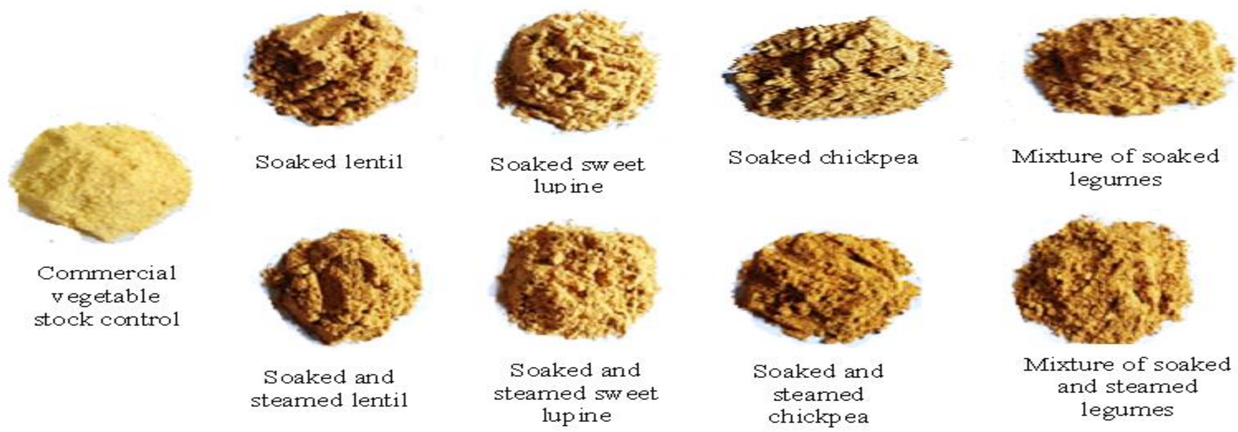


Figure 1: A photograph of the produced instant legume stock powder

Table 1: Formulas of instant legume stock (g/100g)

Ingredients	**%**	**%**	**%**	**%**
Salt	10	10	10	10
Mixture of spices	40	40	40	40
Soaked legumes (F1, F3, and F5)	50	-	-	-
Soaked-steamed legumes (F2, F4, and F6)	-	50	-	-
Mixture of soaked legumes (F7)	-	-	50	-
Mixture of soaked-steamed legumes (F8)	-	-	-	50
Total	100	100	100	100

F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5=Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes.

Physical and functional properties of instant legume stock formulas

Water activity (a_w)

Water activity (a_w) of the stock formulas was measured at the date of manufacturing (zero time) and after six months using Rotronic Hygrolab CH-8303, Switzerland, as mentioned by **Cadden (1988)**.

Color measurement

The color of stock formulas was measured according to the method outlined by **McGuire (1992)** using a hand-held Tristimulus reflectance colorimeter Minolta Chromameter (model CR-400, Konica Minolta, Japan). Color parameters were represented as L* values (100 for lightness, and zero for darkness), a* values for redness (+) to greenness (–), and b* values for yellowness (+) to blueness (–).

The Solubility

The solubility of different formulas was determined as described by **Chisenga *et al.* (2019)**. 0.5 g of dried sample was suspended in 20 mL of water in a centrifuge tube (50 mL) of known weight, heated for 30 min, swirled every 5 min, and centrifuged (8000 rpm for 20 min). The separated supernatant was collected on a pre-weighed evaporating crucible dish, oven dried (105 ºC for 12 h), and the dried residue was weighed. The solubility was expressed as a percentage of dried supernatant weight to the original sample weight and was calculated using the following equation:

$$\text{The solubility } \% = \text{Wsn (g)} - \text{Wd (g)} / \text{Ws} \times 100$$

Where: Wsn = Weight of the supernatant (g), Wd = Weight of dried residue (g), Ws = Original sample weight.

Proximate chemical analysis of instant legume stock formulas

Moisture, crude protein, ash, crude fiber, and fat content of stock formulas were determined according to **AOAC (2019)**. Total carbohydrate was calculated on a dry weight basis by the difference.

Minerals content of instant legume stock formulas

The minerals content of potassium, sodium, magnesium, calcium, manganese, zinc, and iron in stock formulas were determined using the Perkin Elmer (Model 300, USA) atomic absorption spectrophotometer, according to the method outlined in the **AOAC (2019)**.

Phytochemical characteristics of instant legume stock formulas

Total phenolic content

Total phenolic content (TPC) of stock formulas was determined using Folin–Ciocalteau reagent as described by **Kaluza *et al*. (1980).** TPC was expressed as mg of gallic acid equivalents (mg GAE/100g) on a dry weight basis.

Carotenoids content

Carotenoids content (µg/g on a dry weight basis) of stock samples was determined according to **AOAC (2019)** and calculated as follow:

$$\text{Carotenoids content } (\mu g/g) = \text{Absorbance} \times 30.1$$

DPPH radical scavenging activity

The free radical scavenging activity of stock formulas was determined using the 2.2-diphenyl-2-picryl-hydrazyl (DPPH) method according to **Fischer *et al.* (2013)**.

Antioxidant activity was calculated using the following equation:

$$\text{DPPH radical-scavenging activity (\%)} = [(A0-B1) / A0] \times 100$$

Where: A0 and B1 are the absorbance of control and sample after 30 min, respectively.

Sensory evaluation

The sensory attributes including (appearance, color, texture, flavor, taste, overall acceptability, and acceptability index) of instant legume stock formulas were evaluated compared to commercial instant vegetable stock as a control according to **El-Sherif and El-Hadidy (2018)** using the nine-point hedonic-scale scorecard by a trained 10-member panelist selected from the staff members of the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Each formula was dissolved by adding 10 g to 100 ml of boiling water at 100 °C.

Each attribute was scored based on its intensity scaled on a 9-point hedonic scale (9 = liked very extremely, 8 = liked very much, 7 = liked moderately, 6 = liked slightly, 5 = disliked, 4 = disliked slightly, 3 = disliked moderately, 2 = disliked very much, and 1 = disliked extremely).

Microbiological analysis

The microbiological analysis of stock formulas was determined according to **APHA (2001)**. Total bacterial count as well as yeast and mold were detected at the date of manufacturing (zero time) and after storage periods (three and six months) at room temperature. The number of colonies was expressed as (CFU/g).

Statistical analysis

The obtained data were subjected to one-way analysis of variance (ANOVA) and statistically analyzed for means values and standard deviations using Costat statistical software based on a probability level ($P \leq 0.05$) according to **Steel and Torrie (1980).** Duncan's multiple range test for means comparison was applied.

RESULTS AND DISCUSSION

Physical and functional properties of instant legume stock formulas

Moisture content and water activity

Moisture content is a critical parameter that affects foodstuffs' immutability, quality, shelf life, and physical properties, such as clotting in powder products. Results of the moisture content and water activity of instant stock formulas at zero time and after six months of storage are illustrated in Table (2). The moisture content of different stock formulas at zero time ranged from (5.13-6.46%) compared to 0.86% for the commercial stock control. After six months, it varied from (5.96-7.03%), while the commercial stock control was 1.64%. It could be noticed that the commercial stock control had the lowest moisture content; on the contrary, all stock legume formula values recorded the highest moisture content, but it was within the allowed limits. Dried foods have a higher quality and also permit a long shelf life when the moisture content is from 6.8% to 7.2% (**Santos *et al.,* 2018**).

Water activity (a_w) is a measure of free water in the food system and is a main factor for limiting or preventing microbial growth. It predicts food safety and quality, indicating the expected shelf life of dried food products. Results displayed that the water activity values of the stock formulas at zero time ranged from 0.335 to 0.358 compared to 0.324 for the commercial control, while after six months of storage ranged from 0.517 to 0.549 compared to 0.40 for the commercial control. It was observed that the water activity of all stock formulas was less than 0.6, which is below the level of growth of microorganisms, indicating high microbial stability; these results are in agreement with (**Tahmaz *et al.*, 2022**). The water activity should be below 0.70 to protect food components from spoilage by microorganisms **(Razak *et al.*, 2020)**. Also, **Abbas *et al.* (2009)** reported that the growth and activity of all microorganisms could be prevented at water activity levels below 0.6.

Table 2: Moisture content and water activity of instant legume stock formulas

Stock formulas	Zero time		After 6 months	
	Moisture (%)	a_w	Moisture (%)	a_w
Control	0.86±0.01^{d}	0.324±0.01^{e}	1.64± 0.04^{c}	0.400± 0.01^{d}
F1	6.46±0.42^{a}	0.354±0.06^{a}	7.03± 0.03^{a}	0.549± 0.03^{a}
F2	5.70±0.14^{b}	0.354±0.02^{a}	6.47± 0.04^{ab}	0.532± 0.08^{b}
F3	5.76±0.16^{b}	0.350±0.02^{b}	6.94± 0.06^{a}	0.522± 0.02^{bc}
F4	5.25±0.14^{c}	0.349±0.01^{b}	6.78± 0.02^{a}	0.523± 0.03^{bc}
F5	5.60±0.06^{b}	0.343±0.02^{c}	6.71± 0.04^{a}	0.524± 0.05^{bc}
F6	5.13±0.07^{c}	0.341±0.01^{c}	5.96± 0.05^{b}	0.528± 0.02^{b}
F7	6.37±0.19^{a}	0.358±0.01^{a}	7.00± 0.07^{a}	0.531± 0.03^{b}
F8	5.22±0.07^{c}	0.335±0.01^{d}	6.96± 0.16^{a}	0.517± 0.04^{c}

Control= Commercial vegetable stock, F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5= Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \leq 0.05$).

Color parameters of instant legume stock formulas

Color is an important aspect of product appeal, and it is a critical factor in a consumer's ultimate food selection. It is not only acts as a quality indicator, but it may also elicit flavor expectations. The degree of lightness, redness, and yellowness of legume stock formulas are shown in Table (3).

It was noted that the stock control had significantly the highest lightness (L*) value (88.78), and the least redness (a*) and yellowness (b*) values (- 0.26 and 25.38, respectively) compared to all legume stock formulas. Furthermore, soaked stock formulas (F1, F3, F5, and F7) were higher in L* values and lower in a* values than soaked-steamed formulas (F2, F4, F6, and F8). These results agreed with **Grewal and Jood (2006)** who stated that the higher lightness degree (L*) may be due to the soaking process leading to the removal of some pigments by dissolving in water. Whereas the lightness decreases, and the redness increases in the formulas F2, F4, F6, and F8 after steaming, it could be due to the Maillard browning reaction, which is responsible for the change in color and sensory properties of the food during heat treatments **(Lund and Ray, 2017)**. Moreover, it was observed that the degree of redness (*a**) was increased in the lentil stock formulas F2 (4.52) and F1 (4.34) compared to the other formulas, this could be a result of the lentils' anthocyanin **(Xu and Chang, 2012)**. On the other hand, sweet lupine stock formulas (F3 and F4) had significantly the highest yellowness degree, followed by chickpea stock formulas (F5 and F6); this can be attributed to their higher carotenoids content; these findings are in accordance with those reported by **(Rezaei *et al.*, 2016 and Wang *et al.*, 2008)**.

Table 3: Color characteristics of instant legume stock formulas

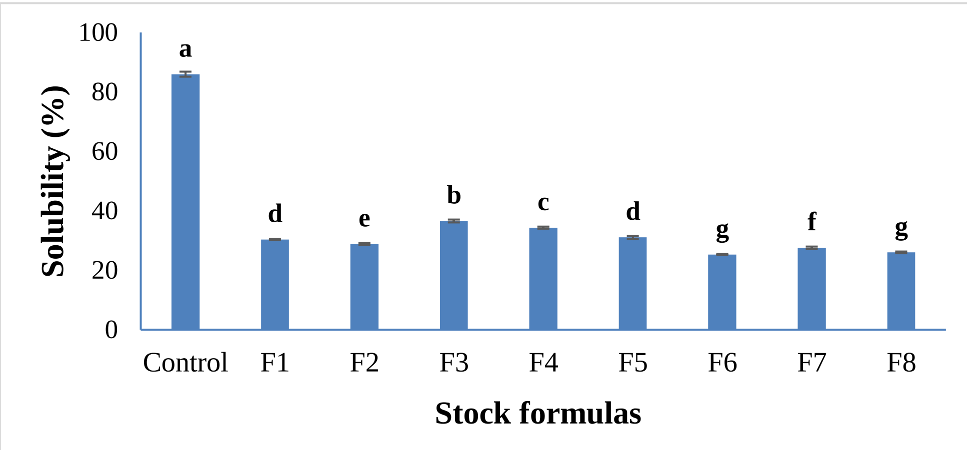
Stock formulas	*L**	*a**	*b**
Control	88.78 ± 0.43^{a}	-0.26 ± 0.12^{g}	25.38 ± 0.28^{f}
F1	79.74 ± 0.17^{d}	4.34 ± 0.11^{ab}	26.55 ± 0.43^{e}
F2	74.94 ± 0.09^{f}	4.52 ± 0.02^{a}	27.40 ± 0.05^{d}
F3	80.24 ± 0.28^{c}	2.90 ± 0.13^{e}	29.96 ± 0.43^{a}
F4	79.39 ± 0.44^{d}	3.16 ± 0.02^{d}	30.07 ± 0.24^{a}
F5	82.20 ± 0.20^{b}	2.11 ± 0.18^{f}	28.39 ± 0.06^{c}
F6	75.28 ± 0.06^{f}	4.17 ± 0.14^{b}	28.84 ± 0.32^{bc}
F7	82.23 ± 0.09^{b}	2.84 ± 0.20^{e}	28.97 ± 0.28^{bc}
F8	77.37 ± 0.12^{e}	3.81 ± 0.70^{c}	29.04 ± 0.42^{b}

Control= Commercial vegetable stock, F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5= Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \le 0.05$).

Solubility of instant legume stock formulas

The solubility of powdered components is very important to manufacturers and consumers as an indicator of consumption quality, and it is a crucial feature to judge the physical properties of any powder. The solubility of instant stock formulas prepared from different legumes is summarized in Figure (2). The results indicated a wide variation in solubility between the stock control and the prepared instant stock formulas, the stock control sample had the highest solubility value (85.96%). The solubility increases in the commercial stock likely occurred due to its high content of water-soluble glutamate salts such as monosodium glutamate, sodium di-guanylate, sodium di-inosinate, and iodine salt. These results agree with **Thuy *et al.* (2020)** who mentioned that monosodium glutamate is an odorless white crystalline solid and has high water solubility. On the other hand, the soaked-steamed chickpea stock (F6) had less solubility value (25.32%) compared to the other instant stock formulas.

A lower solubility was observed in the soaked-steamed formulas (F2, F4, F6, and F8) than in those soaked formulas (F1, F3, F5, and F7). A reduction in the water solubility may be due to heat treatment that causes the gelatinization of legume starch after steaming and dehydration before milling, which contributes to strengthening the bonds between the molecules and thus increasing the crystallization of starch **(Naiker *et al.*, 2020).** Additionally, **Huma *et al.* (2008)** reported that a partial removal of water-soluble amino acids during soaking may cause higher solubility. Notably, the solubility of the F3 and F4 formulas prepared from sweet lupine significantly increased (p≤0.05) compared to lentil and chickpea formulas.



Control= commercial vegetable stock, F1= soaked lentil, F2= soaked-steamed lentil, F3= soaked sweet lupine, F4= soaked-steamed sweet lupine, F5= soaked chickpea, F6= soaked-steamed chickpea, F7= mixture of soaked legumes, F8= mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different (P ≤ 0.05).

Figure 2: Solubility of instant legume stock formulas

Proximate chemical composition of instant legume stock formulas

The chemical constituents of the commercial stock and different legume stock samples are presented in Table (4). The results revealed a significant difference between all prepared stock formulas and the commercial stock control in terms of protein, ash, crude fiber, and fat contents. The data showed that the commercial stock control had significantly the highest ash content (78.53%) while having the lowest protein (6.78%), crude fiber (0.18%), fat (0.59%), and total carbohydrate contents (13.92%). The higher ash content in the commercial stock control may be attributed to the elevated levels of sodium chloride and other taste-enhancing ingredients, such as monosodium glutamate, commonly used as a flavor enhancer. These findings are consistent with the results reported by **Tahmaz *et al.* (2022)**, who observed that ash content of commercial stock was ranged from 58.77 to 67.27%. Among all legume stock formulas, sweet lupine stock F3 and

F4 were high in protein content (26.33% and 26.01%), ash (16.66% and 16.04%), crude fiber (5.70% and 5.45%), and fat (6.91% and 6.44 %) respectively.

Similar findings were observed by **Atudorei *et al.* (2021) and Jahreis *et al.* (2016)** who reported that lupine powder is rich in protein and most of the nutrients compared to lentil and chickpea powder, while it has a low content of carbohydrates.

It is important to note that the effect of soaking and steaming treatment resulted in lower protein, fat, ash, and crude fiber contents compared to soaking treatment only. This reduction was probably caused by heat treatment. **Bressani (1993**) showed that the decrease in fat content could result from the formation of a fat-protein complex during the soaking-cooking treatment. Moreover, **Alajaji and El-Adawy (2006)** found a decrease in fat value after thermal process.

Table 4: Proximate chemical composition of instant legume stock formulas (on dry weight basis)

Stock formulas	Protein (%)	Ash (%)	Crude fiber (%)	Fat (%)	Total carbohydrate (%)
Control	6.78±0.16^{g}	78.53±0.16^{a}	0.18±0.02^{f}	0.59±0.02^{h}	13.92 ±0.16^{g}
F1	18.12±0.12^{d}	15.92±0.12^{d}	4.86±0.08^{c}	2.99±0.06^{f}	58.11 ±0.29^{b}
F2	17.93±0.09^{d}	15.20±0.11^{g}	4.56±0.12^{de}	2.33±0.21^{g}	59.98 ±0.24^{a}
F3	26.33±0.29^{a}	16.66±0.08^{b}	5.70±0.04^{a}	6.91±0.05^{a}	44.40±0.15^{f}
F4	26.01±0.10^{a}	16.04±0.21^{c}	5.45±0.11^{b}	6.44±0.06^{b}	46.06 ±0.18^{e}
F5	15.27±0.13^{e}	15.88±0.07^{d}	4.83±0.12^{c}	6.09±0.03^{c}	57.93 ±0.34^{b}
F6	14.58±0.18^{f}	15.16±0.04^{f}	4.37±0.03^{e}	5.70±0.04^{d}	60.19±0.22^{a}
F7	20.74±0.19^{b}	15.79±0.01^{de}	4.59±0.11^{d}	5.92±0.18^{cd}	52.96 ±0.16^{d}
F8	19.61±0.28^{c}	15.59±0.06^{e}	4.42±0.04^{de}	5.25±0.12^{e}	55.13 ±0.13^{c}

Control= Commercial vegetable stock, F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5= Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \leq 0.05$).

Carbohydrate content among the different stock formulas ranged from 44.40% to 60.19%. An increase in carbohydrate content was also observed in the soaked-steamed formulas compared to the soaked formulas only. Steaming increased the total carbohydrate content, probably due to the leaching of soluble metabolites that increased the content of the insoluble polysaccharides upon thermal processing (**Andersson *et al.*, 2022)**. The above data showed that sweet lupine stock was nutritious followed by lentil stock, then chickpea stock. Hence, it can be consumed as a highly nutritious alternative to commercial stock.

Minerals content of instant legume stock formulas

Table (5) exhibits the mineral content of the instant stock formulas prepared from different legumes and commercial stock as a control. The results display that the commercial stock control had the lowest content of K, Mg, Ca, Mn, Zn, and Fe while it increased significantly in Na content compared to the other formulas; this may be due to containing monosodium glutamate, disodium guanylate and disodium inosinate as a main component of its composition.

Table 5: Minerals content of instant legume stock formulas (mg/100g on dry weight basis)

Stock formulas	Macro-elements				Micro-elements		
	Na*	K	Mg	Ca	Mn	Zn	Fe
Control	28.11±0.21[a]	50.0±0.51[i]	8.50±0.03[i]	11.11±0.2[i]	0.33±0.13[f]	0.79±0.24[e]	1.73±0.02[i]
F1	5.74±0.03[b]	837.56±0.12[a]	100.47±0.01[e]	50.0±0.12[g]	1.65±0.03[d]	2.34±0.03[bc]	8.02±0.08[a]
F2	5.68±0.01[b]	754.41±0.30[c]	92.89±0.40[f]	40.0±0.13[h]	1.01±0.03[e]	1.73±0.03[d]	7.12±0.03[b]
F3	5.31±0.04[d]	116.0±0.40[g]	151.40±0.21[a]	210.22±0.31[a]	4.50±0.05[a]	3.63±0.04[a]	3.20±0.13[g]
F4	5.28±0.02[de]	100.0±0.13[h]	139.23±0.31[b]	201.23±0.12[b]	3.95±0.05[b]	2.71±0.02[b]	2.10±0.03[h]
F5	5.52±0.01[c]	797.94±0.32[b]	75.20±0.41[g]	80.25±0.13[e]	2.11±0.03[d]	2.27±0.03[c]	5.12±0.03[c]
F6	5.44±0.02[cd]	554.50±0.41[d]	55.43±0.31[h]	75.44±0.15[f]	1.59±0.02[d]	1.76±0.03[d]	4.72±0.04[d]
F7	5.79±0.07[b]	371.20±0.13[e]	120.79±0.05[c]	120.44±0.03[c]	2.96±0.05[c]	2.55±0.05[bc]	4.12±0.05[e]
F8	5.65±0.03[bc]	294.09±0.26[f]	105.55±0.13[d]	102.54±0.16[d]	2.69±0.04[c]	1.83±0.02[d]	3.73±0.05[f]

Control= Commercial vegetable stock, F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5= Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes. Na* (g/100g on dry weight basis). Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \leq 0.05$).

Moreover, the formulas containing lentil (F1 and F2) followed by chickpea (F5 and F6), then legumes mixture (F7 and F8) were the highest in K and Fe. Our results are compatible with **Kakaei *et al.* (2024)** and **Abd El-Sattar (2018)**. It is clear from the same Table that the formulas containing sweet lupine F3 and F4 were lower in K (116 and 100 mg/100g, respectively) and higher in Mg, Ca, Mn, and Zn than those formulas containing lentil and chickpea, these results consistent with the results obtained by **Jahreis *et al.* (2016)**.

On the other hand, the soaked legume stock formulas (F1, F3, F5, and F7) had the highest content of macro and micro-elements compared to the soaked and steamed legume formulas (F2, F4, F6, and F8). The reduction in most mineral content after the steaming process might result from heat treatment **(Dhull *et al.*, 2023 and Chupeerach *et al.*, 2021)**.

Data indicated that the instant legume stock supplemented with lentil, sweet lupine, and chickpea powder significantly increased the mineral contents except for sodium compared to commercial stock control.

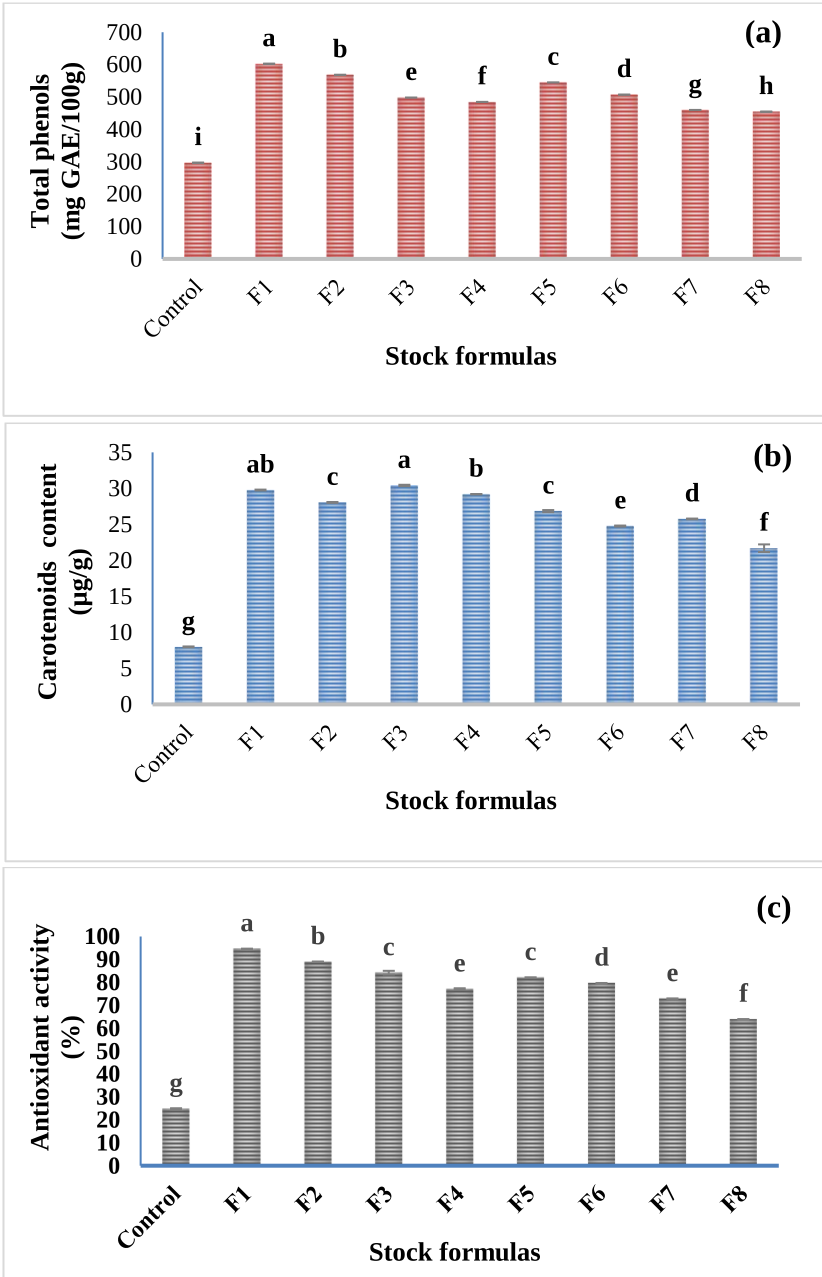
Phytochemical characteristics of instant legume stock formulas

Phytochemicals have biological properties that may be responsible for maintaining the body's health from diseases, which are categorized into some compounds such as total phenols and carotenoids **(Khan *et al.*, 2015)**. Total phenols, carotenoids content, and antioxidant activity of different stocks are explained in Fig (3).

A significant difference ($p \leq 0.05$) was observed in the phytochemicals between the prepared stock formulas from various legumes and the commercial stock control. Data showed that the lowest total phenols, carotenoids content, and antioxidant activity were found in the commercial stock control compared to the other stock formulas. Regarding the legume formulas, it was noted that the lentil formulas (F1 and F2) were higher in total phenols and antioxidant activity than the formulas of lupine and chickpea. These results are consistent with the findings of **Fratianni *et al.* (2014)** and **Siger *et al.* (2012)**.

Furthermore, soaked stock formulas (F1, F3, F5, and F7) had the highest total phenols and antioxidant activity values in comparison with soaked-steamed stock formulas (F2, F4, F6, and F8). Our results agreed with those reported by **Gu *et al.* (2021)** who found that thermal treatment during the steaming process causes a significant decrease in phenolic content, leading to a lower antioxidant activity. Carotenoids are important pigments widely distributed in nature. They act as antioxidants and colorants, which exhibit orange, yellow, red, and purple colors **(Maoka, 2020)**. The carotenoids content of stock formulas ranged from 7.99 µg/g to 30.40 µg/g.

From the above data, it could be observed that the carotenoids content increased significantly in the soaked lupine stock formula (F3) and lentil stock formula (F1), followed by (F4 and F2) which contained soaked-steamed lupine and lentil compared to the other formulas.



(a): Total phenols (b): carotenoids content and (c): Antioxidant activity of formulated stock samples. Control= commercial vegetable stock, F1= soaked lentil, F2= soaked-steamed lentil, F3= soaked sweet lupine, F4= soaked-steamed sweet lupine, F5= soaked chickpea, F6= soaked-steamed chickpea, F7= mixture of soaked legumes, F8= mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \leq 0.05$).

Figure 3: phytochemical characteristics of the instant legume stock formulas

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Sensory evaluation of instant legume stock formulas

Sensory evaluation can improve a product's sensory quality to solve consumers' problems related to food acceptance, and the final product must have an acceptable smell and taste (**Abeysinghe and Illepruma, 2006**). Taste is an important attribute of food preference and a significant deciding factor in the senses of the stock (**Garcia-Bailo *et al.*, 2009 and Setiadharma *et al.*, 2015)**.

Table 6: Sensory attributes of instant legume stock formulas

Stock formulas	Appearance (9)	Aroma (9)	Color (9)	Texture (9)	Taste (9)	Overall acceptability (9)
Control	8.70±0.42^{a}	8.75±0.42^{a}	8.85±0.33^{a}	8.95±0.15^{a}	8.65±0.47^{a}	8.80±0.18^{a}
F1	8.70±0.42^{a}	8.70±0.42^{a}	8.70±0.34^{ab}	8.60±0.45^{ab}	7.60±0.91^{bc}	8.15±0.21^{c}
F2	8.70±0.42^{a}	8.75±0.40^{a}	8.65±0.47^{ab}	8.45±0.55^{ab}	7.65±0.81^{bc}	8.45±0.33^{bc}
F3	8.60±0.50^{a}	8.65±0.47^{a}	8.50±0.40^{ab}	8.35±0.52^{ab}	7.35±0.97^{c}	8.15±0.29^{c}
F4	8.60±0.65^{a}	8.65±0.41^{a}	8.50±0.40^{ab}	8.15±0.81^{b}	7.70±0.85^{bc}	8.45±0.45^{bc}
F5	8.40±0.65^{a}	8.50±0.62^{a}	8.45±0.64^{ab}	7.90±0.90^{b}	7.95±0.68^{b}	8.40±0.55^{bc}
F6	8.50±0.66^{a}	8.55±0.88^{a}	8.40±0.63^{ab}	8.15±0.78^{b}	8.30±0.67^{ab}	8.65±0.54^{ab}
F7	8.60±0.45^{a}	8.50±0.40^{a}	8.27±0.20^{b}	8.00±0.97^{b}	8.25±0.48^{ab}	8.61±0.24^{ab}
F8	8.90±0.21^{a}	8.60±0.45^{a}	8.32±0.40^{b}	8.35±0.62^{ab}	8.50±0.33^{a}	8.75±0.18^{a}

Control= Commercial vegetable stock, F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5= Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \leq 0.05$).

The sensory attributes of the instant stock formulas from various legumes compared to commercial stock control are given in Table (6). Results cleared that there are no significant differences ($p \leq 0.05$) were observed in appearance and aroma scores between commercial stock control and all developed formulas from legume.

Color is an important sensory attribute of food product acceptance. There were no significant differences in color parameter among all developed formulas except for F7 and F8, which contained a mixture of different legumes compared to the control. Regarding the texture, the higher scores of the texture parameter were recorded for the stock control (8.95), followed by F1 (8.60), F2 (8.45), F3 as well as F8 (8.35), and there were minor differences between them. The highest taste and overall acceptability were observed in commercial stock control and a mixture of soaked-steamed legumes (F8), and there were no significant differences between them, followed by soaked-steamed chickpea (F6) as well as a mixture of soaked legumes (F7). The soaked sweet lupine stock (F3) had the lowest taste and overall acceptability scores.

Notably, from the obtained results, the sensory scores of the developed stock formulas were palatable and accepted, so it could be concluded that the prepared stock from a mixture of lentil, sweet lupine, and chickpea can be used as good sources of high nutritional values and overall acceptance, because they have high scores in many sensory characteristics.

Microbiological quality of instant legume stock formulas

The microbial load of the developed instant stock formulas powder stored for 6 months compared to the commercial stock control are shown in Table (7). At zero-time, commercial stock control was observed to be free of total bacterial count as well as yeast and mold count (ND) compared to all the developed instant stock formula powders, which contained too low of a total bacterial count ranging from 2.2×10 cfu/g to 6.1×10 cfu/g, while did not contain yeast and mold (ND). After 3 and 6 months of storage, the commercial stock control recorded the lowest total bacterial count as well as yeast and mold, which may be due to the commercial stock control containing preservatives in its ingredients. Formula F7 showed the highest total bacterial count (8.7×10^2 cfu/g and 15.1×10^2 cfu/g, respectively), while yeast and mold (1.9×10 cfu/g and 3.1×10 cfu/g, respectively) compared to other formulas.

On the other hand, during all storage periods, the soaked-steamed stock formulas had the lowest total bacterial count as well as yeast and mold compared to the soaked stock formulas; this may be due to the steaming process before preparing the soaked-steamed stock formulas. It is worth noting that the total bacterial count as well as yeast and mold was increased by increasing storage periods (after 3 and 6 months of storage) in all stock formula powders, but it was within the permissible limits. The reduction of microbial load of stock formulas might be due to the low moisture content and low water activity during the storage periods that inhibits the microbial growth **(Sarkar *et al.*, 2019)**. Bacterial growth is inhibited at water activity less than 0.75, while all growth is inhibited at less than 0.6 **(Safe food 360, 2014)**. According to **Food Safety (2016),** the legal limits microorganisms in dried food more than 10^4 cfu/g up to less than or equal to 10^6 cfu/g.

Table 7: Microbiological analysis (cfu/g) of instant legume stock formulas during storage periods at room temperature

Stock formulas	Storage periods					
	Zero time		After 3 months		After 6 months	
	Total bacterial count (cfu/g)	Yeast & mold (cfu/g)	Total bacterial count (cfu/g)	Yeast & mold (cfu/g)	Total bacterial count (cfu/g)	Yeast & mold (cfu/g)
Control	ND	ND	1.1×10	ND	2.65×10	0.85×10
F1	3.1×10	ND	3.8×10^2	1.3×10	9.2×10^2	1.8×10
F2	2.6×10	ND	3.2×10^2	ND	8.1×10^2	1.1×10
F3	2.8×10	ND	4.5×10^2	0.8×10	11.8×10^2	1.5×10
F4	2.2×10	ND	2.8×10^2	ND	9.2×10^2	1.1×10
F5	5.5×10	ND	6.7×10^2	1.4×10	11.2×10^2	2.8×10
F6	3.7×10	ND	4.5×10^2	0.5×10	9.8×10^2	1.6×10
F7	6.1×10	ND	8.7×10^2	1.9×10	15.1×10^2	3.1×10
F8	5.2×10	ND	6.6×10^2	1.5×10	12.8×10^2	2.2×10

Control= Commercial vegetable stock, F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5= Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \leq 0.05$).

Economic cost of instant legume stock formulas

The cost of instant stock powder **(**LE/10g pack**)** varies in different countries depending on the availability of raw materials. Since we use locally available raw materials, the cost of our newly developed instant legume stock formulas is shown in Table (8). It could be observed that the average cost price for all formulas was 0.8979 LE. EGP (89.79 piasters), whereas the average selling price in the market was about 1.2570 LE. EGP (125.70 piasters), and the average profit margin was 0.3591 LE. EGP (35.91 piasters). It was also noted that formulas F5 and F6, which contained chickpea, were the highest priced (1.4543 LE. EGP for each). These prices are moderately acceptable in contrast to the price of the commercial stock control, whose selling price in the market was about 3.00 LE. EGP (300 piasters).

In addition, the acceptable instant legume stock formulas had high nutritional values, high quality with appreciable microbial stability and could be used as an innovative and safe food, so their price could be very suitable for the Egyptian market and lower than locally available commercial instant stock powder.

Table 8: The economic cost of different formulas for instant legume stock (LE/10g pack)

Stock formulas	Stock ingredients					Energy (15% of ingredients cost)	Labor (15% of ingredients cost)	Total cost/ LE (EGP)	Gross profit margin (40% of cost)	Total price for market / LE (EGP)
	Lentil (g)	Sweet lupine (g)	Chickpea (g)	Mixture of spices and salt (g)	Ingredients cost / LE (EGP)					
Control	-	-	-	-	-	-	-	-	-	3.00
F1	5	-	-	5	0.6741	0.1011	0.1011	0.8763	0.3505	1.2268
F2	5	-	-	5	0.6741	0.1011	0.1011	0.8763	0.3505	1.2268
F3	-	5	-	5	0.5991	0.0898	0.0898	0.7788	0.3115	1.0903
F4	-	5	-	5	0.5991	0.0898	0.0898	0.7788	0.3115	1.0903
F5	-	-	5	5	0.7991	0.1198	0.1198	1.0388	0.4155	1.4543
F6	-	-	5	5	0.7991	0.1198	0.1198	1.0388	0.4155	1.4543
F7	1.67	1.67	1.66	5	0.69047	0.10357	0.10357	0.8976	0.3590	1.2566
F8	1.67	1.67	1.66	5	0.69047	0.10357	0.10357	0.8976	0.3590	1.2566
Average cost	-	-	-	-	-	-	-	0.8979	0.3591	1.2570

Control= Commercial vegetable stock, F1= Soaked lentil, F2= Soaked-steamed lentil, F3= Soaked sweet lupine, F4= Soaked-steamed sweet lupine, F5= Soaked chickpea, F6= Soaked-steamed chickpea, F7= Mixture of soaked legumes, F8= Mixture of soaked-steamed legumes. Data are expressed as means of three replicates ± standard deviation. Values in the same column followed by different superscripts are significantly different ($P \leq 0.05$).

Conclusion

Most of the available instant stock in the local market does not have enough nutritional value, and it might contain some food preservatives and allergenic ingredients. Thus, it can be improved by incorporating natural sources as legumes powder (lentil, sweet lupine, and chickpea), that contain high protein and other essential nutrients to prepare high-nutritional instant stock powder with highly acceptable sensory properties. This study successfully developed eight instant stock powder formulas supplemented with some legume powders, utilizing soaked-steamed soaked-steamed legumes. The results demonstrated that these legume-based stock powders are nutritionally superior to commercial instant vegetable stock, particularly in protein, crude fiber, minerals, and phytochemicals. Soaked legume-based formulas exhibited higher antioxidant properties due to higher total phenol and carotenoids content. This research presents a healthier, nutrient-rich alternative to commercial stock powders, characterized by appreciable microbial stability, and low sodium content. The findings can help manufacturers develop nutrient-rich, economical-cost, and consumer-accepted stock powders, promoting health benefits and sustainable food options.

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