The Effect of Soaking and Boiling on Physical and Chemical Properties of Read Kidney Beans Instant

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Abstract. Red kidney beans are a plant-based food that contains protein, carbohydrates, dietary fiber, vitamins, and minerals,. Red kidney beans take a long time to cook and have a rough texture. As a result, instant red kidney beans must be developed. Soaking, boiling, and drying are the steps in the production of instant goods. The objective of this research was to determine the physical and chemical characteristic of soaked-boiled red kidney beans and instant red kidney beans based on soaking and boiling times. The study used a factorial completely randomized block design. The first factor was soaking time, which had three treatments (0 hours, 6 hours, and 12 hours). The second factor was cooking time, which had three treatments (0 minutes, 10 minutes, or 20 minutes). The study was carried out three times. Data analysis was conducted statistically using analysis of variance (ANOVA) at a 5% significance level to determine the effect of treatment on test parameters. If the treatment has a significant effect, a further Duncan test will be conducted to determine the differences between treatments. The results showed that soaking and boiling affected the physical and chemical characteristics of instant red beans. The weight, yield, and hydration capacity of instant red beans increased with the longer soaking and boiling, and the hardness, density of the kamba, and color intensity of instant red beans decreased with the longer soaking and boiling. Soaking for 6 hours and boiling for 10 minutes was the optimal time to produce instant red beans. The physical and chemical characteristics of instant red beans included weight 161.5 g, density of kamba 0.71 g/ml, hardness 2.83 cm/kg, hydration capacity 66.67%, water content 8.02%, and soluble protein 6.71%.

Keywords: ***instant***, ***boiling, read kidney beans, soaking***

INTRODUCTION

Red kidney beans (*Phaseolus vulgaris*) are a kind of legume that are widely utilized in cuisine in many countries, including Indonesia, in dishes such as red bean ice, soup, and porridge. Red kidney beans are also used to make a variety of culinary items, including semi-finished red kidney beans flour [1, 2], yogurt [3], red kidney beans cookies [4], and red kidney beans kefir [5]. Red kidney beans provide a variety of high-quality nutrients, including protein, carbohydtares, dietary fiber, minerals, and vitamins [6, 7,8,9,10]. Red kidney beans can also function as functional food because they contain active components such as phenolics and have antioxidant activities [11, 12, 13].

Although red kidney beans have high nutritional content and good active components, their use is limited by their hard texture. This creates a need for instant red bean-based products that can provide convenience in a short time. Soaking, boiling, and drying are the three processes involved in producing instant red kidney beans. Soaking is a common treatment for most legumes before cooking. In general, legumes are soaked in cold water for 8–12 hours. Soaking can also be done at high temperatures and soaking in salt or alkali solutions [14]. Soaking serves to soften the cell walls of legume seeds and facilitate the subsequent cooking process [15]. Heating food ingredients at a temperature of 100 °C or more with the main aim of obtaining a better taste, better aroma, and softer texture to kill microbes and inactivate all enzymes. Heating can be done by boiling and steaming at a temperature of 100 °C [16]. Drying is the final stage in making instant products. Various drying methods can be done, such as oven drying, freeze drying, and vacuum drying. An important characteristic of instant products is the rehydration process, and this is also influenced by the drying process [17].

The technique of producing instant red kidney beans has not been widely used. The physical and chemical characteristics of red kidney beans throughout the soaking and boiling processes, which produce soaked-boiled red beans, and drying, which produces instant red kidney beans, must be understood. Therefore, this study aims to determine the effect of soaking and boiling on the physical and chemical characteristics of soaked-boiled red beans

and instant red beans and to determine the optimal soaking and boiling times of soaked-boiled red beans and instant red beans.

METHODS

The study was conducted experimentally using a factorial completely randomized block design. The first factor was the soaking time with three levels (0 hours, 6 hours, and 12 hours). The second factor was the boiling time with three levels (0 minutes, 15 minutes, and 30 minutes). The study was conducted with three repetitions. The materials used to make instant red kidney beans are red kidney beans from Gintung market in Bandar Lampung. The tools used to make instant red kidney beans and physical and chemical characteristics are scales, pans, stoves, sieves, oven, measuring cups, and hardness testers.

The making of instant red kidney beans is done in stages, namely soaking, boiling, and drying. In the first stage, red kidney beans are soaked in water with a ratio of 1:3 for 0 hours, 6 hours, and 12 hours. Soaked red kidney beans are boiled in water for 0 minutes, 10 minutes, and 20 minutes with a ratio of 1:4 for 10-minute cooking and 1:6 for 20-minute cooking. Boiled red kidney beans are dried at a temperature of 50^{o}C for 20 hours.

Tests conducted on red kidney beans include weight, yield, bulk density, hardness, and hydration capacity.

a. Weight (g)

Weighing raw red kidney beans, soaked-boiled red kidney beans, and dried red kidney beans separately

b. Yield (%)

Weighing raw red kidney beans, soaked-boiled red kideny beans, and instant red kidney beans separately. Yield is determined by the formula:

$$\text{Yield (\%)} = \frac{\text{weight of soaked-boiled red kidney beans}}{\text{weight of raw red kidney beans}} \times 100\%$$

c. Bulk density (g/mL)

Put raw red kidney beans, soaked-boiled red kidney beans, and instant red kidney beans into a 100-mL measuring cup separately. Knock the measuring cup on the table 25-30 times to compress the red kidney beans evenly. Weigh the weight of the red kidney beans in the measuring cup. Bulk density is determined by the formula:

$$\text{Density of beans (g/ml)} = \frac{\text{weight of red kidney beans (g)}}{\text{volume of red kideny beans (mL)}}$$

d. Hardness

Measuring the hardness of raw red kidney beans, soaked-boiled red kideny beans, and dry red kidney beans (instant) with a penetrometer. Place the material on the penetrometer. Set the penetrometer needle to zero, then press the penetrometer lever on the material. The penetrometer needle will move, and the number listed on the penetrometer is the hardness value of the material.

e. Hydration capacity

Measuring the rehydration capacity of instant red kideny beans with the following steps: 1) preparing 200 ml of water; 2) boiling the water; 3) weighing 10 g of instant red kidney beans; 4) putting the instant kidney beans into a pan containing boiling water; 5) boiling red kidney beans for 5 minutes; 6) turning off the stove; 7) throwing away the boiled water; 8) draining the rehydrated red kidney beans; 9) weighing the rehydrated red kidney beans; 10) calculating the rehydration capacity of instant red kidney beans using the formula:

$$\text{Hydration capacity (\%)} = \frac{\text{weight of rehidration reb kidney beans} - \text{weight of instan red kidney bean}}{\text{weight of instan red kidney bean}} \times 100\%$$

RESULTS AND DISCUSSION

Physical Characteristic

Weight of Soaked-boiled Red Kidney Beans

Soaking and boiling affected the weight of soaked-boiled red kidney beans (P<0.05). The weight of soaked-boiled red kidney beans ranged from 200 g to 414.33 g (Figure 1). The yield of soaked-boiled red kideny beans ranged from 100% to 207.17%. The weight of red kideny beans after soaking for 6 hours (B1) and 12 hours (C1) was higher than that of unsoaked red kidney beans (A1). The weight of red kidney beans increased due to soaking. The weight of red kidney beans after boiling for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) was higher than that of unboiled red kidney beans (A1, B1, C1). The weight of red kidney beans increased due to boiling. However, the weight of red kidney beans after soaking for 6 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (B1, B2, B3) and 12 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (C1, C2, C3) were relatively the same. The weight of red kidney beans did not increase with the longer soaking and boiling.

Based on [18] water absorption will increase if the soaking and boiling time of red kidney beans increases. The water absorption of red kidney beans increased by 54.3%, 60.2%, and 75.7%, respectively, at soaking for 0 hours, 6 hours, and 12 hours with boiling for 10 minutes. According to [19], soaking and boiling cause water to enter the red kidney beans due to the difference in water content of the red kidney beans with the soaking water and boiling water. This difference causes the soaking water and boiling water to be pushed into the red kidney beans. Based on mass balance, diffusion will occur from high concentration to low concentration until equilibrium is reached. Based on [16] stated that legumes, including red kidney beans, contain starch granules composed of amylose and amylopectin. The entry of water into red kidney beans can damage the crystallinity of amylose and damage the helix so that the granules swell.

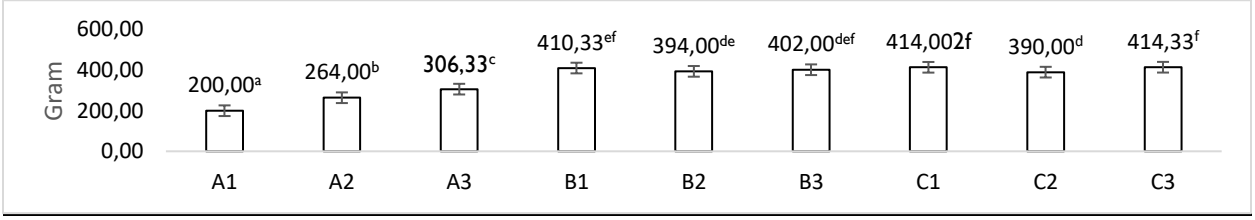

Figure 1. Weight of soaked-boiled read kidney beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 12 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 10 minute	C2	soaking 12 hours, boiling 10 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 20 minute	C3	soaking 12 hours, boiling 20 minute

Bulk Density of Soaked-boiled Red Kidney Beans

Soaking and boiling affected the density of soaked-boiled red kidney beans (P<0.05). The density of soaked-boiled red kidney beans ranged from 0.65 to 0.78 (Figure 2). The density of red kidney beans soaked for 6 hours (B1) and 12 hours (C1) was lower than that of unsoaked red kidney beans (A1). The density of red kidney beans decreased due to soaking. The density of red kidney beans boiled for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) was lower than that of unboiled red kidney beans (A1, B1, C1). The density of red kidney beans decreased due to boiling. However, the density of red kidney bean after soaking for 12 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (C1, C2, C3) was higher than after soaking for 6 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (B1, B2, B3). The density of red kidney bean increased with the longer soaking and boiling.

According [20], the bulk density can indicate the number of empty cavities between the material particles. The greater bulk density in a material, the fewer the number of empty cavities. The bulk density is influenced by the type of material, water content, shape, and size of the material. Food ingredients are declared bulk if their bulk density is small. The smaller bulk density, more porous the product is. This shows that the soaking and boiling can produce hollow red kidney beans, which are important during the instant red kidney bean hydration process.

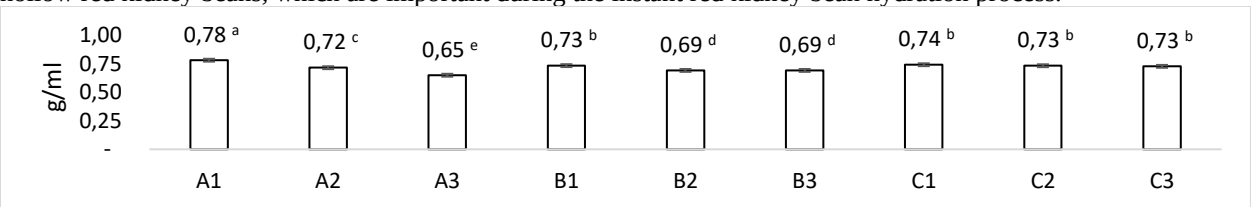

Figure 2. Bulk density of soaked-bioled red beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 12 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 10 minute	C2	soaking 12 hours, boiling 10 minute

A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 20 minute	C3	soaking 12 hours, boiling 20 minute

Hardness of Soaked-boiled Red Kidney Beans

Soaking and boiling affected the hardness of soaked-boiled red kidney beans (P<0.05). The hardness of soaked-boiled red kidney beans ranged from 1.52 to 18.19 cm/kg (Figure 3). The hardness of red kidney beans after soaking for 6 hours (B1) and 12 hours (C1) was lower than that of unsoaked red kidney beans (A1). The hardness of red kidney beans decreased due to soaking. The hardness of red kidney beans after boiling for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) was lower than that of unboiled red kidney beans (A1, B1, C1). The hardness of red kidney beans decreased due to boiling.

According to [18], the decrease in hardness occurs due to the decomposition of pectin and the weakening of the relationship between cells, as well as decreased shear strength during boiling. In addition, the bean and microstructure of the bean are responsible for facilitating rapid softening of the bean during soaking.

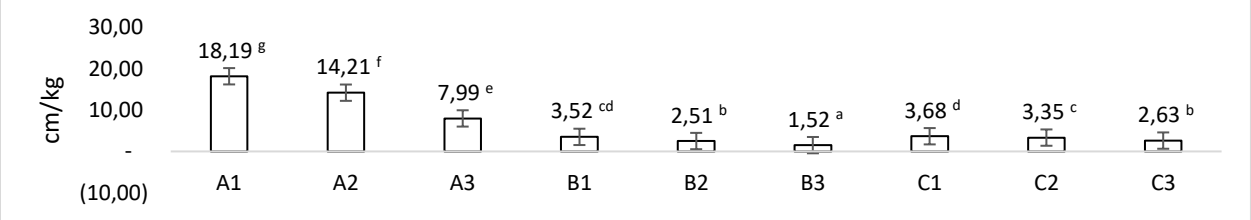

Figure 3. Hardness of soaked-bioled red beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 6 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 10 minute	C2	soaking 6 hours, boiling 10 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 20 minute	C3	soaking 6 hours, boiling 20 minute

Weight of Red Kidney Beans Instant

Soaking and boiling affected the weight of instant red kidney beans (P<0.05). The weight of instant red kidney beans ranged from 200g to 153.5g (Figure 4). The weight of instant red kidney beans soaked for 6 hours (B1) and 12 hours (C1) was lower than that of red beans without soaking (A1). The weight of instant red kidney beans decreased due to soaking. The weight of instant red kidney beans boiled for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) was lower than that without boiling (A1, B1, C1). The weight of instant red kidney beans decreased due to boiling. However, the weight of instant read kidney beans soaked for 12 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (C1, C2, C3) was higher than that of soaking for 6 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (B1, B2, B3). The weight of instant red kidney beans increases as they are soaked for longer.

The weight of instant red kidney beans decreases due to longer soaking and boiling. Red kidney beans are able to absorb large amounts of water during soaking and boiling. Drying red kidney beans causes the water in the red kidney bean matrix to evaporate and causes a decrease in the weight of instant red kidney beans.

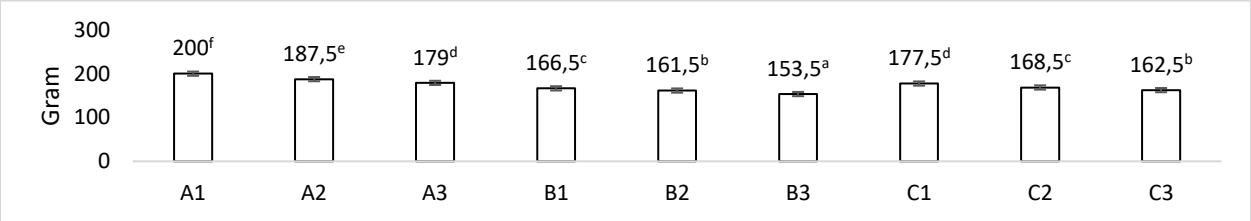

Figure 4. Weight of instant read kidney beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 12 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 10 minute	C2	soaking 12 hours, boiling 10 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 20 minute	C3	soaking 12 hours, boiling2 0 minute

Bulk Density of Instant Red Kidney Beans

Bulk density is one of the physical parameters of instant products. Instant products that have low bulk density indicate that the product structure is porous, while high bulk density indicates a dense product structure (Boukouvalas et al., 2006).

Soaking and boiling affected the density of instant red kidney beans (P<0.05). The density of instant red kidney bean ranged from 0.69 to 0.78 (Figure 5). The same pattern in the density of soaked-boiled red kidney bean occurred in the density of instant red kidney bean. The density of instant red kidney bean soaked for 6 hours (B1) and 12 hours (C1) was lower than that of instant red kidney beans without soaking (A1). The density of instant red kidney bean decreased due to soaking. The density of instant red kidney bean boiled for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) was lower than that of instant red kidney beans without boiling (A1, B1, C1). The density of instant red kidney bean decreased due to boiling. However, the density of red kidney bean after soaking for 12 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (C1, C2, C3) was higher than after soaking for 6 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (B1, B2, B3).

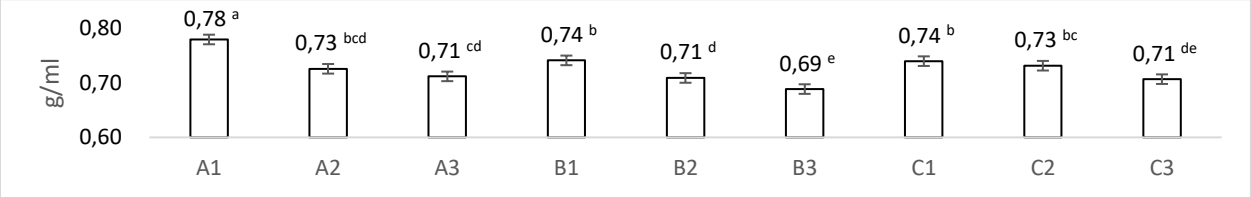

Figure 5. Bulk density of instant read kidney beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 6 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 0 minute	C2	soaking 6 hours, boiling 0 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 0 minute	C3	soaking 6 hours, boiling 0 minute

Hardness of Instant Red Kidney Beans

Soaking and boiling affected the hardness of instant red kidney beans (P<0.05). The hardness of instant red kidney beans ranged from 1.93 to 12.13 cm/kg (Figure 6). The same pattern of hardness of soaked-boiled red kidney beans occurred in the hardness of instant red kidney beans. The hardness of instant red kidney beans after soaking for 6 hours (B1) and 12 hours (C1) was lower than that of red kidney beans without soaking (A1). The hardness of instant red kidney beans decreased due to soaking. The hardness of instant red kidney beans after boiling for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) was lower than that of instant red kidney beans without boiling (A1, B1, C1). The hardness of instant red kidney beans decreased during boiling. However, the hardness of instant red kidney beans after soaking for 12 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (C1, C2, C3) was higher than after soaking for 6 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (B1, B2, B3).

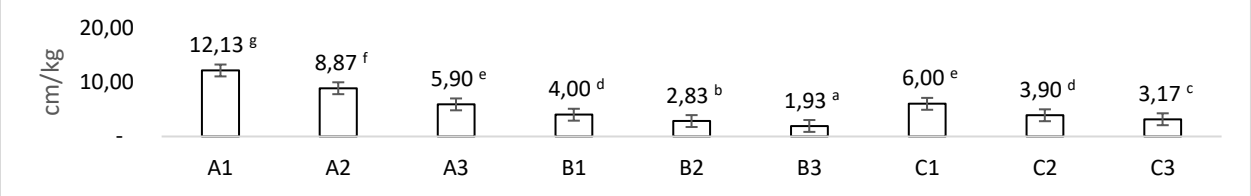

Figure 6. Hardness of instan read kidney beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 6 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 0 minute	C2	soaking 6 hours, boiling 0 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 0 minute	C3	soaking 6 hours, boiling 0 minute

Hydration Capacity of Instant Red Kidney Beans

Soaking and boiling affected the hydration capacity of instant red kidney beans (P<0.05). The hydration capacity of instant red kidney beans ranged from 18.33% to 109.17% (Figure 7). Hydration capacity is the ability of instant red kidney beans to reabsorb water after receiving drying treatment (Sukasih et al., 2020). The hydration capacity of instant red kidney beans at 6-hour soaking (B1) and 12-hour soaking (C1) was higher than that of red kidney beans without soaking (A1). The hydration capacity of instant red kidney beans at 10-minute boils (A2, B2, C2) and 20-minute boils (A3, B3, C3) was higher than that of instant red kidney beans without boiling (A1, B1, C1). The hydration capacity of instant red kidney beans after soaking for 12 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (C1, C2, C3) was higher than after soaking for 6 hours with boiling for 0 minutes, 10 minutes, and 20 minutes (B1, B2, B3).

The hydration capacity of instant red kidney beans increases with increasing soaking and boiling times. Instant red kidney beans, after the boiling and soaking process, become more porous so that when cooked they will absorb a lot of water.

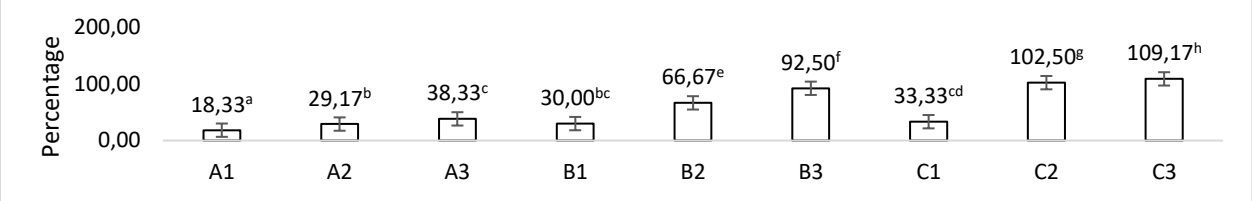

Figure 7. Hydration capacity of instan read kidney beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 12 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 10 minute	C2	soaking 12 hours, boiling 10 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 20 minute	C3	soaking 12 hours, boiling 20 minute

Soaked-boiled red kidney beans and instant red kidney beans are presented in Figures 8 and 9. The soaking and boiling processes affect the color of soaked-boiled red kidney beans and instant red kidney beans. Red kidney beans without soaking and boiling have a red color; after the soaking and boiling process and drying, there is a decrease in the intensity of the red color. The red color in red kidney beans comes from anthocyanin, which is water-soluble [22]. Anthocyanin will dissolve due to soaking and boiling, causing the color of the red kidney beans to fade.

0 minutes 10 minutes 20 minutes — Soaking 0 hours
0 minutes 10 minutes 20 minutes — Soaking 6 hours
0 minutes 10 minutes 20 minutes — Soaking 12 hours

Figure 8. Soaked-boiled red kidney beans

0 minutes 10 minutes 20 minutes — Soaking 0 hours
0 minutes 10 minutes 20 minutes — Soaking 6 hours
0 minutes 10 minutes 20 minutes — Soaking 12 hours

Figure 9. Instant red kidney beans

Moisture Content of Instant Red Kidney Beans

Moisture content is an important parameter in a food ingredient, such as the shelf life of a food product. The lower the water content of a food ingredient, the higher its shelf life. Soaking, boiling, and drying affect the moisture content of instant red kidney beans ($P<0.05$). The water content of instant red kidney beans ranges from 6.73% to 12.47% (Figure 10).

Soaking for 6 hours (B1) and 12 hours (C1) showed that the moisture content of instant red kidney beans was lower than red kidney beans without soaking (A1). Soaking for 6 hours (B1) and 12 hours (C1) caused the cell walls to absorb water and soften. However, with elasticity, the cell walls will return to their original shape when dried. Soaking can affect the elasticity of the cell walls after drying, so that water will be absorbed from the environment into the cell walls of the material.

The boiling for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) showed that the moisture content of instant red kidney beans was higher than that of instant red kidney beans without boiling (A1, B1, C1). Unlike soaking, boiling has the effect of reducing the moisture content of instant red kidney beans. During boiling, red kidney beans absorb more water, causing the beans to be more porous. During drying, water can be easily evaporated, thus reducing the moisture content of instant red kidney beans.

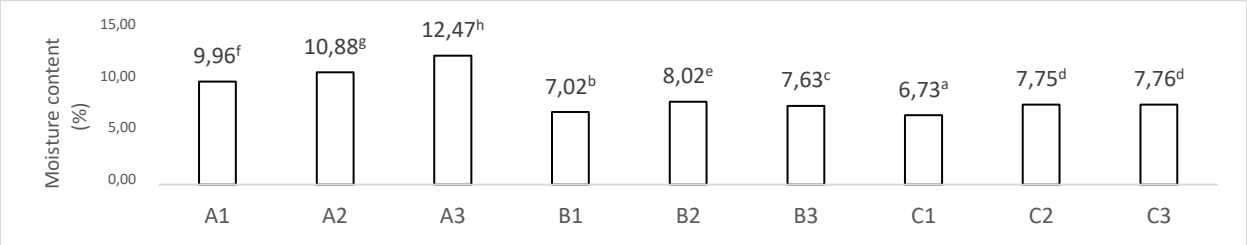

Figure 10. Moisture content of instan read kidney beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 12 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 10 minute	C2	soaking 12 hours, boiling 10 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 20 minute	C3	soaking 12 hours, boiling 20 minute

Soluble Protein of Instant Red Kidney Beans

Legumes are a source of vegetable protein ranging from 19% to 30%. Red kidney beans contain protein ranging from 16.7 to 27.7 g/100 g. Albumins (<20%) and globulins (>50%) are the two dominant types of proteins found in legumes [15]. Albumin is a water-soluble protein and coagulated by heat, while globulin is a water-insoluble protein, coagulated by heat, soluble in dilute salt solutions, and precipitated in high-concentration salt solutions [23].

Soaking and boiling affected the soluble protein of instant red kidney beans ($P<0.05$). The protein content of instant red kidney beans ranged from 1.56% to 18.46% (Figure 11). The soluble protein of instant red kidney beans soaked for 6 hours (B1) and 12 hours (C1) was lower than that of red kidney beans without soaking (A1). The soluble protein of instant red kidney beans boiled for 10 minutes (A2, B2, C2) and 20 minutes (A3, B3, C3) was lower than that of instant red kidney beans without boiling (A1, B1, C1). The soluble protein of instant red kidney beans decreased due to soaking, but the soluble protein of instant red kidney beans decreased even more due to boiling. The red kidney bean protein will dissolve in the soaking water and the boiling water, causing the soluble protein to be high in the soaking water and the boiling water.

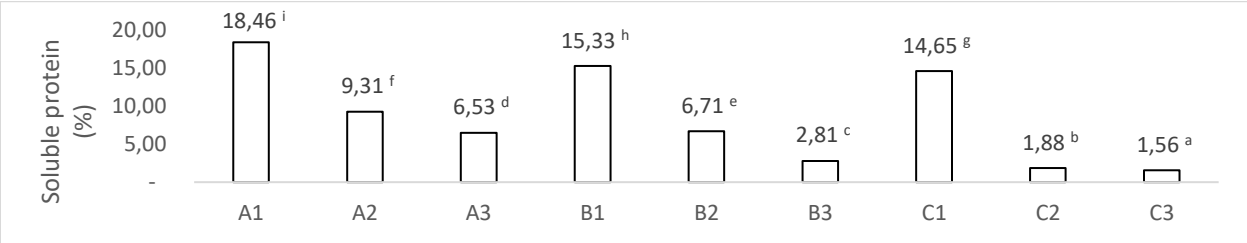

Figure 11. Soluble protein of instan read kidney beans

Keterangan

A1	soaking 0 hours, boiling 0 minute	B1	soaking 6 hours, boiling 0 minute	C1	soaking 12 hours, boiling 0 minute
A2	soaking 0 hours, boiling 10 minute	B2	soaking 6 hours, boiling 10 minute	C2	soaking 12 hours, boiling 10 minute
A3	soaking 0 hours, boiling 20 minute	B3	soaking 6 hours, boiling 20 minute	C3	soaking 12 hours, boiling 20 minute

CONCLUSIONS

Soaking and boiling affect the physical and chemical characteristics of soaked-boiled red kidney beans and instant red kidney beans. The optimal soaking and boiling time to produce soaked-boiled red kidney beans is soaking for 6 hours and boiling for 10 minutes, resulting in a weight of 394.99 g, a density of 0.69 g/ml, and a hardness of 2.51 cm/kg. The optimal time to produce instant red kidney beans is soaking for 6 hours and boiling for 10 minutes, resulting in a weight of 161.5g, a density of 0.71g/ml, a hardness of 2.83 cm/kg, a hydration capacity of 66.67%, a water content of 8.02%, and a soluble protein of 6.71%. The color intensity of red kidney beans decreases due to soaking and boiling.

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