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Effect of Sprouting on Selected Macronutrients and physical Properties of four Zambian Common Bean (*Phaseolus Vulgaris*) Varieties

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Abstract Sprouting is one of the popular methods used to prepare legumes for human consumption. In this study, the effect of sprouting on selected macronutrients (crude protein, crude fat, crude fibre and ash) and physical properties (hydration capacity after 24 hrs and equilibrium hydration capacity) of four common bean Zambian varieties were investigated. The varieties studied were *Lyambai parent*, *Lyambai 4-4-B*, *Lundazi* and *Carioca-38*. The crude protein values ranged from 17.6-24.4% before sprouting to 28.0-30.72% at day 6 of sprouting. Crude fibre content ranged from 4.1-5.9 before sprouting to 6.0-7.8% at day 6 of sprouting. Crude fat content ranged from 1.5-3.1% before sprouting to 3.8-6.3% at day 6 of sprouting. Ash content ranged from 4.1-4.8% before sprouting to 7.2-8.1 after 6 days of sprouting. Hydration capacity ranged from 0.210 to 0.475 g/seed among the four varieties after 24 hrs of soaking. Equilibrium hydration capacity was reached at different times among the four varieties. *Carioca 38* was first at 72 hrs and *Lundazi* was last at 120 hrs. Sprouting was found to have a positive effect on crude protein, crude fat, crude fibre and ash contents of the selected common bean varieties investigated. Further, these common bean varieties demonstrated varying hydration patterns.

Keywords: *sprouting, common beans, macronutrients, physical properties*

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1. Introduction

Legumes play a significant role in the diets of people in many regions of the world. They include Peas, beans, lentils, peanuts and other podded plants that are used as food [1,2]. Common bean *(Phaseolus vulgaris)* is one of the most commonly consumed legume in the world. It is an important food crop with an outstanding potential to resolve nutritional, health, income generation and agricultural sustainability needs of developing countries in Sub-Saharan Africa and elsewhere in the world [3]. The contribution of common bean to world nutrition remains significant especially in developing countries where it is the main source of protein to the poor majority. This is because protein has always been recognized as the most significant macronutrient in common bean despite it being a good source of carbohydrate, fiber, minerals and vitamins as well [3].

Legumes are prepared or processed in many ways for human consumption. Different processing methods are applied depending on the intended use of the final product and the availability of the processing facilities [4]. Among the processing technologies, sprouting is one of the technique used to prepare a number of legumes including common bean for human consumption. Sprouting of seeds has been shown to significantly enhance their nutraceutical value and nutrients bioavailability [5,6]. Previous studies have reported that the original composition of seeds essentially changes during germination [7]. Enhancement of nutraceutical phenolics in common beans and bambara groundnuts after sprouting has been reported [6]. Thus germination can lead to the development of functional foods that have positive effect on the human organism and help in maintaining the health [8]. The attention of experts dealing with the healthy nutrition in the last decades had shifted more towards the determination of the biological value of the nutritional sprouts [9]. The consumption of sprouted seeds has become common in Western Europe as sprouts were perceived to meet the modern nutrition requirements [9].

In this study, the effect of sprouting on crude protein, crude fat, crude fibre and ash contents of four common bean Zambian varieties (*Lyambai parent*, *Lyambai 4-4-B*, *Carioca 38* and *Lundazi*) were investigated. *Lyambai 4-4-B* and *Carioca 38* are newly developed varieties through irradiating of the parents *Lyambai* and *Carioca* respectively while *Lundazi* is a landrace [10]. Further, selected physicochemical properties (hydration capacity and equilibrium hydration capacity) prior to sprouting were also investigated. Scientific data regarding the effect of sprouting on the nutritional and physicochemical properties of these common bean varieties is limited.

2. Materials and Methods

2.1. Sample Collection

The red (*Lundazi)* common bean variety was collected from Chipata at Saturday market while red-speckled *Lyambai-parent*, *Lyambai-4-4-B* and white *Carioca 38* common bean varieties were collected from the Department of Plant Science in the School of Agricultural Sciences, University of Zambia. The seeds were manually cleaned by removing dust, dirt and cracked seeds.

2.2. Determination of Hydration Capacity after 24 hrs of Soaking

The hydration capacity was determined according to the method described by [3,11]. Fifty (50) seeds for each variety were placed in the measuring cylinder with 100ml of water and left to hydrate for 24 hrs. The initial weights of the seeds before imbibition were then subtracted from weight of the seeds after imbibition. The difference in weight was then divided by the number of seeds to determine the seeds hydration capacity.

$$Hydration\ Capacity = \frac{\begin{pmatrix} Weight\ of\ seeds\ after\ imbibition \\ -weight\ of\ seeds\ before\ imbibition \end{pmatrix}}{Number\ of\ seeds}.$$

2.3. Determination of Equilibrium Hydration Capacity

Equilibrium hydration capacity was determined by the method of weight gain until a constant weight was attained. Fifty (50) seeds for each variety were placed in the measuring cylinder with 100 ml of water and allowed to hydrate. The weight of hydrated seeds was noted every after 24 hours. The equilibrium hydration capacity was reached when there was no more increase in weight.

2.4. Sprouting

Hundred (100) seeds of each variety were soaked in 100 ml distilled water for 12 hours for the seeds to absorb water. The seeds were then spread on a damp filter paper and allowed to germinate at room temperature (25°C) up to 6 days. Bean samples were analyzed for crude protein, crude fat, crude fibre, and ash contents after 3 and 6 days of sprouting respectively.

2.5. Chemical Analysis

Chemical composition analyses of the seeds for crude fat, crude protein, total ash and crude fiber were determined using AOAC official methods of 934.01, 920.39 (A), 984 (A – D), 942.05 and 978.10 respectively [12].

2.6. Data Analysis

Data was analysed using the Statistical Package for Social Sciences (SPSS) Software version 20. Results were expressed as mean values ± standard error. One-way Analysis of Variance (ANOVA) was used to analyse the data and values at $p < 0.05$ were considered statistically significant.

3. Results and Discussion

3.1. Hydration Capacity

Hydration capacity after 24 hrs of soaking of common bean varieties is presented in Table 1. The hydration capacity ranged from 0.210 to 0.475 (g/seed) among the four varieties. *Lundazi* had the maximum hydration capacity with 0.475 (g/seed) while *Carioca 38* had the minimum with 0.210 (g/seed). *Lyambai 4-4-B* had 0.459 (g/seed) while *Lyambai parent* had 0.445 (g/seed) respectively. There were no significant differences ($p > 0.05$) in the equilibrium hydration capacity of *Lyambai 4-4-B* and *Lyambai parent.* Hydration capacity has been shown to be inversely related to the cooking time [3,11]. Therefore, *Carioca 38* having the lowest hydration capacity, would most likely require longer cooking times than the other varieties. A similar relationship was observed between hydration capacity and the rate of sprouting in this study. The higher the hydration capacity, the faster the sprouting of the seeds. *Carioca 38* which recorded the lowest hydration capacity took longer than the others to start sprouting.

Table 1. Hydration capacity of the Zambian common bean varieties after 24 hrs of soaking

Common bean varieties	Hydration capacity (g / seed)
Lyambai parent	0.445 ± 0.005^a
Lyambai 4-4-B	0.459 ± 0.004^a
Carioca 38	0.210 ± 0.006^b
Lundazi	0.475 ± 0.005^c

Means in the same column for each legume type with different superscripts were significantly (p <0.05) different.

3.2. Equilibrium Hydration Capacity

The hydration pattern of the common bean varieties up to the time when equilibrium hydration capacity was reached is presented in Figure 1.

All the varieties were observed to have imbibed substantial amount of water during the first 24 hrs period. After this period, small but gradual increments in change of weight were recorded. *Carioca 38* was the first to reach constant weight after 72hrs (day 3). This was followed by the two *Lyambai* varieties *(Lyambai 4-4-B* and *Lyambai* *parent)* after 96hrs (day 4) and *Lundazi* was the last after 120hrs (day 5). There were no significant differences ($p > 0.05$) in the equilibrium hydration capacity of *Lyambai 4-4-B* and *Lyambai parent*. This may be so because *Lyambai 4-4-B*, being a mutant of *Lyambai parent*, most likely possessed a closely similar cell matrix to the parent. It has been reported that water uptake increase of a seed with time depends on the number of cells within the seed to be hydrated [13]. This likely may have contributed to the differences in the hydration pattern noted in the other common bean varieties investigated.

3.3. Ash Content

The ash contents of the unsprouted and sprouted *Lyambai parent*, *Lyambai 4-4-B, Carioca 38* and *Lundazi* are presented in Figure 2.

The ash contents of the unsprouted seeds ranged from 4.1% to 4.8%. *Lyambai 4-4-B* had the highest with 4.8% and *Lyambai parent* had the least with 4.1 %. On day 3, the ash contents of the sprouted seeds ranged from 5.2% to 5.8%. *Lundazi* had the highest (5.8%), *Lyambai 4-4-B* (5.6%), *Carioca 38* (5.4%) and *Lyambai parent* (5.2%). On day 6, the sprouted seeds ash content ranged from 7.2% to 8.1%. *Lundazi* recorded the highest (8.2%), *Lyambai 4-4-B* (8.1%), *Lyambai parent* (7.8%) and *Carioca 38* (7.2%).

There were significant differences ($P<0.05$) in the ash content among the sprouted seeds. Significant increase in ash content of seed after sprouting has been observed previously by other workers [14,15]. The increase in ash content is attributed to loss of starch during sprouting [16].

3.4. Crude Fat Content

The crude fat contents of the unsprouted and sprouted *Lyambai parent*, *Lyambai 4-4-B*, *Carioca 38* and *Lundazi* presented in Figure 3.

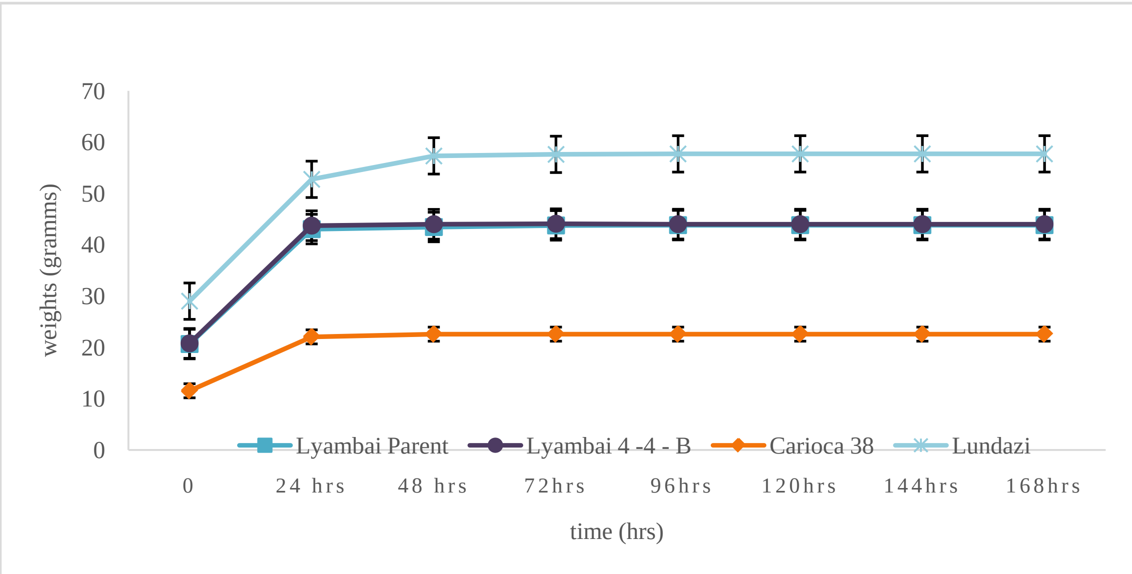

Figure 1. Hydration pattern of different common bean varieties with time

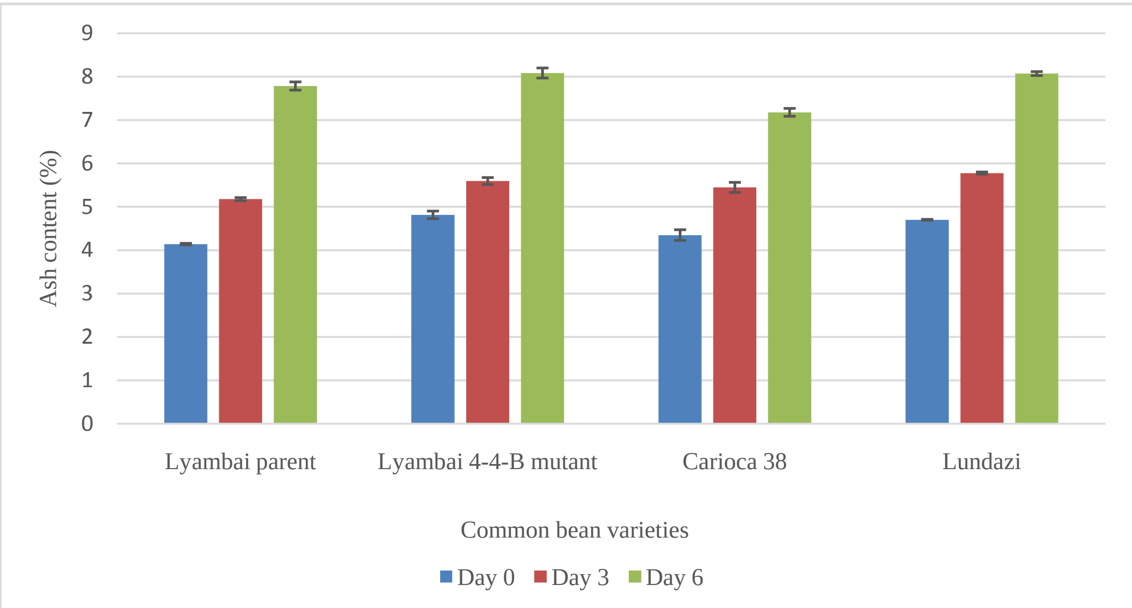

Figure 2. Ash content of the unsprouted and sprouted common bean varieties

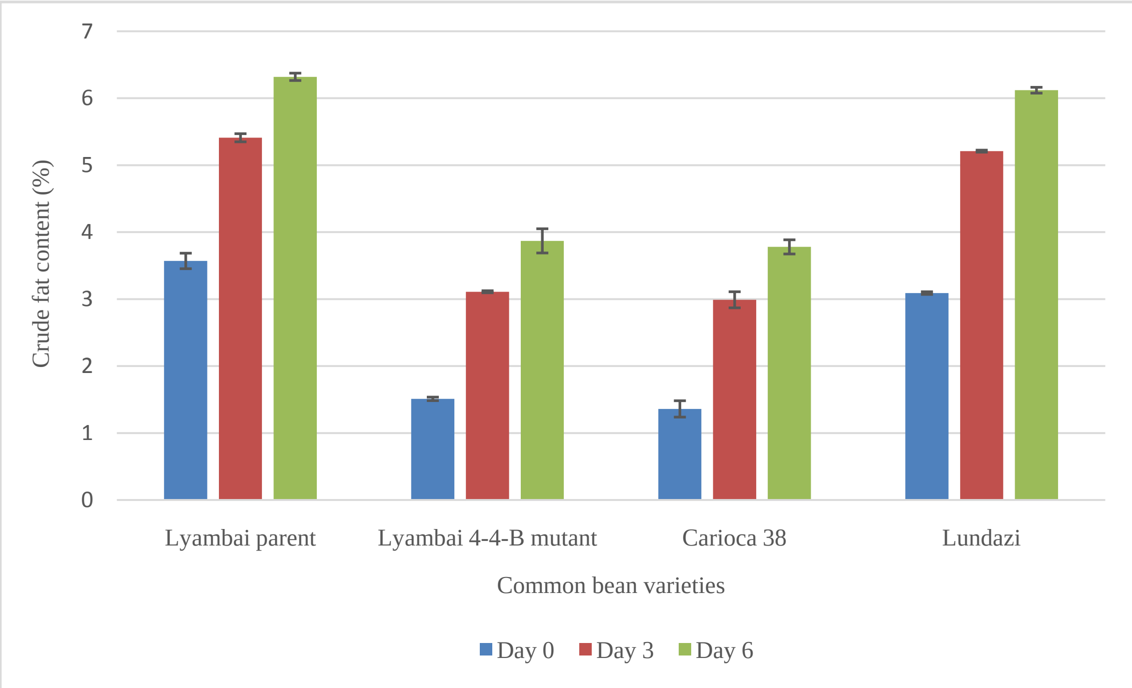

Figure 3. Crude fat content of the unsprouted and sprouted common bean varieties

The crude fat content of the unsprouted seeds ranged from1.5% to 3.6%. *Lyambai parent* had the highest content at day 0 with 3.6% and *Lyambai 4-4-B* the least (1.5%). On day 3 of sprouting, crude fat content ranged from 3.0% to 5.4%. *Lyambai parent* had the highest (5.4%) and *Carioca 38* the least (3.0%). On day 6 of sprouting, crude fat content in four varieties ranged from 3.8% to 6.3%. *Lyambai parent* recorded the highest (6.3%) and *Carioca 38* the least (3.8%).

There were significant differences ($P < 0.05$) in crude fat content among the sprouted seeds. The findings obtained for crude fat in this study are similar to what has previously reported by [17] in which fat concentrations in African Locust bean and Pigeon pea were observed to increase after sprouting. On the other hand, these findings are in contrast to what was found by [5] in a study on Mung bean and Chick Pea, but are in agreement with [18] where *Carioca-9*, *Solwezi Rose* and *Kablangete* common bean varieties were sprouted for 8 days. In the current study, it is generally observed that sprouting enhances the crude fat contents of the investigated varieties of common beans. This may be attributed to breaking of the food matrix, more especially carbohydrates leading to the release of more quantifiable crude fat.

3.5. Crude Protein

The crude protein contents of the unsprouted and sprouted *Lyambai parent*, *Lyambai 4-4-B*, *Carioca 38* and *Lundazi* are presented in Figure 4.

The crude protein content in the unsprouted seeds ranged from was 17.6% to 24.4%. *Lyambai 4-4-B* had the highest content (24.4%) and *Lundazi* the least (17.6%). On day 3, the crude protein content ranged from 25.7% to 28.7%. *Lyambai 4-4-B* recorded the highest (28.7%) and *Lundazi* least (25.7%). On day 6, crude protein content of the sprouted seeds ranged from 28.0% to 30.7%. *Lyambai 4-4-B* recorded the highest (30.7%) whereas *Lundazi* the least (28.0%). It is observed that in all the common bean varieties investigated, there was an increase in the protein content as a result of sprouting.

There were was significant differences ($P < 0.05$) in the crude protein content among the sprouted seeds. A similar trend for crude protein content increase after sprouting has been reported for other legumes by other researchers. A 19.15% increase in crude protein content after 28 hrs of sprouting in Cowpea has been observed previously [19]. Other workers have also reported a significant increase in crude protein after sprouting of mung beans, chicken peas and other legumes [5,20]. Considering the fact that during sprouting, there is a breakdown of reserve protein to give NH3, which accumulates in the form of amide such as glutamic acid and aspartic acid [21]. Such breakdowns give rise to more quantifiable crude protein. The increase in crude protein could likely be attributed to these changes. Metabolic enzymes such as proteinases are activated during sprouting which may lead to release of some amino acids and peptides and synthesis or utilization of these may form new proteins. Consequently, nutritional quality of proteins is enhanced [22].

3.6. Crude Fibre Content

The crude fibre contents of the unsprouted and sprouted *Lyambai parent*, *Lyambai 4-4-B*, *Carioca 38* and *Lundazi* presented in Figure 5.

The crude Fibre content of the unsprouted seeds ranged from 4.1% to 5.9%. *Lundazi* had the highest crude fibre content (5.9%) and *Carioca 38* the least (4.1%). On day 3 crude fibre content for the sprouts ranged from 4.6% to 6.4%. *Lundazi* still recorded the highest (6.4%) and *Carioca 38* least (4.6%). On day 6, crude fibre content for sprouts ranged from 6.0% to 7.8%. *Lundazi* had the highest at (7.8%) and *Carioca 38* the least (6.0%).

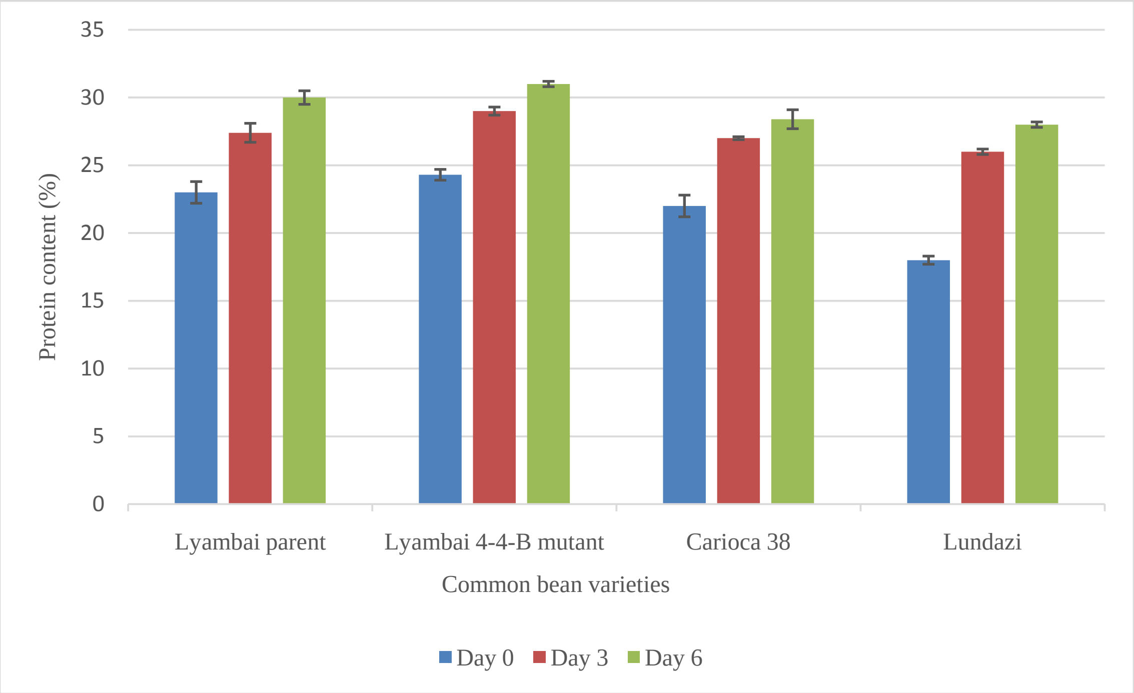

Figure 4. Crude protein content of the unsprouted and sprouted common bean varieties

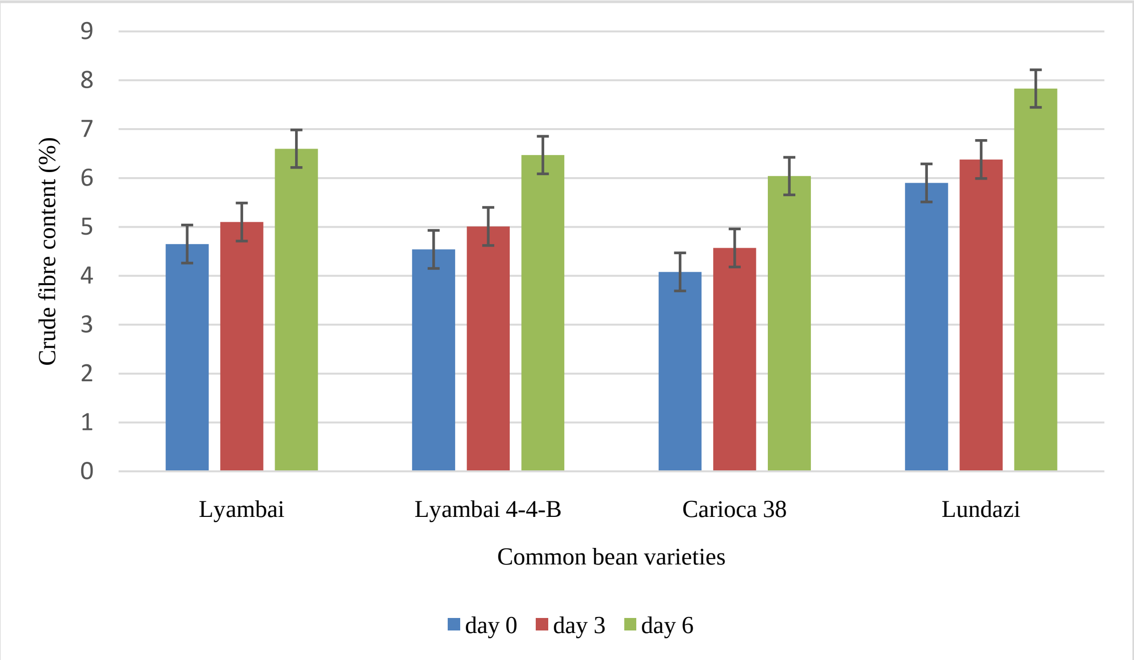

Figure 5. Crude fibre content of the unsprouted and sprouted common bean varieties

There were significant differences ($P < 0.05$) in the crude fibre content among the sprouted seeds of the four varieties. A similar trend for crude fibre content has been reported for other legumes by other researchers. A significant increase in the crude fibre content for all the genotypes of cowpea after 6 days of sprouting has been reported previously [14]. The current findings are also in agreement with the observations reported for other legumes in which substantial increase in crude fibre contents were noted [15,20,23]. Increase in crude fibre content is considered only as apparent and may be attributed to the disappearance of starch during sprouting, which is used to form new plant materials such the cell walls for the developing plant. The formation of these contributes to both soluble and insoluble fibres.

4. Conclusion

Sprouting had positive effects on the selected nutritional qualities of *Lyambai parent*, *Lyambai 4-4-B*, *Carioca 38* and *Lundazi* varieties investigated. For all the varieties, crude protein, crude fat, crude fibre, and ash contents were higher in the sprouted compared to the unsprouted seeds. Sprouting was thus found to enhance the nutritional profiles of the varieties investigated.

Further, these varieties demonstrated varying hydration behaviors prior to sprouting.

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