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Soaking and Cooking Techniques: A Study on Nutritional Enhancement of Common Beans (*Phaseolus vulgaris L.*) in Libyan Cuisine

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ABSTRACT

This study investigates the effect of soaking duration, cooking time, and the type of water used on the mineral and nutritional content of common beans (*Phaseolus vulgaris L.*) available in the Libyan market. Common beans are a significant source of essential minerals, making them a staple food in Libya. The research involved preparing beans through various methods: uncooked (control), unsoaked, boiled in desalinated water, and soaked for 12 hours in four different types of water (distilled, desalinated, artificial river, and well water) before boiling. Samples were measured using a flame atomic absorption spectrophotometer. The results demonstrated that soaking beans significantly reduced cooking time and enhanced the retention of vital minerals. The concentrations of minerals (mg/100 ml) in the cooked beans were as follows: sodium (Na) ranged from 2.8 to 49.3, calcium (Ca) from 8.4 to 20.8, potassium (K) from 189.0 to 742.8, zinc (Zn) from 1.1 to 2.1, barium (Ba) from 159.1 to 300.9, and iron (Fe) from 1.2 to 37.7, depending on the soaking and cooking conditions. Additionally, the type of water used for soaking and cooking influenced the mineral content, with artificial river and well water yielding higher concentrations of beneficial nutrients such as Na ranged from 400 to 628 mg/100 ml and Ca ranged from 50 to 73 mg/100 ml. The measured concentration of heavy metals in the samples is low and falls within the normal range according to the Libyan food specifications. This research contributes to the understanding of how traditional cooking practices can be improved for better health outcomes. The findings highlight the importance of proper soaking and cooking techniques in maximizing the nutritional value of common beans, providing practical recommendations for consumers and food preparers.

KEYWORDS: Common Beans, Cooking Time, Cooking Water Type, Minerals, Nutrients.

1. INTRODUCTION

Common beans (*Phaseolus vulgaris L.)* are one of the most widely consumed globally, especially in Africa [(1)], recognized for their rich nutritional profile and significant role in the human diet. It belongs to the order Fabales, Family Fabaceae, Genus Phaseolus L. and Species *Phaseolus vulgaris L.* [(2,3)]. In Libya, common beans are a staple food, providing a crucial source of nutrition for the population. It is an excellent source of vegetable protein, dietary fiber, complex carbohydrates, vitamins, and essential minerals, making them a vital component of food security and nutrition, particularly in developing countries [(4-7)]. Therefore, beans could improve health and also decrease the risk of developing certain diseases, including diabetes, obesity and heart disease [(6)].

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Despite their nutritional benefits, the preparation methods of beans can significantly influence their health-promoting properties.

Traditional cooking practices often involve soaking and boiling, which can affect the retention of nutrients and the presence of anti-nutritional factors. Soaking beans before cooking has been shown to reduce cooking time and enhance the bioavailability of minerals by leaching out certain anti-nutritional compounds such as phytic acid and tannins [(8,9)]. Furthermore, the type of water used for soaking and cooking can also impact the mineral content of the beans, as different water sources may contain varying levels of essential nutrients. This study aims to investigate the effects of soaking duration, cooking time, and the type of water used on the mineral and nutritional content of common beans available in the Libyan market. By studying these elements, the research aims to find the best ways to prepare beans in order to maximize their nutritional advantages; thus, this study will provide valuable insights for consumers, nutritionists, and food scientists, emphasizing the

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importance of proper preparation techniques in enhancing the health benefits of legumes in the diet.

2. The EXPERIMENT

2.1. Materials and methods:

In this study, all chemicals were used as received without further purification. Common beans (*Phaseolus vulgaris L.)* from an Egyptian source were purchased on 28 August 2023 from Sunbulah National Food Industries Company, one of the wholesale stores located south of the capital city, Tripoli, which is known for selling food to all commercial food stores in Libya. After purchasing the grains, they were transported to the laboratories of the Libyan Advanced Center for Chemical Analysis in Tripoli. Four types of water, namely distilled, desalinated, artificial river and well water were used for soaking and cooking as well. In addition, appropriate and relevant equipment, such as hotplates, pots and beakers with the same specifications, were used for soaking and cooking to control extraneous variables.

2.2. Preparation of the samples

The preparation of the samples in this study involved several systematic steps (Fig. 1.) to ensure the proper handling and cooking of common beans (*Phaseolus vulgaris L.*). Here's a detailed description of the sample preparation process:

1. ***Sorting*:** The common beans were manually sorted to remove any undesirable elements, including bad beans, stones, damaged seeds, and immature seeds. This step ensured that only high-quality beans were used for the study.
2. ***Grouping:*** The sorted beans were divided into six distinct groups for the experiment:

- **Group 1:** Raw sample (control sample) - these beans were not soaked or cooked and were used for comparison.
- **Group 2:** Unsoaked beans - these beans were boiled in desalinated water for three different cooking times (30, 60, and 90 minutes).
- **Group 3:** Beans soaked for 12 hours in distilled water, then boiled for one minute, and subsequently divided into three parts for cooking in distilled water at three different times (30, 60, and 90 minutes).
- **Group 4:** Beans soaked for 12 hours in desalinated water, boiled for one minute, and then divided into three parts for cooking in desalinated water at three different times (30, 60, and 90 minutes).
- **Group 5:** Beans soaked for 12 hours in artificial river water, boiled for one minute, and divided into three parts for cooking in the same water at three different times (30, 60, and 90 minutes).
- **Group 6:** Beans soaked for 12 hours in well water, boiled for one minute, and divided into three parts for cooking in the same water at three different times (30, 60, and 90 minutes).

3. ***Soaking:*** The beans in Groups 3 to 6 were soaked overnight for approximately 12 hours in their respective types of water (distilled, desalinated, artificial river, and well water). This soaking process is crucial for enhancing the nutritional quality and reducing cooking time (10,11).
4. **Boiling:** After soaking, all beans were briefly boiled for one minute in the soaking water before being washed. This step helps to eliminate some of the anti-nutritional factors present in the beans.
5. ***Cooking:*** The beans were then cooked in clean water (the same type used for soaking) for the specified times according to their group assignments. This cooking process was conducted in triplicates to ensure consistency and reliability of the results.
6. ***Chemical Digestion:*** After cooking, all boiled samples, including the control sample, were dried overnight at 60 °C. They were then subjected to a chemical digestion process according to (12-14). Briefly, 25 ml of concentrated nitric acid was added to 5 g of each sample and boiled on a hot plate at 100 °C until all the dark fumes rose, then 10 ml of 30% perchloric acid was added and boiled until the solution concentrated and changed color. 3 ml of concentrated nitric acid was added to increase the digestion process, then the solution was desalinated in a volumetric flask using Whatman filter paper grade 0.42.

This systematic preparation of samples allowed for a comprehensive analysis of the effects of soaking and cooking methods on the nutritional content of common beans, ensuring that the results were valid and applicable.

Nutrient minerals {Ferrous (Fe) , Calcium (Ca), Sodium (Na) and Potassium (K)} were measured using a flame photometer, while heavy metals {Zinc (Zn), Chrome (Cr), Lead (Pb), Cadmium (Cd) and Barium (Ba)} were measured using a flame atomic absorption spectrophotometer.

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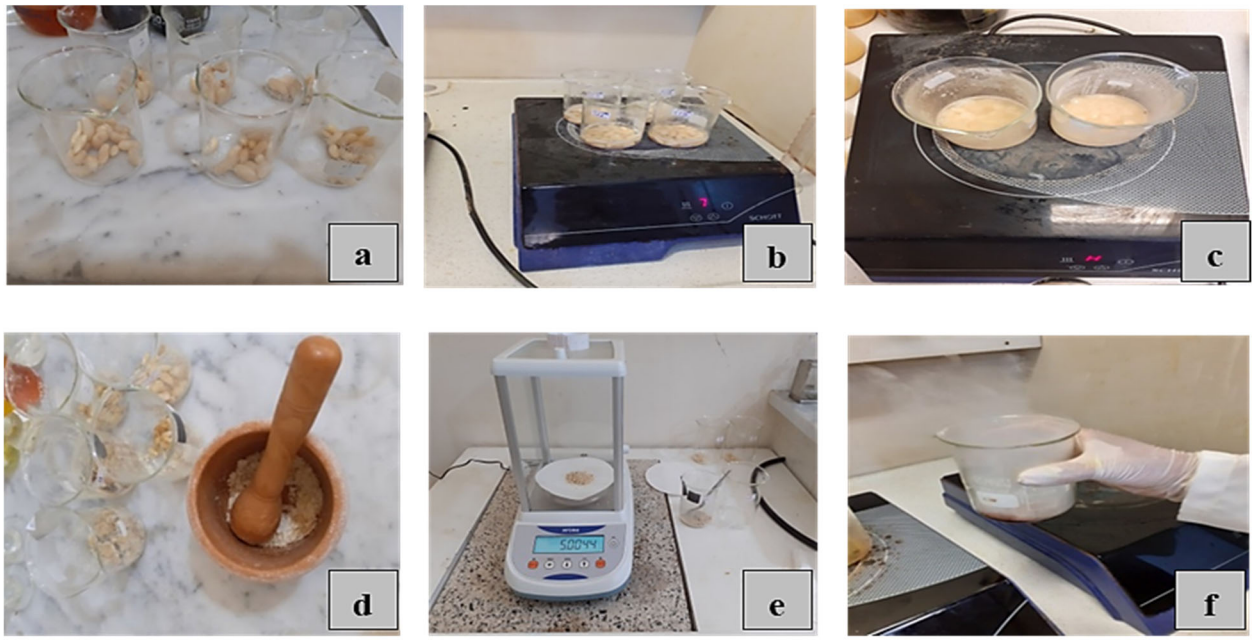


Fig. 1. (a) Soaking the beans. (b,c) cooking process. (d) grinding the samples. (e) weighing the samples and (f) chemical digestion process.

2.3. Statistical analysis

The data was analyzed using statistical software (SPSS) to determine the significance of the effects of soaking and cooking times on mineral content. Applying appropriate statistical tests (such as ANOVA and t-tests) to compare the means of mineral concentrations across different groups. The software calculates the p-value, which indicates the probability of observing the data.

3. RESULTS AND DISCUSSION

The result highlights the significant impact of soaking and the type of water used on the cooking and nutritional quality of common beans (*Phaseolus vulgaris L.*). Soaking beans for 12 hours not only reduce cooking time but also enhances the retention of beneficial minerals and reduces anti-nutritional factors, leading to a more nutritious product.

Table 1. Concentrations of based minerals (mg/100ml) at different cooking time and water types.

Samples	Type of water	Cooking time (min)	Na	K	Ca	Ba	Fe	Zn
			mg/100ml					
Raw beans	Direct chemical digestion		10.6±3.0	477.9±27.4	9.1±0.1	376.0±8.1	4.8±0.2	1.6±0.6
Cooked without soaked beans (CWS)	Desalination	60	42.0±4.1	314.7±6.6	9.8±0.5	276.9±15.8	2.8±1.2	1.7±0.8
		90	49.3±4.5	298.1±31.7	17.2±2.8	255.4±18.0	2.6±1.5	1.1±0.1
		120	44.4±1.7	189.0±10.7	8.4±0.5	170.0±6.8	2.6±0.7	1.7±0.7
Soaked and cooked beans	Distilled	60	4.5±0.1	649.1±19.2	12.5±0.7	246.1±5.9	3.8±2.2	1.7±0.4
		90	3.3±0.5	659.5±58.9	13.4±1.6	252.6±33.4	5.6±0.7	1.9±0.3
		120	2.8±0.2	656.3±19.9	13.6±2.3	300.9±49.0	25.2±0.1	1.6±0.1
	Desalinated	60	29.6±3.6	742.8±90.3	20.8±2.8	297.7±38.7	6.3±5.9	1.9±0.1
		90	28.4±0.9	701.9±56.9	20.0±4.2	270.0±29.2	4.9±2.9	1.5±0.1
		120	36.1±1.1	619.2±77.0	19.9±0.1	235.8±35.8	16.2±9.0	1.7±0.1
	Artificial river	60	441.8±47.4	573.3±19.6	52.0±6.3	128.4±25.6	37.7±7.4	2.1±0.2
		90	498.0±35.6	560.7±77.1	59.5±5.7	170.8±24.8	1.2±0.7	1.8±0.2
		120	628.4±5.8	666.5±72.5	73.5±4.0	214.5±0.4	2.7±0.8	1.8±0.1
	Well	60	400.2±40.8	614.7±11.6	50.1±2.7	212.0±1.9	2.7±0.8	2.1±0.4
		90	443.9±54.9	697.5±12.6	60.7±2.6	219.7±21.3	1.7±0.6	1.8±0.1
		120	575.2±9.5	573.2±19.9	72.6±1.9	159.1±69.7	3.0±1.7	2.0±0.1

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3.1 Effect of soaking process on cooking time

Soaking beans before cooking is beneficial as it reduces cooking time, enhances nutrient retention, and minimizes anti-nutritional factors, leading to a more nutritious and digestible final product. Ferreira et al. [15] reported similar findings. Cooking beans without soaking typically requires a longer cooking time compared to beans that have been soaked. Soaking beans for several hours (e.g., 12 hours) helps to soften the beans, which reduces the overall cooking time and improves the retention of essential minerals. Similar results were reported by Mamiro et al. [16]. Soaking beans before cooking can significantly increase the concentration level of K and Ca ($P < 0.05$). However, the concentration level of Na, Ba and Zn is not affected by soaking process ($P > 0.05$). These results is agree with those of the majority of previous studies. During soaking, some anti-nutritional factors, such as phytic acid and tannins, leach into the soaking water, which can improve the bioavailability of minerals like iron and zinc in the cooked beans [16].

3.2 Impact of water type on mineral content

The results found that the type of water used for soaking and cooking common beans significantly affected the mineral concentrations in the cooked beans. Yulianti et al. [10] reported similar findings, indicating that water with higher mineral content could enhance the nutritional profile of legumes. The following are the main differences reported in mineral concentrations based on the type of water used (Fig. 2).

1. ***Distilled Water:*** This type of water is free from impurities and minerals, which may help in preserving the natural mineral content of the beans while allowing for effective leaching of anti-nutritional factors. Beans soaked and cooked in distilled water showed the lowest level of Na and Ca retention (Table 1).
2. ***Desalinated Water:*** Similar to distilled water, it may not contribute additional minerals, but it can help in maintaining the natural mineral content of the beans while allowing for some leaching of anti-nutritional factors.
3. ***Artificial River Water:*** This type of water likely contains various minerals and organic matter, which can enhance the mineral content of the beans. The study indicated that beans cooked in artificial river water had increased concentrations of certain minerals, such as Na, Ca, and Fe, compared to those cooked in distilled or desalinated water. Shaltami et al. and Omoikhoje et al. [17,18] also found that the type of water used for cooking legumes significantly influenced mineral retention. Their study showed that mineral-rich waters enhanced the mineral content of cooked legumes.
4. ***Well Water:*** The mineral content of well water can vary widely based on the geological characteristics of the area. Beans cooked in well water may show increased concentrations of specific minerals, depending on the mineral composition of the well water used [17].

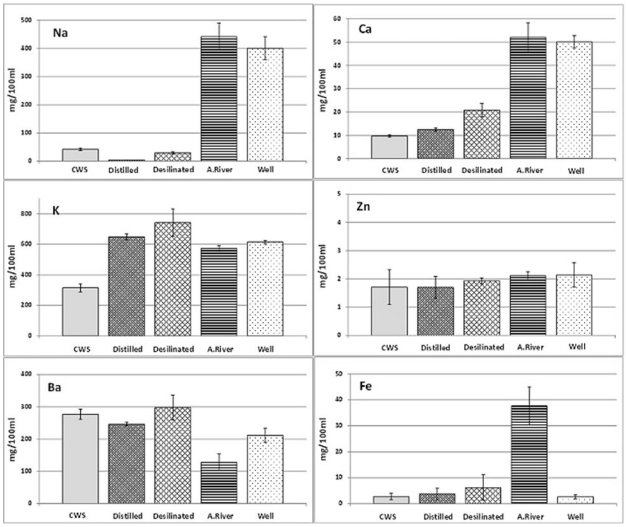


Fig. 2. Concentrations of essential minerals in common beans cooked in different types of water (cooking time at 60 min). CWS = cooking without soaking.

Overall, the results indicated that beans cooked in artificial river water and well water generally had higher concentrations of essential minerals compared to those cooked in distilled or desalinated water. This suggests that the mineral content of the cooking water can significantly influence the nutritional profile of the cooked beans [17]; this result was similar to the results of Feitosa et al. [19].

The type of water used for soaking and cooking plays a crucial role in determining the mineral content and overall quality of the cooked beans. Beans soaked and cooked in mineral-rich waters, such as artificial river water and well water, exhibited higher concentrations of essential minerals compared to those cooked in distilled or desalinated water. This suggests that the mineral composition of the cooking water can significantly enhance the nutritional profile of the beans.

Additionally, the study indicates that the texture and flavor of the cooked beans can vary based on the type of water used, with mineral-rich waters potentially contributing to a more desirable sensory experience. Overall, the findings underscore the importance of both soaking practices and the choice of cooking water in optimizing the nutritional and culinary qualities of common beans, which are a vital source of protein and nutrients in the diet, particularly in regions like Libya.

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Furthermore, the study analyzed the mineral content in different types of water used for soaking and cooking common beans. The concentrations of specific minerals (in mg/100 ml) in various water types were as follows (Table 2).

Table 2. Concentrations of some minerals in different types of water used (mg/L).

Type of water	Na	K	Ca	Ba	Li
Distilled	0.00	0.00	0.00	0.00	0.00
Desalinated	2.90	0.01	1.70	0.65	0.01
Artificial river	25.7	0.83	8.78	0.05	0.01
Well	25.3	1.20	9.23	0.05	0.04

The results indicated that well water and artificial river water, which are sources of groundwater, contained higher concentrations of Na and Ca (25 and 9 mg/L, respectively) compared to desalinated water (2.9 and 1.7 mg/L, respectively). This is attributed to the presence of dissolved salts in groundwater, which includes essential minerals like sodium, potassium, calcium, and magnesium.

3.3 Effect of type of water on cooking time

The type of water used for soaking and cooking beans has a significant effect on cooking time. Beans soaked and cooked in distilled water may require a standard cooking time, but the lack of additional minerals in the water can lead to a more straightforward cooking process without any enhancements in cooking efficiency. Similar to distilled water, desalinated water does not contribute extra minerals, and the cooking time may be comparable to that of beans soaked in distilled water. However, the overall cooking time may still be slightly reduced due to the soaking process. Beans soaked and cooked in artificial river water may have a reduction in cooking time compared to those soaked in distilled or desalinated water. The presence of minerals and organic matter in artificial river water can facilitate a more efficient cooking process, potentially leading to quicker softening of the beans. The mineral content of well water can vary, and this variability can affect cooking time. Depending on the specific mineral composition, beans cooked in well water may either cook faster or slower than those cooked in other types of water. Overall, the results suggest that beans soaked and cooked in artificial river water and well water may have reduced cooking times compared to those soaked in distilled or desalinated water (Table 1). The mineral content and characteristics of the water used play a crucial role in determining the efficiency of the cooking process [20, 21].

3.4 Comparison of nutritional content of uncooked (control) and cooked samples

This comparison highlights the importance of cooking methods and times in determining the nutritional quality of common beans, emphasizing the need for optimal cooking practices to maximize nutrient retention. The duration of cooking significantly influenced nutrient concentrations; cooking for 60 minutes generally increased sodium and calcium concentrations while decreasing potassium, iron, and zinc levels. This suggests that while some nutrients become more available through cooking, others may be lost in the process. However, with 90 minutes often yielding the highest levels of certain nutrients like sodium and calcium, while longer cooking times led to decreased retention of potassium, iron, and zinc, similar findings were reported by Stephen [22].

3.5 Heavy metals content

Heavy metals may negatively affect the nutritional quality of common beans. They can accumulate in plant tissue, therefore reducing their usability as a healthy food. Heavy metals such as lead, cadmium, and mercury can affect the absorption of essential nutrients from the soil and may lead to an imbalance in the mineral content within legume plants, leading to a lower level of good nutrients such as iron and zinc. These metals may inhibit the growth and production capacity of plants. High concentrations of heavy metals can also cause toxicity to plants, leading to cell death and tissue deterioration. The results indicated the following concentrations (mg/100 ml) for various heavy metals in raw common beans (Table 3).

Table 3. Heavy metal composition (mg/100 ml) of raw common bean seeds.

Minerals	Pb	Cd	Cu	Cr
Raw beans	0.03±0.02	< 0.001	0.01±0.01	1.19±0.08

The findings suggest that the concentration of heavy metals in the samples is low and falls within the normal range according to the Libyan food specifications. This aligns with results from previous studies, indicating that the beans are safe for consumption regarding heavy metal content.

Additionally, the study noted that the concentration of heavy metals in the water used for soaking and cooking was also lower than the detection limit, particularly in distilled and desalinated drinking water, which is designed to remove such contaminants.

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4. CONCLUSION

The conclusion of the study emphasizes the critical role of soaking and the type of water used in enhancing the cooking and nutritional quality of common beans (*Phaseolus vulgaris L.*). Soaking beans for 12 hours significantly reduce cooking time and improves the retention of essential minerals while also minimizing anti-nutritional factors. The type of water used for soaking and cooking has substantial effect on the mineral content and overall quality of the cooked beans. Mineral-rich waters, such as artificial river water and well water, contribute to higher concentrations of beneficial nutrients compared to distilled or desalinated water. The study also highlights that the texture and flavor of cooked beans can vary based on the water used, suggesting that using mineral-rich water may improve the sensory qualities of the beans. Finally, adopting proper soaking techniques and selecting appropriate cooking water are essential practices for maximizing the health benefits and culinary qualities of common beans. These insights can guide dietary practices and cooking methods, particularly in regions where beans are a staple food.

5. RECOMMENDATIONS

The study recommends the following practices to enhance the nutritional quality and culinary qualities of common beans (*Phaseolus vulgaris L.*):

1. **Soaking Duration:** Soaking beans for 12 hours is advised as it significantly reduces cooking time and improves the retention of essential minerals while minimizing anti-nutritional factors.
2. **Type of Water:** The type of water used for soaking and cooking has a substantial impact on the mineral content of the beans. It is recommended to use mineral-rich waters, such as artificial river water and well water, as they contribute to higher concentrations of beneficial nutrients compared to distilled or desalinated water.
3. **Cooking Techniques:** Proper soaking techniques and the selection of appropriate cooking water are essential practices for maximizing the health benefits and culinary qualities of common beans.
4. **Sensory Qualities:** The study highlights that the texture and flavor of cooked beans can vary based on the water used, suggesting that using mineral-rich water may improve the sensory qualities of the beans.

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