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Culinary Techniques in the pre-preparation and preparation of legumes: weight changes and cooking times

A Técnica Dietética no pré-preparo e preparo de leguminosas: alterações de peso e tempos de cocção

Abstract

Objective: To evaluate legumes for weight change indicators related to dry cleaning, hydration, and cooking, as well as cooking times, to systematize data concerning these stages of pre-preparation and culinary preparation. *Methods*: Thirty varieties of legumes varieties were assessed for soaking effects and cooking times using moist heat methods (boiling or pressure cooking) and dry heat (oven roasting - for peanuts only). *Results and Discussion*: The correction factors ranged from 1 to 1.05. The hydration index ranged from 1.78 (purple beans) to 2.35 (soybean). The conversion index (CI) for moist-heat cooking ranged from 1.05 for green beans to 3.12 for lentils, both without soaking. The CI for soaked legumes ranged from 1.99 (purple beans) to 2.64 (pigeon peas). Roasted peanuts had a CI of 0.94. In legumes cooked by boiling without prior soaking, cooking times ranged from 15 minutes (red lentils) to 56 minutes (green beans). For pressure cooking, the cooking time ranged from 2 to 36 minutes for mung beans and peanuts without soaking, and from 3 to 18 minutes for adzuki beans and black beans when preceded by soaking. Resulting textures varied from *al dente* to soft, depending on cooking duration. *Conclusion*: Soaking and pressure cooking were found to reduce cooking time compared to no soaking and boiling cooking.

Keywords: Fabaceae. Cooking. Dietary technique. Pulses.

Resumo

Objetivo: Avaliar leguminosas quanto aos indicadores de alteração de peso relacionados à limpeza seca, à hidratação e à cocção, e os tempos de cocção, com o intuito de sistematizar dados referentes a essas etapas do pré-preparo e preparo culinário. *Métodos*: Trinta tipos de leguminosas foram avaliados com presença ou ausência de remolho e tempos de cocção por métodos de calor úmido (ebulição ou panela de pressão) e seco (assado em forno – apenas amendoim). *Resultados e Discussão*: Os fatores de correção variaram entre 1 e 1,05. O índice de hidratação variou de 1,78 (feijão roxo) a 2,35 (soja). O índice de conversão (IC) com cocção sob calor úmido foi de 1,05 para o feijão verde, a 3,12 para a lentilha, ambos sem remolho. Nas leguminosas submetidas ao remolho, o IC ficou entre 1,99 (feijão roxo) e 2,64 (feijão guandu). Amendoim torrado apresentou IC de 0,94. Nas leguminosas preparadas com ebulição, sem remolho prévio, o tempo de cocção variou de 15 (lentilha vermelha) a 56 minutos (feijão verde). Para a cocção sob pressão, o tempo variou de 2 a 36 minutos para o feijão mungo e o amendoim sem remolho, e de 3 a 18 minutos, correspondendo ao feijão azuki e ao feijão preto, quando a cocção foi precedida do remolho. As texturas obtidas foram *al dente* e/ou macia, a depender do tempo de cocção. *Conclusão*: Observou-se que realizar o remolho e cozinhar com panela de pressão reduzem o tempo de cocção quando comparados à ausência do remolho e cocção por ebulição.

Palavras-chave: Fabaceae. Culinária. Técnica dietética. Pulses.

INTRODUCTION

Legumes belong to the Fabaceae family and produce a variety of seeds within their pods, including beans, peas, fava beans, chickpeas, lentils, soybeans, and peanuts.[1] The term *pulses* specifically refers to the dry grains of various legumes, excluding soybeans and peanuts, which are classified as oilseed legumes. This classification also excludes green harvested grains, categorized as vegetables, such as green beans and fresh peas.[2]

The consumption of these grains plays anessential role in shaping the cultural identity of numerous nations, where a wide array of traditional dishes are prepared using this food group. In Brazil, beans are the most widely consumed legume,[3] featuring traditional dishes such as feijoada, acarajé, baião de dois, tutu de feijão, feijão tropeiro, and feijão de leite, among others. Arabic dishes such as falafel and hummus, made with chickpeas, and Indian lentil-based dishes such as *dhal* and *pappadums* are also noteworthy examples.[4]

In order toraise awareness about consumption, the FAO designated 2016 as the International Year of Pulses, aligning with the 2030 Agenda for Sustainable Development. In this regard, pulses can contribute to food security and promote the adoption of healthy and sustainable diets.[5-7]

Due to their rich nutrient content and bioactive compounds, consumption of this food group is related with beneficial effects on human health.[8,9] However, despite these observed benefits, global legume consumption remains limited. Among 94 countries, 11 reported an average consumption of cooked legumes exceeding 50 g per day. Six of these countries were in Asia and the Pacific, three in Latin America and the Caribbean (including Brazil, with an average of 83 g/day), one in Europe, and one in the Middle East.[10] In Brazil, according to data from the Surveillance of Chronic Diseases by Telephone Survey (VIGITEL), the consumption of beans on five or more days per week decreased from 66.8% to 58.6% between 2007 and 2023.[11]

Numerous aspects can influence legume consumption, including lack of knowledge about preparation methods or culinary versatility, as well as concerns about intestinal discomfort.[12] The *Brazilian Dietary Guidelines* (*Guia Alimentar para a População Brasileira*) highlight the importance of consuming beans and other legumes and provide preparation instructions.[13] In this context, Culinary Techniques is the field of Nutrition that consolidates and generates knowledge related to pre-preparation and preparation stages, involved in the consumption and meal planning for individuals and communities.[14] These premises are intrinsically linked to culinary skills, which encompass the use of foods and cooking techniques, as well as individual aspects such as confidence, interest in cooking, and culinary knowledge. Promoting these skills can contribute to the adoption of healthy diets, which include recommendations for the routine consumption of legumes.[15] Knowing and mastering these techniques can facilitate preparation, as legumes can be incorporated into both sweet and savory recipes, including salads, cakes, pasta dishes, stews, purées, sauces, spreads, and desserts.[16]

Regarding pre-preparation, soaking or maceration aids in reducing cooking time and decreasing antinutritional factors and oligosaccharides that may cause flatulence, such as raffinose, stachyose, and verbascose.[17,18] Most legumes are cooked using moist heat methods such as boiling or pressure cooking, though dry heat methods can also be used.[19] Several factors influence cooking time of grains, including variety; quality; storage conditions and duration (e.g., hard-to-cook beans),[20] soaking or lack thereof; and cooking equipment such as pressure cookers. Furthermore, the morphological structure of the grains and their processing for commercial purposes, such as the removal of seed coat, can influence their behavior during soaking and cooking.

Considering the scarcity of data on weight change indicators and cooking times for legumes in the literature, systematizing these results can aid in estimating preparation quantities, time spent on preparation, and waste reduction, serving as a valuable support tool for both home cooking and food service establishments (Unidades Produtoras de Refeições - UPR). Therefore, this study aimed to evaluate weight change indicators associated with dry cleaning, hydration, and cooking, as well as cooking times for legumes during culinary processing.

METHODS

All legume varieties (n=30) available in supermarkets, health food stores, and open-air markets in Rio de Janeiro and São Paulo were purchased in bulk or retail. The following parameters were investigated, documented, and described for each legume variety: scientific name, synonyms, commercial classification, price per kilogram (Kg), and primary culinary preparation methods.

Evaluations of weight change indicators (correction factor, hydration index, and conversion index) and cooking times were conducted at the Culinary Techniques Laboratory of the Universidade do Estado do Rio de Janeiro-UERJ (State University of Rio de Janeiro).

The samples were weighed using an Original Line® digital scale with a maximum capacity of 10 kg and 1 g precision. The contents of the purchased package underwent dry cleaning, during which defective grains were removed. The ratio between gross weight and net weight was then calculated to establish the correction factor.

$$CF = \frac{Gross\ weight}{Net\ weight}$$

For the preparation experiments, which were conducted in triplicate or duplicate, 100 g of raw or dried legume (net weight) were used. Legumes were made with or without soaking (hydration), with peas, lentils, green beans, mung beans, and peanuts not undergoing this process. The legumes were soaked in water at a 4:1 ratio (water to legumes) for 10 hours, after which the soaking water was immediately discarded. Subsequently, the weight was measured after soaking, and the hydration index (HI) was calculated:

$$HI = \frac{Weight\ after\ hydratation}{Net\ weight}$$

Samples were cooked using household stoves, using moist-heat methods (pressure cooking or open-pot boiling) or dry-heat methods (oven roasting), with the latter applied exclusively to peanuts. Hydrated legumes received 700 mL of water, while non-soaked legumes received 1,000 mL. No additives such as salt, oil, acids, seasonings, or baking soda were introduced to the soaking or cooking water. Filtered water at room temperature was used for both soaking and cooking. The cooking pans used varied in design and capacity (10 L, 6 L, 4.5 L, 2 L), reflecting the diverse range of cookware typically found in both household and institutional environments.

The cooking time until achieving a crispy texture (for roasted peanuts only), *al dente* (firm to bite), or soft grain was recorded. These features were subjectively evaluated through tasting by the team. For boiling cooking, the total cooking time was measured from the moment the pan containing water and legumes was placed on the heat until the grains were fully cooked. For pressure cooker cooking, preparation time was measured from the onset of pressurization. For both methods, moderate fire intensity was applied. The final weight without broth after cooking was measured to calculate the conversion index (CI):

$$CI = \frac{Weight\ after\ cooking}{Net\ weight}$$

Descriptive statistical analysis was conducted using Excel® software, calculating means and standard deviations for weight change indicators and cooking times.

RESULTS AND DISCUSSION

After market research, 30 legume varieties were purchased. Table 1 presents their scientific names, synonyms, purchase price per kg, and primary culinary applications. Figure 1 shows the photos of the grains of dried and raw legumes.

Table 1. Common name, scientific name, other common names, price (R$/kg) and main revenues with legumes evaluated. Rio de Janeiro-RJ and São Paulo-SP, 2023.

Common legume names	Scientific name	Other common names	Average price per kilo (R$)*	Usual culinary applications
Black beans	*Phaseolus vulgaris*		7.59	Feijoada, bean soup, cooked in broth
Mulatinho beans	*Phaseolus vulgaris*		8.98	Baião de dois, cooked, and salads
Pink beans	*Phaseolus vulgaris*		29.90	Cooked beans, minestrone
Carioca beans	*Phaseolus vulgaris*	*Carioquinha*	7.70	Feijãotropeiro and cooked in broth
White bean	*Phaseolus vulgaris*		9.90	Soups, stews, cassoulet, mocotó, dobradinha, or buchada
Kidney beans	*Phaseolus vulgaris*		11.45	Cooked and feijoada
Bolinha beans	*Phaseolus vulgaris*	Canary beans	11.15	Salads and soups
Purple beans	*Phaseolus vulgaris*		11.45	Cooked, virado of purple beans
Manteiga beans	*Phaseolus vulgaris*		19.99	Cooked, soups, stews, dobradinha, or Buchada
Broad beans	*Phaseolus vulgaris*		13.63	Cold salads
Jalo beans	*Phaseolus vulgaris*	Jalo beans pinto	12.60	Soups, salads, feijãotropeiro
Pinto beans	*Phaseolus vulgaris*		12.30	Cooked, feijão tropeiro, feijão à toscana
Cowpeas (marketed as Black-eyed peas)	*Vigna unguiculata*		8.50	Acarajé, Cold salads, vinaigrettes, and baião de dois
Cowpeas (marketed as green beans)	*Vigna unguiculata*		40.00	Salads, arrumadinho of green beans and baião de dois
Cowpeas (marketed as *manteiguinha*beans)	*Vigna unguiculata*		61.10	Salads, baião de dois, mexido com carne seca
Cowpeas (marketed as string beans)	*Vigna unguiculata*		17.54	Cooked, baião de dois, farofa, and salads
Adzuki beans	*Vigna angularis*		33.30	Cooked, salads, manju, and anko

Table 1. Common name, scientific name, other common names, price (R$/kg) and main revenues with legumes evaluated. Rio de Janeiro-RJ and São Paulo-SP, 2023.(continues)

Common legume names	Scientific name	Other common names	Average price per kilo (R$)*	Usual culinary applications
Mung beans	*Vigna Radiata*	Green gram, golden gram, maash, mongo bean, Jerusalem pea	35.80	Preparation of sprouts, kichadi, cooked
Black speckled lima beans	*Phaseolus lunatus*	Butter bean, sieva bean, double bean, madagascar bean	28.00	Cooked, salads, and stews
Red speckled lima beans	*Phaseolus lunatus*	Butter bean, sieva bean, double bean, madagascar bean	25.00	Cooked, salads, and stews
White lima beans	*Phaseolus lunatus*	Butter bean, sieva bean, double bean, madagascar bean	16.50	Cooked, salads, and stews
Chickpeas	*Cicer Arietinum*	Garbanzo beans, ceci beans, bengal gram, egyptian pea, chana	18.58	Salads, hummus, falafel, hamburger
Soybeans	*Glycine max*		15.66	Soy meat, hamburger, and kibe
Peas	*Pisumsativum*		16.78	Soup, cream, and sautéed
Lentils	*Lens culinaris*		14.55	Soup, broth, hamburger, rice with lentils, *dhal*, and *pappadums*
Red lentils	*Lens culinaris*		17.50	Soup, broth, hamburger, rice with lentils, *dhal*, and *pappadums*
Black lentils	*Lens culinaris*	Beluga lentils	49.96	Soup, broth, hamburger, rice with lentils, *dhal*, and *pappadums*
Green lentils	*Lens culinaris*		47.40	Soup, broth, hamburger, rice with lentils, *dhal*, and *pappadums*
Pigeon peas	*Cajanus Cajan*	Congo peas	13.90	Cooked, combined with rice and salads
Peanut	*Arachis hypogaea*		23.90	Roast, pé de moleque, paçoca, pasta,farofa

*Legumes purchased between August 2022 and December 2023 from supermarkets, stores, and open-air markets in Rio de Janeiro and São Paulo municipalities.

Figure 1. Photos of the 30 cooked legumes and the toasted peanuts.

The predominant group identified was common beans *(Phaseolus vulgaris*), comprising 12 pulse varieties, followed by cowpeas (*Vigna unguiculata*) and lentils, each represented by four distinct types. Red lentils and peas were purchased in their split form, without the seed coat. While, soybeans (*Glycine max*) and peanuts (*Arachis hypogaea*) were among the products purchased.

The shortage of certain legume varieties was observed in commercial establishments, even in major urban centers such as Rio de Janeiro and São Paulo. Certain varieties, such as purple jalo beans, fava beans, and lupins, were unavailable in dried form. Meanwhile, other types such as *manteiguinha* beans, black lentils, and green lentils were only found in one supermarket and had high prices. Commercial availability may also be influenced by the region's culinary traditions, as well as distribution logistics and consumer demand for grains. This is exemplified by certain legumes found exclusively in São Paulo, such as purple beans, pigeon peas, white *lima* beans, and *bolinha* beans. In contrast, some legumes, including common beans, peas, peanuts, soybeans, and chickpeas, were extensively found.

Table 2 presents the mean values and standard deviations for the hydration index, conversion index, and cooking time of the 30 evaluated legumes. Additionally, information was included regarding the grade (categorized as 1, 2, or 3), cookingtechnique used, variation in cooking time, and texture of the cooked grain. Figure 2 shows the photos of cooked legume grains.

Table 2. Weight change parameters and cooking times for 30 legumes during pre-preparation and preparation: hydration index (after 10-hour soaking), conversion index, and cooking time for prepared legumes (100 g): with or without soaking at room temperature, using moist heat methods (boiling in an uncovered pan [total time over medium heat] or pressure cooker [total time from pressure onset]) or dry heat (roasted peanuts [total time in 200ºC oven]). Rio de Janeiro-RJ and São Paulo-SP, 2023. (continues).

Legume	Variety*	Hydration index#	Conversion index+	Preparation technique	Average time of cooking (minutes)	Variation of time of cooking (minutes)	Cooked grain texture
Black beans	Grade 1	2.00±0.01 No soaking	2.25±0.14 2.09±0.05	Pressure cooker	18.00±1.15 27.00±2.52	18-20 25-30	Soft *Al dente/Soft*
Mulatinho beans	Type 2	2.25±0.02 No soaking	2.42±0.05 2.29±0.08	Pressure cooker	10.00±0.00 23.00±0.00	10 23	Soft Soft
Pink beans	Indefinite	2.01±0.04 No soaking	2.26±0.16 2.25±0.10	Pressure cooker	10.00±0.00 28.00±0.58	10 27-28	Soft Soft
Carioca beans	Grade 1	2.22±0.02 No soaking	2.58±0.05 2.23±0.04	Pressure cooker	10.00±0.00 27.00±1.15	10 26-28	Soft Soft
White bean	Grade 1	2.03±0.01 No soaking	2.38±0.07 2,30±0.05	Pressure cooker	9.00±1,15 32.00±0.58	8-10 31-32	Soft Soft
Kidney beans	Grade 1	2.00±0.01 No soaking	2.38±0.04 2.07±0.09	Pressure cooker	15.00±0.00 27.00±2.52	13-15 25-30	*Al dente/Soft* *Al dente/Soft*
Bolinha Beans	Indefinite	1.86±0.01 No soaking	2.04±0.03 2.04±0.16	Pressure cooker	10.00±2.12 26.00±1.41	8-11 25-27	Soft *Al dente/Soft*
Purple beans	Indefinite	1.78±0.01 No soaking	1.99±0.10 2.05±0.09	Pressure cooker	12.00±0.00 19.00±0.00	12 19	Soft Soft
Manteiga beans	Type 2	2.10±0.03 No soaking	2.41±0.02 2.30±0.06	Pressure cooker	10.00±0.00 19.00±1.41	10 23-25	Soft Soft
Broad beans	Indefinite	2.03±0.02 No soaking	2.31±0.02 2.20±0.01	Pressure cooker	8.00±0.00 28.00±0.00	8 28	Soft Soft
Jalo beans	Indefinite	2.09±0.01 No soaking	2.46±0.06 2.18±0.04	Pressure cooker	8.00±0.00 17.00±0.00	8 17	Soft Soft
Pinto beans	Type 2	2.11±0.08 No soaking	2.52±0.06 2.17±0.03	Pressure cooker	11.00±1.15 27.00±1.15	10-12 28-26	Soft Soft
Black-eyed peas	Type 3	2.15±0.02 No soaking	2.59±0.07 2.51±0.04	Pressure cooker	7.00±2.31 19.00±1.41	6-10 18-20	Soft Soft

Table 2. Weight change parameters and cooking times for 30 legumes during pre-preparation and preparation: hydration index (after 10-hour soaking), conversion index, and cooking time for prepared legumes (100 g): with or without soaking at room temperature, using moist heat methods (boiling in an uncovered pan [total time over medium heat] or pressure cooker [total time from pressure onset]) or dry heat (roasted peanuts [total time in 200ºC oven]). Rio de Janeiro-RJ and São Paulo-SP, 2023. (continues).

Legume	Variety*	Hydration index#	Conversion index+	Preparation technique	Average time of cooking (minutes)	Variation of time of cooking (minutes)	Cooked grain texture
Green beans	Indefinido	No soaking No soaking	1,05±0,02 1,15±0,00	Boiling Pressure cooker	56,00±0,00 5,00±0,00	56 5	Soft Soft
Butter beans	Type1	1,85±0,03 No soaking	2,26±0,02 2,28±0,01	Pressure cooker	9,00±0,71 16,00±0,00	8-9 16	Soft Soft
String beans	Indefinite	2,22±0,05 No soaking	2,61±0,02 2,60±0,14	Pressure cooker	8,00±0,00 15,00±0,00	8 15	Soft Soft
Adzuki beans	Indefinite	2,16±0,03 No soaking	2,43±0,03 2,39±0,05	Pressure cooker	3,00±0,00 6,00±1,41	3 5-7	Soft *Al dente*/Soft
Mung beans	Indefinite	No soaking No soaking	2,77±0,27 2,64±1,19	Boiling Pressure cooker	35,00±7,07 2,00±1,41	30-40 1-3	*Al dente*/Soft *Al dente*/Soft
Black lima beans	Indefinite	1,94±0,04 No soaking	2,26±0,08 2,24±0,05	Pressure cooker	10,00±0,00 25,00±0,00	10 25	Soft Soft
Kidney lima beans	Indefinite	2,09±0,01 No soaking	2,30±0,02 2,12±0,08	Pressure cooker	10,00±0,00 25,00±0,00	10 25	Soft Soft
White lima beans	Indefinite	2,07±0,04 No soaking	2,38±0,04 2,27±0,05	Pressure cooker	15,00±0,00 30,00±0,00	15 30	Soft Soft
Chickpea	Type2	2,11±0,02 No soaking	2,42±0,07 2,26±0,11	Pressure cooker	8,00±2,00 30,00±2,89	6-10 25-30	*Al dente*/Soft *Al dente*/Soft
Soy	Type 2	2,35±0,02 No soaking	2,53±0,10 2,40±0,13	Pressure cooker	15,00±0,00 25,00±0,00	15 25	Soft Soft
Pea	Type1 e 3 Type2	No soaking No soaking	2,16±0,11 1,80±0,25	Boiling Pressure cooker	29,00±1,67 8,00±2,12	27-31 6-9	*Al dente* Soft
Lentil	Indefinite	No soaking No soaking	2,72±0,01 3,12±0,16	Boiling Pressure cooker	33,00±2,89 3,00±1,41	30-35 2-4	*Al dente*/Soft Soft
Red lentil	Indefinite	No soaking	2,36±0,24	Boiling	15,00±7,07	10-20	*Al dente*/Soft
Black lentil	Indefinite	No soaking No soaking	2,08±0,11 2,36±0,32	Boiling Pressure cooker	17,00±3,54 5,00±0,58	15-20 4-5	*Al dente*/Soft *Al dente*/Soft
French lentil	Indefinite	No soaking No soaking	2,21±0,11 2,49±0,06	Boiling Pressure cooker	34,00±0,00 6,00±0,00	34 6	Soft Soft

Table 2. Weight change parameters and cooking times for 30 legumes during pre-preparation and preparation: hydration index (after 10-hour soaking), conversion index, and cooking time for prepared legumes (100 g): with or without soaking at room temperature, using moist heat methods (boiling in an uncovered pan [total time over medium heat] or pressure cooker [total time from pressure onset]) or dry heat (roasted peanuts [total time in 200ºC oven]). Rio de Janeiro-RJ and São Paulo-SP, 2023. (continues).

Legume	Variety*	Hydration index#	Conversion index+	Preparation technique	Average time of cooking (minutes)	Variation of time of cooking (minutes)	Cooked grain texture
Pigeon peas	Indefinite	2,22±0,09 No soaking	2,64±0,08 2,50±0,09	Pressure cooker	10,00±0,00 25,00±0,00	10 25	Soft Soft
Shelled peanuts	Type2	No soaking	1,55±0,04	Pressure cooker	36,00±1,73	35-38	Soft
Roasted shelled peanuts*	Type2	No soaking	0,94±0,04	oven	21,00±0,71	20-22	*Al dente*/Crocante

*Cooking was carried out in duplicate or triplicate for each sample. The amount of water used for cooking the legumes that were subjected to soaking was 700mL, while for those that did not go through this process it was 1000mL. hydration #Índice=hydrated weight/net weight; +Conversion index=weight of cooked food (with cooking water drainage)/net weight. Texture evaluated by tasting: the longer the cooking time within the indicated variation, the softer the texture obtained.

Figure 2. Photos of the 30 cooked legumes and the toasted peanuts

Source: the author

In packaged legumes, the term "grade" indicates the percentage of defective grains in the package. According to Technical Regulation No. 12, issued on March 28, 2008, concerning bean quality standards, grade 1 beans have a lower percentage of defective grains compared to grade 3 beans. Specifically, grade 1 beans contain 2.5% minor defects and 3.6% major defects, while grade 3 beans include 16.0% minor defects and 14.3% major defects. In this study, no significant defects such as foreign matter or impurities were identified in the legumes. Only whole and uniform grains were used for the experiments, excluding damaged, crushed, immature, broken, or split grains.[21] Legumes from categories 1, 2, and 3 were found; however, several were purchased in bulk without specific grade specifications.

The correction factor (CF) is an indicator that assesses the disposal of unused food parts during the pre-preparation stage, calculated as the ratio between the gross weight and the net weight of the food. For legumes, the correction factor is determined by weighing the dry grains (unwashed) before and after dry cleaning. In this study, correction factors for all legumes ranged from 1 to 1.05, and discarded material consisted solely of defective grains, with no foreign matter detected. In the past, grains often contained impurities, as they were sold immediately after harvest, requiring consumers to accurately sort through them before use. Nowadays, with the mechanical processing of grains, this does not occur so often.[22]

A common preliminary step in the pre-preparation of legumes is soaking, also known as maceration. This process involves soaking the grains in water for a specific duration. Depending on the legume variety, soaking duration may be longer.[17] The use of this technique reduces grain hardness proportionally to soaking time until reaching a peak.[23,24] Some legumes, such as peas and lentils, usually do not require pre-hydration and can be cooked directly.[9,17] Soaking can be performed in both household and institutional settings. According to Fernandes et al.,[25] 49% of nutritionists overseeing UPR (food service establishments) reported soaking beans, primarily for operational reasons, and in 69% of these establishments, the soaking water is discarded before cooking.

The hydration index reflects water absorption during the soaking phase and is applicable to foods immersed in water prior to cooking, such as grains and legumes. In this study, the HI ranged from 1.78 ± 0.01 for purple beans to 2.35 ± 0.02 for soybeans. These findings indicate the amount of water absorbed during soaking, which typically doubles the weight. This information is essential for estimating the hydrated weight in preparations where legumes are used after rehydration, followed by dry heat cooking, such as in dishes such as acarajé and falafel. Furthermore, HI can serve as a freshness indicator, as the rehydration capacity of dried foods tends to decrease over time.[14]

Neves & Sampaio[26] reported hydration indices comparable to those in the present study for lupin (2.39), black-eyed peas (2.28), lentils (2.17), adzuki beans (2.12), white beans (2.12), chickpeas (2.06), cowpeas (2.04), peas (2.00), black beans (1.99), bolinha beans (1.98), *carioca* beans (1.93), and chili beans (1.79).

The conversion index, also known as the "cooking factor," "absorption index," or "thermal factor,"[14] represents the ratio between the cooked weight and the net weight of food. This metric is essential in menu planning as it aids in estimating the yield of prepared foods after cooking. This enables accurate prediction of the raw food quantity required for cooking, preventing waste or underestimation.[27] A CI greater than 1 indicates weight gain during cooking, which is expected in legumes cooked using moist heat methods.

All legumes, except for roasted peanuts, exhibited a conversion index greater than 1, ranging from 1.05 ± 0.02 to 3.12 ± 0.16 for green beans and lentils, respectively, which were cooked without prior soaking. For soaked legumes, this index ranged from 1.99 ± 0,10 (purple beans) to 2.64 ± 0,08 (pigeon peas). It should be noted that this indicator may differ depending on the cooking time of the legume, and the weight of the legumes was measured without the cooking liquid. Furthermore, green beans are not classified as dry legumes due to their earlier harvest time compared to pulses. This can affect their carbohydrate content, particularly starch, which has water retention properties when gelatinized during cooking.[20] Consequently, the minimal weight gain during cooking resulted in a lower conversion index compared to other legumes. Its significance in Brazilian culinary preparations, particularly in the Northeast region, justifies its incorporationin the study.

Peanuts were the only legume prepared using dry heat cooking, which is feasible due to their unique compositional characteristics, including higher fat content (43.9%) and lower carbohydrate content (20.3%) compared to pulses.[28] This composition also explains the low CI (1.55) observed in cooked peanuts, as weight changes are primarily associated with water absorption by the starch present in the grain. Regarding its CI, oven-roasted peanuts presented a mean value of 0.94. This disparity arises from the cooking method, as dry heat causes moisture loss in the food, resulting in a reduced final weight.

Usually, a conversion or yield ratio of 2 to 3 times is expected for legumes cooked by moist heat compared to their raw, dry state. In the present study, the CI of dry legumes prepared with moist heat (except for green beans and peanuts) ranged from 1.80 to 3.12, for split dried peas and lentils, respectively. According to the FAO's assessment of 31 legumes,[29] using similar pre-preparation and preparation procedures as this study - including soaking, cooking, and draining the cooking water - the conversion index rangedfrom 2.20 for moth beans to 3.08 for mung beans. Observed Conversion Index Values were also reported for chickpeas (2.25), pigeon peas (2.30), split peas (2.33), black beans (2.35), pinto beans (2.38), lima beans (2.50), navy beans (2.60), kidney beans (2.61), whole green lentils (2.65), whole red lentils (2.65), cowpeas (2.67), and adzuki beans (2.80). Silva et al.[30] reported similar CI values for black beans (2.00), cowpeas (2.44), chickpeas (1.92), and lentils (2.64) to those found in the present study.

An essential aspect of legume quality is cooking time, which can be influenced by grain quality (e.g., genetic factors, environmental conditions, and post-harvest storage); legume type and size; pre-preparation methods (e.g., soaking or lack thereof); and cooking methods (e.g., pressure cooking, boiling).[23] Pre-hydrating legumes can reduce cooking time. In contrast, boiling takes longer than pressure cooking. In addition, legumes whose skins have been removed, such as split peas and lentils, have shorter cooking times and usually do not require prior hydration.[31]

Although Corzo-Ríos et al.[32] stated that physical features such as weight, width, length, and thickness were the main determinants of cooking times for Mexican beans, low correlation coefficients were found between these characteristics and cooking time. It is suggested that the genetics of the cultivar, the microstructure of the bean, and the chemical and enzymatic changes occurring during the storage process were more relevant. This finding may elucidate certain values observed in the present study, such as the discrepancy in cooking times between jalo beans (8-17 minutes) and *bolinha* beans (10-26 minutes), with the former being visibly larger.

Among the legumes that were not soaked and were cooked by boiling, the average cooking time ranged from 15 ± 7.07 to 56 ± 0.00 minutes for red lentils and green beans, respectively. Certain legumes, such as lentils, peas, and mung beans, do not require soaking due to their relatively short cooking times compared to other legumes.

For unsoaked legumes cooked in a pressure cooker, the average cooking time ranged from 2.00 ± 1.41 minutes for mung beans to 36 ± 1.73 minutes for peanuts. For soaked legumes, cooking times ranged from 3.00 ± 0.00 minutes for adzuki beans to 18 ± 1.15 minutes for black beans.

Corzo-Ríos et al.[32] examined *Phaseolus vulgaris* and *Phaseolus coccineus species* cultivated in Mexico. Cooking time was assessed, considering both fresh and hardened grains. The average cooking time for fresh grains ranged from 25 to 40 minutes, while for hardened grains, this range extended from 60 to 70 minutes. Extended cooking times can be attributed to various factors, including bean storage duration, temperature, humidity, hydration rate, and chemical and enzymatic changes that may includein the grain structure.[33]

Numerous studies examine the culinary processing of legumes, focusing on assessing how pre-preparation and preparation operations affect nutritional content, bioactive compounds, and antinutritional factors. However, these studies often lack detailed analysis of processing parametersnecessary to achieve optimal grain texture for consumption and culinary applications. In this regard, our findings diverge from those of Oliveira et al.,[34] who applied a uniform cooking duration (30 min) for black-eyed peas, pinto beans, *bolinha* beans, and pink beans, all of which underwent a 24-hour soaking period.

The culinary processing of legumes can also be adapted to meet specific nutritional requirements, which may influence cooking time. Martinez-Pineda et al.[35]explored cooking methods to encourage pulse consumption among individuals with chronic kidney disease. Theirstudyfound that after a 12-hour soaking period, chickpeas and lentils required 150 and 30 minutes of boiling time, respectively. However, using a pressure cookersignificantly, reduced the cooking times to 40 minutes for chickpeas and 15 minutes for lentils.

Schoeninger et al.[36] optimized the cooking time of carioca beans to 9 minutes after processing that involved soaking the grains for 13.1 hours, adding baking soda, and drying at 55°C.

Regarding the texture of cooked grains, which is influenced by cooking time, most legumes achieved softer textures, ideal for dishes cooked in broth, soups, stews, and other preparations. Conversely, certain varieties achieved an *al dente* texture, including chickpeas, adzuki beans, black beans, kidney beans, mung beans, *bolinha* beans, lentils, and peas. This texture is preferred in preparations such as salads and baked legume snacks following moist-heat cooking.

The cooking time of beans without soaking under pressure was 25 to 30 minutes for black beans and kidney beans, 25 to 27 minutes for *bolinha* beans and 5 to 7 minutes for adzuki beans. For mung beans, boiling times ranged from 30 to 40 minutes, while pressure cooking reduced this to 1 to 3 minutes. For the preparation of salads and farofas, firmer grains are ideal to achieve an *al dente* texture. On the other hand, a softer texture is preferred for dishes such as feijoada, dishes cooked in broth, soups, and stews. In the case of adzuki beans, the softer grains are often used in sweet dishes, such as *manju* and *anko*.

Cooking times for lentils varied by type: brown lentils required 30-35 minutes, red lentils (without skin) 10-20 minutes, black lentils 15-20 minutes, and green lentils 34 minutes when boiled. In the pressure cooker, cooking times varied: 2 to 4 minutes for regular lentils, 4 to 5 minutes for black lentils, and 6 minutes for green lentils. Data regarding the cooking time of red lentils in a pressure cooker were omitted from the table due to previous experiments, which revealed that the grains dissolved after only one minute of pressure cooking. For the preparation of salads and rice with lentils, a more *al dente* is typically desired. Conversely, for dishes such as soups, broths, burgers, and *dhal*, achieving softer textures is preferable.

Among the challenges in legume consumption are the lack of knowledge about making these grains and the perception of the time needed for cooking.[4] Understanding cooking duration is crucial for achieving proper texture; overcooking can lead to excessive softening and disintegration, while undercooking results in a hardened texture, preventing the thickening of broths, as seen in the preparation of bean stews. In this context, the cooking time results can serve as a resource for recipe development and may be beneficial in culinary preparations involving other food groups, such as rice with lentils, which may have variable cooking times.

Understanding the culinary properties of legumes is essential for nutritionists, chefs, and consumers, given their prevalent use in home cooking and their role in ultra-processed food reduction (UPR), a key aspect of Brazilian food culture. By evaluating differentsoaking methods (or the absence thereof) and cooking techniques, and their effectson cooking time and texture, this research provides valuable insights for using these grains in various culinary preparations. These findingscan be adapted to meet specific recipe requirements and preferences. Additionally, the data can be applied in teaching Culinary Techniques, developing technical specifications for institutional food services, and supporting food and nutrition education strategies related that promote culinary skills.

Some limitations of the study should be noted. Numerous culinary preparations involving legumes incorporate oil before cooking (e.g., for sautéing garlic and/or onion) or other ingredients such as salt, acids, or bases (e.g., sodium bicarbonate), which can affect cooking time and grain softening. These conditions were not assessed in the conducted experiments, as the grains were cooked only in filtered water to simulate typical household and institutional cooking practices. Another consideration is that no rheological assessment was conducted on the purchased grains to evaluate hard-to-cook beans, for example. Furthermore, hot water soaking, recommended for inactivating soybean lipoxygenases or widely used in institutional food preparation for legumes such as beans, was not evaluated under the experimental conditions of this study.

CONCLUSION

The study offered valuable insight into weight changes across a variety of legumes under consistent pre-preparation and preparation conditions, leading tothe creation of a comparative table. This table can serve astechnical guidance forchoosing or omitting soaking methods and cooking techniques based on available time or when cooking legumeswith other ingredients.

As expected, all legumes showed weight gain during soaking and moist-heat cooking, thoughthis behavior varied by grain type, resulting in distinct weight change indicators Additionally, soaking and pressure cooking significantlyreduced cooking time compared to not soaking and boiling.

Hydration and conversion indices offer valuable insights for bothconsumers and food industry professionals, providing practical guidance for planningculinary preparations. These indices are also highly useful in teaching culinary nutrition, applying them in food service settings, and developing educational materials. However, the existing literature lacks comparable data tothe findings presented in this study. Therefore, further research is needed to either validate or challenge these findings and potentially broaden the scope of experimental conditions.

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Contributors

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