



Effect of Packaging Materials and Storage Periods on the Protein Content of Three Soybean Varieties from Makurdi, Benue State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2019/v30i330180

Editor(s):

(1) Dr. Abhishek Naik, Acsen Hyveg Pvt. Ltd., Vegetable Seed Division, India.

Reviewers:

(1) R. Mahalakshmi, India.

(2) Mariatulqabtiyah Abdul Razak, Universiti Putra Malaysia, Malaysia.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/52205>

Original Research Article

Received 12 August 2019
Accepted 24 October 2019
Published 02 November 2019

ABSTRACT

Soybeans are the leguminous vegetable of the pea family that grows in a tropical, subtropical and temperate climate. Protein and oil are soybeans seed components of great economic value. This work was carried out at the Seed Science Laboratory in the Federal University of Agriculture Makurdi, Nigeria. It was aimed at assessing the protein content of soybeans stored under ambient condition. The experimental design was factorial in 3x5x6x factorial completely randomized design (CRD) comprising 3 varieties, 5 storage periods and 5 packaging materials by 3 replicates. The varieties investigated were TGx 932- 3F, TGx1904- 6F and TGx1448- 2E stored in cloth, glass bottle, plastic container, low-density polyethylene and laminate paper. The storage periods were 0, 2, 4, 6 and 8 months Least significant (LSD) at 5% was used to compare the treatment means. The seeds in storage were sampled periodically (2, 4, 6 and 8 months) to determine the protein content. The protein content of the samples was determined according to the standard method. TGx 1448- 2E (V₃) had the highest protein content while TGx 1904- 6F (V₂) had the least. The highest protein content was recorded in soybeans packaged in a plastic container (43.55) while the least was recorded in soybeans that were not packaged in anything (control). The investigation showed that soybeans stored for 8 months had the highest protein content of 44.01 and the lowest was in 0

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months (36.47). It was observed that the protein content increased with increase in storage period. Significant differences ($P < 0.05$) were observed in all the main effects. The result of the interaction between variety and storage period showed V_3 (TGX-1448-2E) had the highest protein content when stored for 8 months and the lowest was V_2 (TGX-1904-6F) at 0 month (30.8) and the next lowest one was V_2 at 2 months (36.79). The interaction effect of storage period and packaging material on protein showed that the highest protein content was recorded at 8 months and the lowest was recorded at the 0 months (36.467). The interaction effect of variety and packaging material on protein content showed variation. The highest protein content recorded was in V_3 (44.795) while the lowest was for V_2 (39.847). The highest interaction was between $V_3 \times$ LDPE (44.795) and the lowest was $V_2 \times$ laminate paper. However, there were significant differences ($P < 0.05$) in all the interaction effects. The present study revealed that the protein content of stored soybeans varied with storage period, packaging material and variety.

Keywords: Soybean; variety; packaging material; storage period; interaction effect.

1. INTRODUCTION

Soybeans are the leguminous vegetable of the pea family that grows in tropical, subtropical and temperate climate [1]. Soybeans are often called the "Miracle crop" [2]. They are the world's foremost provider of vegetable protein and oil. The bushy, green soybean plant is a legume related to peas, groundnut (peanuts) and alfalfa [3]. Nigeria presently produces about 500,000 MT of soybeans annually making it the largest producer of the product on the African continent. Soybean is a legume which is produced mostly in the middle belt of the country with Benue State accounting for about 45% of the total production in the country. Soybean oil is the largest component of the world's edible oils. The world production of edible oils consists of 30% soybean [4]. Soybean is an important source of high and inexpensive protein and oil with an average protein content of 40% and an oil content of 20%. Soybeans have the highest protein content of all food crops and second only to groundnut in terms of oil content among food legumes. Soybeans are used in the production of milk, edible oil and animal feeds. Its high protein content and price makes it the best option in terms of treating malnutrition which currently is estimated at the US \$40 billion [5]. Changes associated with seed deterioration are depletion in food reserve, increased enzyme activity, increased fat acidity and membrane permeability. As the catabolic changes continue with increasing age, the ability of the seed to germinate is reduced [6].

Protein and oil are soybeans seed components of great economic value. On average protein content of commercial varieties is around 40%, to 53% [7]. Use of soy proteins in human diets is gaining impetus, because of its low cost,

increased availability and excellent functional characteristics in food systems continued innovative efforts in including variety of products and above all its positive nutritional profile [8]. Proper packaging and ideal conditions of storage are required to maintain seed quality [9]. The present work is aimed at investigating the effect of packaging material and storage period on the protein content of soybeans. The hydrophilic nature of high protein content of soybean helps in more absorption of water, increases the hydrolytic enzyme activity, enhances respiration and increases in free fatty acid content and finally, deteriorates the seed quality [10,11].

Seed deterioration has been ascribed to physical, physiological, biochemical and pathological detrimental changes occurring in seeds leading to death and has been characterized as inexorable, irreversible, inevitable, and minimal at the time of physiological maturity and variable among kinds of seeds, varieties and seed lots [12]. The study is aimed at determining the effect of variety, packaging material and storage period on the protein content of three (3) varieties of soybeans.

2. MATERIALS AND METHODS

2.1 Study Area

Newly harvested soybeans were purchased from National Cereal Research Institute, Yandev substation. The beans were cleaned and dried and the moisture content was taken. It was then stored in various packaging material at the Strategic Grain Reserve, Federal Ministry of Agriculture Makurdi for the period of 8 months (March 2017 –November 2017). The laboratory work was carried out at the seed science laboratory in the Federal University of

Agriculture, Makurdi. Makurdi, the capital of Benue state lies between latitude 7° 15-70 N and longitude 8° 40'E in the Guinea savanna vegetation of Nigeria. Five hundred grams (500 g) each of the varieties of soybeans were measured into the packaging material. They were then stored for 0 months, 2 months, 4 months, 6 months and 8months. The varieties under consideration were TGx 932- 3F, TGx 1904- 6F and TGx 1448-2E. The packaging materials were: Cloth bag, laminate paper bag. Glass bottle, low-density polyethene bag, plastic container and the control.

2.2 Experimental Design and Procedure

The experimental design was factorial in 3x5x6 comprising 3 varieties, 5 storage periods and 6 packaging materials by 3 replicates. Least significant (LSD) at 5% was used to compare the treatment means. The seeds in storage were sampled periodically (2, 4, 6 and 8 months) to determine the protein content. Analysis of variance of the parameter (protein content) was computed using statistics version 21.

2.3 Determination of Protein

The protein content of the samples was determined according to AOAC [13]. 0.5 g of the finely grounded samples were weighed into a digestion flask and Kjeidhal catalyst tablet was added; 10 ml of concentrated H₂SO₄ was added and digested for 5hours until a clear solution was obtained. The digest was cooled and transferred into 100 ml volumetric flask and made up to mark with distilled water. 20 ml of boric acid was

dispensed into a conical flask and 5 drops of indicator and 75ml of distilled water were added to it. Crude protein was calculated by the nitrogen content being multiplied with a factor of 6.25 (i.e. 100/16) [14].

Calculation of protein content in soybean seeds.

The Nitrogen (N) content in each sample will be calculated as follows:

$$N(\text{g.kg}^{-1}) = \frac{(\text{mlHCl} - \text{ml blank}) \times \text{Normality} \times 14.01}{\text{weight of sample (g)} \times 10}$$

3. RESULTS AND DISCUSSION

3.1 The Main Effect of Variety on Protein Content of Soybeans

The result showed that the protein content of V₃ recorded the highest value while V₂ recorded the lowest (42.55 and 39.46 respectively). However, a significant difference (P<0.05) was observed in the protein content of soybean varieties as seen in Fig. 1. The significant difference (P< 0.05) might be due to the different physical, structural and chemical composition of the seeds. The variation in the composition brought about the differences in the protein content of the soybeans. The present study is in line with the work of Odoaba et al. [15] who reported that the storability of different soybean cultivars is also regulated by initial seed quality, physical and chemical composition of seed as different cultivars possess different physical structural and chemical composition which determine the viability of seed in storage.

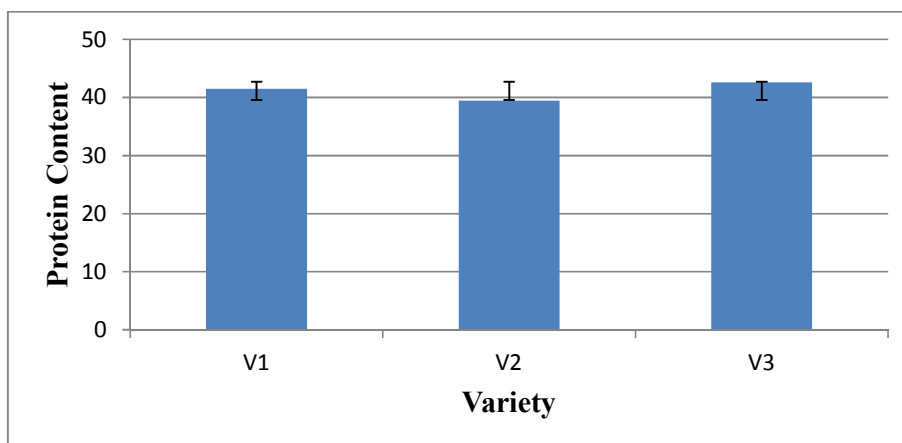


Fig. 1. Effect of variety on the Protein Content of stored soybeans
 key: V1 – Variety (TGX-932-3F) V2 – Variety (TGX-1904-6F)
 V3 – Variety (TGX-1448-2E)

3.2 Effect of Packaging Material on the Protein Content of Soybeans

The investigation showed that protein content in soybeans in packaging material varied. It showed that the highest protein content was recorded in soybeans packaged in a plastic container (43.55) while the least was recorded in soybeans that were not packaged in anything (control). The soybeans that were not packaged had a protein content of 36.47 while among the ones packaged, the least was in cloth (41.45) as seen in Fig. 2. Glass bottle and LDPE had the protein content of 42.64 and 42.06 respectively. The main effect showed that packaging materials have a significant difference ($P < 0.05$) on the protein content of stored soybeans. The

significant difference in the protein content due to packaging materials might be due to the air-tight nature of some of the packaging material. Those that were exposed to hazards such as moisture, air, fluctuating relative humidity and temperature had their carbohydrate used up by respiratory activity. Due to the fungal activity and decline in the carbohydrate, the protein content in stored soybeans increased depending on the properties of the packaging material. The present study confirms the report of *Fagbohun et al.*, [16] who reported that the increase in moisture content, crude protein and ash content along with variation in other nutrients may be attributed to the degrading activity of different mycoflora during storage.

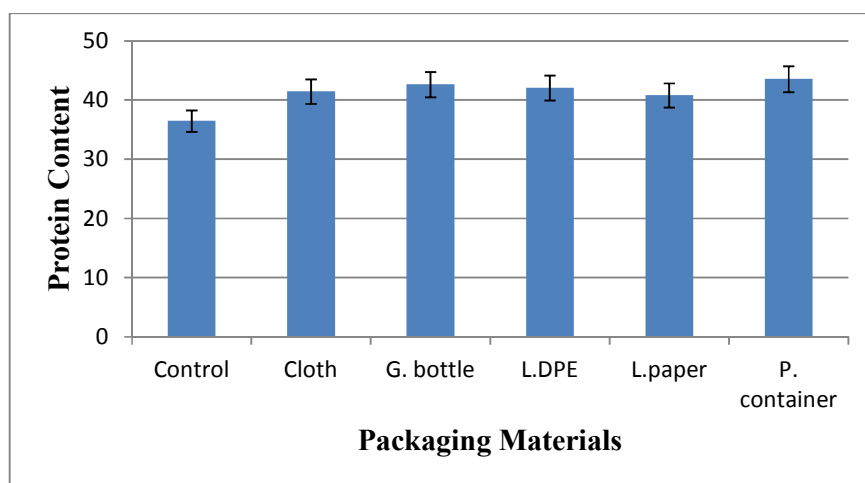


Fig. 2. Effect of packaging material on the Protein Content of stored soybeans

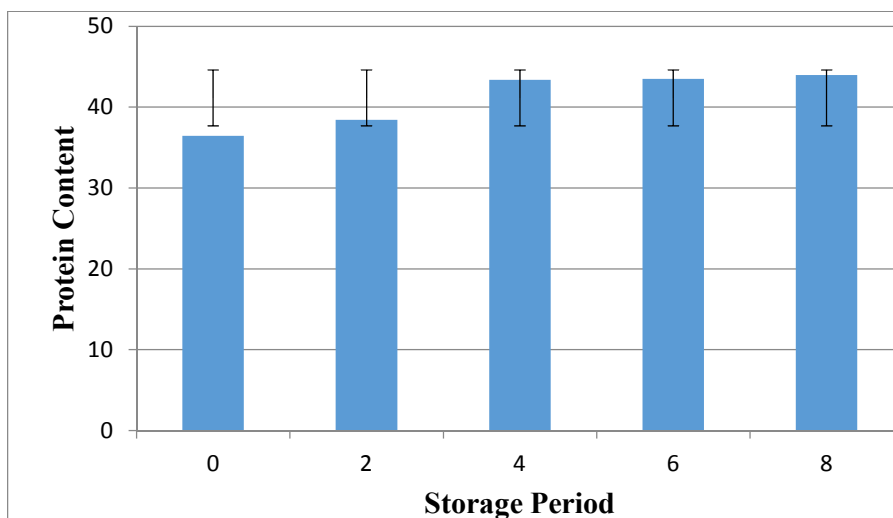


Fig. 3. Effect of Storage Period on the Protein Content of stored soybeans

3.3 Effect of Storage Period on the Protein Content of Soybeans

The investigation showed that soybeans stored for 8 months had the highest protein content of 44.01 and the lowest was in 0 months (36.47). It was observed that the protein content increased with increase in storage period as seen in Fig. 3. The least among the stored soybeans was at 2 months of storage (38.45). The soybeans stored for 4 months and 6 months had a protein content of 43.38 and 43.51 respectively. A significant difference ($P < 0.05$) was observed in the protein content of soybean seeds among different storage period. The difference in the protein content might be due to the fungal deterioration and the fact that carbohydrate was used up for the respiratory activity. This led to the increase in protein content with increase in storage period. These findings are in line with the work of Isaac et al., [17] who reported that storing soybean seeds for six months recorded the highest mean percentage protein content (30.14%) while seeds without storage (28.37%) obtained the least.

3.4 Interaction Effect of Variety and Storage Period on the Protein Content of Soybean

The interaction effects of varieties and storage period on the protein content of soybean are presented in Table 1. The protein content among varieties ranges between 30.8- 45.084. The highest protein content (45.084) was recorded for V_3 (TGX 1448-2E) while the lowest was recorded for V_2 . The protein content of soybean increased with storage period. Storage period of 8 months showed the highest protein content while the lowest was recorded at the 0 months (control) of the storage period. The result of the interaction between variety and storage period showed V_3 (TGX-1448-2E) had the highest protein content when stored for 8 months and the lowest was V_2 (TGX-1904-6F) at 0 months (30.8) and the next lowest one was V_2 at 2 months (36.79). Significant differences ($P < 0.05$) were observed among the varieties and storage periods in protein content (Table 1). The Protein content among soybean varieties vary. Generally, the protein content of soybean is known to increase with storage time. The protein in this study increased with increase in storage period. The increase could be attributed to the physical, chemical and biochemical alteration which had taken place. This work agrees with Arathoon [18]

who reported that the storage period of 120 days showed the highest protein content while the lowest was recorded after 30 days of storage. It is also in line with the findings of Isaac et al. [17] who reported that the percentage of protein content increased periodically in storage. As fungal deterioration advances however and carbohydrate was used in the respiratory processes, protein increases when protein test was conducted and calculated.

3.5 Interaction Effect of Packaging Material and Storage Period on the Protein Content of Soybeans

The effect of packaging material and storage period on the protein content is as presented in Table 2. The protein content in all the packaging material increased from what it was initially (control). The highest protein content was observed in a plastic container (47.414) and the lowest was the control (36.467). The effect of storage period on protein showed that the highest protein content was recorded at 8 months and the lowest was recorded at the 0 months (36.467). The significant difference could be due to the degrading activity of some mycoflora that might be present during storage. A similar report was given by Emmanuel et al. [19] who reported that increase in moisture content, crude protein and ash content along with variation in other nutrients may be attributed to the degrading activity of different mycoflora during storage.

3.6 Interaction Effect of Variety and Packaging Material on the Protein Content of Soybean

The interaction effect of variety and packaging material on protein content is presented in Table 3. The interaction effect of variety and packaging material on protein content showed variation. The highest protein content recorded was in V_3 (44.795) while the lowest was for V_2 (39.847). The highest interaction was between $V_3 \times$ LDPE (44.795) and the lowest was $V_2 \times$ laminate paper. There were significant differences ($P < 0.05$) observed among variety and packaging material on the protein content of soybean. The significant difference could be as a result of the genetic make-up of the individual variety and the packaging material effect. Some packaging materials are more pervious than others. Fagbohun et al. [16] gave a similar report that the increase in moisture content, crude protein and ash content along with variation in other nutrients

Table 1. Interaction effect of variety and storage period on the protein content of soybean

	0 months	2 months	4 months	6 months	8 months
V1	40.000	39.143	42.258	42.349	43.679
V2	30.8	36.794	43.135	43.277	43.269
V3	38.000	39.403	44.733	44.914	45.084

LSD variety*month= 0.084;

Key: V1 – Variety (TGX-932-3F); V2 – Variety (TGX-1904-6F); V3 – Variety (TGX-1448-2E)

Table 2. Interaction effect of packaging material and storage period on the protein content of soybean

	0months	2 months	4 months	6 months	8months
Control	36.467	36.467	36.467	36.467	36.467
Cloth	36.467	39.09	43.844	43.884	43.978
G. bottle	36.467	39.373	45.679	45.677	46.023
L density	36.467	37.243	44.331	44.946	47.291
L. paper	36.467	38.986	42.881	42.798	42.891
P. container	36.467	39.520	47.050	47.310	47.414

LSD pm*month=0.119

Table 3. Interaction effect of variety and packaging material on the protein content of soybean

	Control	Cloth	Bottle	Density	Paper	Plastic
V1	40	41.093	43.093	40.064	40.393	44.271
V2	30.8	40.273	41.304	41.308	39.847	43.198
V3	38.6	42.991	43.535	44.795	42.173	43.187

LSD variety*pm=0.092

Key: V1 – Variety (TGX-932-3F); V2 – Variety (TGX-1904-6F); V3 – Variety (TGX-1448-2E)

may be attributed by the degrading activity of different mycoflora during storage.

4. CONCLUSION

Soybeans can be stored at ambient temperature and still have its quality parameters intact only for a short while. The packaging materials, the variety, the storage environment and the moisture at the time of storage all determine the storability of soybeans. TGx 1448- 2E (V₃) had the highest protein content while TGx 1904- 6F (V₂) had the least. The highest protein content was recorded in soybeans packaged in a plastic container (43.55) while the least was recorded in soybeans that were not packaged in anything (control). The investigation showed that soybeans stored for 8 months had the highest protein content of 44.01 and the lowest was in 0 months (36.47). It was observed that the protein content increased with increase in storage period. The result of the interaction between variety and storage period showed V₃ (TGX-1448-2E) had the highest protein content when stored for 8 months and the lowest was V₂ (TGX-

1904-6F) at 0month (30.8) and the next lowest one was V₂ at 2months (36.79). The interaction effect of storage period and packaging material on protein showed that the highest protein content was recorded at 8month and the lowest was recorded at the 0 months (36.467). The interaction effect of variety and packaging material on protein content showed variation. The highest protein content recorded was in V₃ (44.795) while the lowest was for V₂ (39.847). The highest interaction was between V₃ x LDPE (44.795) and the lowest was V₂ x laminate paper. However, there significant differences (P<0.05) in all the interaction effects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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