**PROXIMATE AND ANTINUTRIENT COMPOSITIONS OF POTATO (*Solanum tuberosum*) TUBER FROM SELECTED STORAGE METHODS**

**ABSTRACT**

**Aims**: To evaluate the effects of four storage methods consisting of pit storage (PS), room storage (RS), metal-in-block evaporative cooling system (EC), and charcoal cooling chamber (CC) on the chemical composition of potato (*Solanum tuberosum L*) tuber.

**Study design:** The study employed a randomized complete block design involving these four storage methods. 4.8-5.0 kg of potato from the various storage methods were analyzed fortnightly for 8 weeks, while a set of fresh potato without blemish and storage served as the control.

**Methodology**: The proximate and antinutrient compositions of stored potato were assessed using standard methods, data obtained were subjected to analysis of variance, and means were separated using Duncan multiple range test.

**Results:** The findings of this study were that; storage methods had significant effects (*P*<0.05) on the proximate composition of potatoes during storage in various storage techniques as potatoes from these storages varied in moisture content (59.25-82.98%), ash content (0.78-0.64%), crude protein (1.34-2.06%), and total carbohydrate content (13.23-37.61%). The antinutrient composition also ranged from 2.85-5.56 mg/100g (phenols), 1.31-1.72 mg/100g (cyanide), 5.73-6.91 mg/100g (saponnins), 1.63-3.82 mg/100g (alkaloids), and 1.22-1.93 mg/100g (tannins).

**Conclusion:** The study concluded that the chemical composition of potato was significantly influenced by the different storage methods, and the EC and CC were the most effective methods for potato storage. The study, therefore recommended CC for adoption based on its nutrient retention and affordability.

*Key words: chemical, potato, phytochemicals, quality, storage, techniques*

1. **INTRODUCTION**

Potato (*Solanum tuberosum* L.) is the most cultivated tuber crop in the world, and it ranks fourth after rice, wheat, and corn in terms of cultivation (Liu *et al*., 2020). About 375 million metric tonnes of potato is produced worldwide on average each year (Food and Agricultural Organization Statistical Database , 2024). Significant production growth is observed mainly in Asia and Africa, with over half of potato global output in developing countries (Wijesinha-Bettoni & Mouille, 2019; Devaux *et al*., 2021). China is the world’s leading producer with 95.5 million metric tonnes (FAOSTAT, 2024). In Africa, the estimated harvested potato is at 16.9 million metric tonnes, and Egypt is the leading producer with a production of 6.1 million metric tonnes. Nigeria is the fourth largest potato producer in sub-Saharan Africa, and eighth in Africa, with an output of 1.2 million metric tonnes (FAOSTAT, 2024).

Potato is a nutritious vegetable (Dereje & Chibuzo, 2021), in terms of nutrient composition, potato has about 77% water, 16.3% starch, 0.9% sugar, 4.4% protein, 0.9% minerals, 0.59% fibre, 0.14% crude fat, and considerable quantities of vitamins, minerals, and different potent compounds that impede tumor growth and prevent a majority of illnesses (Beals, 2019; Navarre *et al*., 2019). More than 1.3 billion people eat them as a staple (Devaux *et al*., 2021). Potato is usually cooked before consumption, through baking, boiling, and frying (Tian *et al*., 2016; Yang *et al*., 2016). In Africa, it is usually consumed directly in cooked form; it is added to pounded yam preparation, or processed into flour and blended with yam flour to produce edible dough such as *amala* in Nigeria (Ikeyi, 2013). However, about 60% of potato is consumed in developed nations in the form of potato chips, mashed potato, French fries, canned potato, etc. (Kusur *et al*., 2020), or processed into starch for the industry, animal feed, glue, or re-used as seed potato (Ojo, 2013).

Potato undergo significant deterioration in its physical and chemical properties during storage, these physiological transformations are revealed by the loss of moisture and decay (Ozturk & Polat 2016). Similarly, Gikundi *et al.* (2021) and Gumbo *et al.* (2021) reported that other major signs of quality loss in potato include; sprouting, greening, weight loss, and rotting. Reports of Senkumba *et al*. (2017) and Jakubowski & Krolczyk (2020) showed that respiration, transpiration and sprouting were responsible for weight loss in potato and that the processes are influenced by the potato cultivar, temperature, and relative humidity of the storage environment. Sprouting reduces the market value, nutritional, and processing qualities. There are also concerns over “greening” on the possible presence of glycoalkaloids, which can be toxic to humans if consumed in high dose (Jansky *et al*., 2019; Musita *et al*., 2019).

Charcoal is a cheap and readily available substance obtained from combustion of wood, It is a good absorbent and can absorb moisture from the transpiration process in potato, maintain the relative humidity of storages and keep it cool, It can absorb respiratory gases and reduce the effects of those likely to stimulate ripening and ageing. It is black and can prevent sunlight from getting to the potato, and consequently reducing the occurrence of “greening”, Its porosity also facilitates ventilation in the storage. However, with all these derivable benefits of charcoal and its potentials in contributing to the reduction of post-harvest losses, there is paucity of information in the literature on charcoal and its influence on the proximate and phytochemical composition of potato during storage. Constructing a Charcoal cooling chamber and comparing it with the existing storage methods is therefore imperative in providing information on the storage method’s potentials on maintain ing potato’s chemical composition, safety and possible contributions to human’s nutrition.

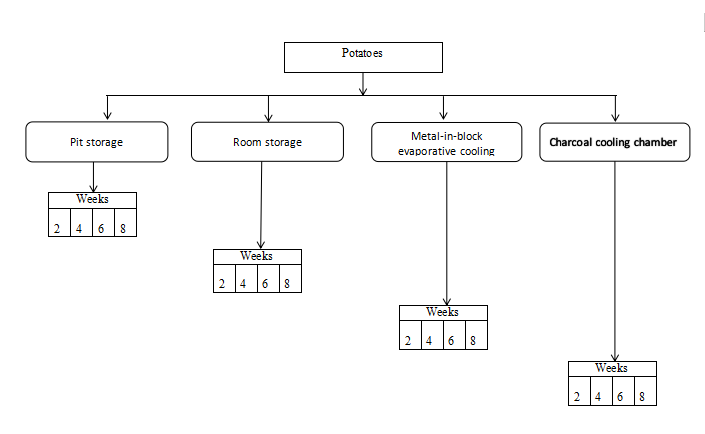
1. **MATERIALS AND METHODS**

**2.1 Source of Raw Materials**

Freshly harvested Nicola variety of potato (*Solanum tuberosom*) without any form of mechanical damage, at 14 weeks after planting, was used for this study. It was sourced from Zingak’s farm in Bokkos, Jos, identified and authenticated at the Department of Crop Production and Protection Department of Ahmadu Bello University Zaria, Kaduna State, Nigeria. The study was carried out from November to January at Nigerian Stored Products Research Institute (NSPRI) Kano, Nigeria, located at latitude 12°3′ N and longitude 8°31′ E, with average temperature of 24.6 °C, and relative humidity of between 38 to 50%.

**2.2 Experimental Design**

The experimental design is presented in Scheme 1. A randomized complete block design (RCBD) was used for the research; this involved four storage methods consisting pit; well-ventilated room; metal-in-block evaporative cooling system; and charcoal cooling chamber. Sets of 4.8-5.0 kg of potato (72-76 g) from each of these storage methods were collected without replacement, observed, and analyzed for their tuber properties fortnightly for 56 days. A storage method was discontinued when over 50% spoilage was recorded. Freshly harvested potato without storage was analyzed and processed immediately after curing and used as the control.



Scheme 1: Experimental Design for the Potato Storage using four different Methods

**2.3 Methods**

**2.3.1 Determination of Proximate Composition of Stored Potato Tuber**

### Protein content of stored Potato was determined by AOAC (2019) method no 2001.11, crude fat AOAC (2019) method no. 963.15, crude fibre AOAC (2019) method no 978.10, ash content AOAC (2019) method no 923.03, moisture content AOAC (2019) method no 925.10, and the carbohydrate content was obtained by difference.

**2.3.2 Anti-nutrients Analysis and Toxicity Test of Stored Potato Tuber**

Tannins in the potato pulp was determined using the method described by Okoo (2020), total glycoalkaloids and saponins determination was done with spectrophotometer by adopting the method described by Obum-Nnamdi *et al.* (2022), phenol content by Yamin (2021), and cyanide concentration was measured using the picrate paper technique, developed by Mburu *et al*. (2012).

**2.4 Statistical Analysis**

Statistical analysis was done using Statistical Package for Social Science (SPSS) version 16.0 (IBM SPSS, Inc., Chicago, IL, USA). Data obtained from this research were analyzed using analysis of variance (ANOVA) and Duncan multiple range tests was used to test significant differences between means (*P*<0.05). All determinations were done in triplicates, and all values were expressed as means ± standard deviations.

1. **RESULTS AND DISCUSSION**

**3.1 Proximate Compositions of Potato Tuber**

The result of proximate composition of potato tuber during storage is presented in Table 1 for moisture, ash, crude fibre, crude fat, crude protein, and carbohydrate contents.

3.1.1 **Moisture Content of Potato Tuber**

The results revealed that the moisture content in potato without storage (control) was 82.98%. This decreased during the storage period, and at week two, the moisture content ranged from 77.17% in potato from the charcoal cooling chamber to 79.29% in that from the room storage. There were no significant differences (p<0.05) in moisture content between potato stored in the pit and room. By week four, moisture content ranged from 75.54 to 77.18%, potato stored in the charcoal cooling chamber had

Table 1: Proximate Compositions of Potato Tuber in the Different Storage Methods

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sample | Moisture Content (%) | Crude Fibre (%) | Crude Fat (%) | Total Ash (%) | Crude Protein (%) | Total Carbohydrates (%) |
| Control | 82.98a ±0.14 | 0.85cdef±0.12 | 0.30bc±0.03 | 0.66bcd±0.07 | 1.98ab±0.13 | 13.23h±0.42 |
| After two weeks of storage | | | | | | |
| PS2 | 79.19b±0.68 | 0.88cdef±0.21 | 0.29bc±0.07 | 0.66bcd±0.09 | 2.03ab±0.18 | 16.96g±0.84 |
| RS2 | 79.29b±0.32 | 0.89cde±0.12 | 0.30bc±0.03 | 0.69abcd±0.06 | 2.06a±0.13 | 16.77g±0.06 |
| EC2 | 78.45bc±0.85 | 0.75efg±0.04 | 0.32abc±0.05 | 0.64d±0.07 | 2.01ab±0.09 | 17.83fg±0.91 |
| CC2 | 77.17bcd±1.09 | 1.07a±0.11 | 0.31bc±0.02 | 0.66bcd±0.06 | 2.06a±0.13 | 18.73efg±1.18 |
| After four weeks of storage | | | | | | |
| PS4 | 76.35cd±1.58 | 0.94abc±0.06 | 0.36ab±0.05 | 0.72abcd±0.05 | 1.83bc±0.15 | 19.81ef±1.76 |
| RS4 | 77.18bcd±1.48 | 0.91bcde±0.02 | 0.39a±0.04 | 0.73abcd±0.03 | 1.57de±0.09 | 19.23efg±1.39 |
| EC4 | 76.37cd±2.20 | 0.79cdefg±0.03 | 0.35abc±0.02 | 0.75abcd±0.02 | 1.71cd±0.13 | 20.04ef±2.32 |
| CC4 | 75.54d±1.41 | 1.05ab±0.08 | 0.34abc±0.04 | 0.73abcd±0.03 | 1.73cd±0.19 | 20.80e±1.66 |
| After six weeks of storage | | | | | | |
| PS6 | 70.65e±2.43 | 0.79cdefg±0.04 | 0.29bc±0.03 | 0.70abcd±0.05 | 1.42ef±0.05 | 26.14d±2.55 |
| RS6 | 69.34e±0.58 | 0.84cdef±0.04 | 0.34abc±0.02 | 0.77abc±0.04 | 1.54def±0.05 | 27.17d±0.59 |
| EC6 | 69.77e±0.39 | 0.76defg±0.01 | 0.29bc±0.04 | 0.66bcd±0.04 | 1.69cd±0.05 | 26.83d±0.47 |
| CC6 | 67.04f±0.19 | 0.92bcd±0.04 | 0.32abc±0.02 | 0.68abcd±0.40 | 1.64cd±0.10 | 29.40c±0.29 |
| After eight weeks of storage | | | | | | |
| RS8 | 59.25h±0.66 | 0.73fg±0.03 | 0.29bc±0.02 | 0.78a±0.10 | 1.34f±0.05 | 37.61a±0.57 |
| EC8 | 61.77g±2.12 | 0.66g±0.03 | 0.33abc±0.03 | 0.77ab±0.05 | 1.57de±0.09 | 34.90b±2.26 |
| CC8 | 60.41gh±0.52 | 0.84cdef±0.07 | 0.32abc±0.01 | 0.76abc±0.03 | 1.56de±0.07 | 36.11ab±0.53 |

Values are expressed as means ±SD of triplicate determinations. Means with different superscripts in the same column indicate significant differences (*P*< 0.05)

Keys:

Control: Potato without storage

PS2, PS4, and PS6: Potato stored in pit for 2, 4, and 6 weeks respectively

RS2, RS4, RS6, and RS8: Potato stored in a room for 2, 4, 6, and 8 weeks respectively

EC2, EC4, EC6, and EC8: Potato stored in metal-in-block evaporative cooling system for 2, 4, 6, and 8 weeks respectively

CC2, CC4, CC6, and CC8: Potato stored in the charcoal cooling chamber for 2, 4, 6, and 8 weeks respectively

the lowest moisture content, while that stored in the room had the highest. Potato in these storage methods varied significantly (p<0.05). By week six, moisture content ranged from 67.04% in potato stored in the charcoal cooling chamber to 70.65% in that stored in the pit, and potato stored in the charcoal cooling chamber was significantly different (p<0.05) in moisture content from all the other methods. After eight weeks, the moisture content of potato varied significantly (p<0.05) from 59.25% in the room storage to 61.77% in the metal-in-block evaporative cooling system.

Moisture content in this research is comparable to the 76.96 to 85.77% in some varieties of potatoes in China, 69.35% in locally cultivate potato in Adamawa State and 75.55 to 81.03% for selected potato cultivars in Kenya reported by Zhou *et al*. (2019), Ezekiel *et al*. (2020) and Gikundi *et al*. (2021), respectively. The moisture content of the potato continued to decrease with an increase in the storage time, and this was because most of the moisture escaped through the periderm and the sprout via evaporation and transpiration, respectively. After the first six weeks of storage, the potato stored in the room had the lowest moisture loss, and this could be attributed to the hard periderm and sturdy sprout that limited the moisture loss, however, after week eight of storage, it recorded the highest moisture loss and this could be due to the low relative humidity in the room which led to drying out of the potato. Food moisture content is an important component of food as it serves as an indicator of its shelf life. The level of moisture content affects the water activity in the food, which in turn determines the availability of water for microbial and enzymatic reactions. The high moisture content in the potato may have been a contributing factor to their rapid deterioration, thereby categorizing them as semi-perishable food (Ugonna *et al*., 2013; Siddiqui *et al*., 2022).

**3.1.2 Crude Fibre Content of Potato Tuber**

The crude fibre content of the fresh potato tuber (control) was 0.85%, and after two weeks of storage, the fibre content ranged from 0.73 to 1.07%, potato stored in the metal-in-block evaporative cooling system had the lowest crude fibre content, while that stored in the charcoal cooling chamber had the highest. By week four, the fibre content of stored potato varied from 0.79% in the metal-in-block evaporative cooling system to 1.05% in the charcoal cooling chamber. By week six, the crude fibre content ranged from 0.76% in potato stored in the metal-in-block evaporative cooling system to 0.92% in potato stored in the charcoal cooling chamber, and after eight weeks, the crude fibre content varied from 0.66% in potato stored in the metal-in-block evaporative cooling system to 0.84% in potato stored in the charcoal cooling chamber. The crude fibre content varied significantly (p<0.05) in all the storage methods throughout the storage period.

The results obtained in this study were within the range of 0.77 to 1.11% reported by Gikundi *et al*. (2021) for raw potato varieties, but higher than the 0.45% reported by Ezekiel *et al*. (2020). The variations in these results could be due to varietal differences and weather conditions of the place where the potato was cultivated (Omayio *et al*., 2016; Tatarowska *et al*., 2023). The fibre content of the potato in this study increased with an increase in storage time in all the storage methods, except the metal-in-block evaporative cooling system and this could be due to higher moisture loss in the other methods, which led to the concentration of the fibre in their potato pulp. Fibre is an important component of food; it adds bulk to foods, and also helps in the peristalsis of the gut (bowel movement) Okache *et al*. (2020).

**3.1.3 Crude Fat Content of Potato Tuber**

The results revealed that the crude fat of the control was 0.30%, and after two weeks of storage, the crude fats content ranged from 0.29 to 0.32%, among potato samples from the various storage methods. Potato stored in pit had the lowest fat content, while that in the metal-in-block evaporative cooling system had the highest and was significantly different from those in other methods. After four weeks, the crude fat content ranged from 0.34% in potato stored in the charcoal cooling chamber to 0.39% in the room-stored potato. There was no significant difference (p<0.05) in the crude fat content of potato stored in the metal-in-block evaporative cooling system and charcoal cooling chamber. By six weeks of storage, the crude fat content ranged from 0.29% in potato stored in the pit and metal-in-block evaporative cooling system, however, potato stored in the room and charcoal cooling chamber were not significantly different (p<0.05). After eight weeks of storage, the fat content ranged from 0.29% in the potato stored in the room to 0.33% in potato stored in the metal-in-block evaporative cooling system, and potato stored in the metal-in-block evaporative cooling system was not significantly different (p<0.05) from that stored in the charcoal cooling chamber.

The fat content from this research were higher than the 0.07 to 0.08% fat content of potato reported by Gikundi *et al*. (2021), but were lower than the 0.7 to 1.0 g/100g in four varieties of Nigerian sweet potatoes by Obomeghei *et al*. (2020). Increase in crude fat content with storage time in all the storage methods could be due to the concentration of the pulp as a result of moisture loss in potato during storage. Fats in diets are significant as they impact flavour in food, serve as a source of energy, and give warmth to the body. Fats are also carriers of vitamins such as Vitamins A, D, E, and K and can help to absorb and distribute these vitamins in the body. The fat content in this study is low and may not predispose consumers to coronary heart disease or arteriosclerosis.

**3.1.4 Ash Content of Potato Tuber**

The ash content of potato stored in the various storage methods showed an increase with time in all the storage methods employed. The Ash content of the control (fresh potato without storage) was 0.66%..After two weeks of storage, the ash content varied from 0.64% in the metal-in-block evaporative cooling system to 0.69% in the room-stored potato, there was no significant difference (p<0.05) between potato stored in the pit and the charcoal cooling chamber. After four weeks of storage, the ash content varied from 0.72% in the pit-stored potato to 0.75% in potato stored in the metal-in-block evaporative cooling system, however, there was no significant differences (p<0.05) in ash content among potato in all the storage methods. By six weeks of storage, ash content varied from 0.66% in the charcoal cooling chamber to 0.77% in the room-stored potato. Potato stored in the pit and that stored in the charcoal cooling chamber were not significantly different (p<0.05) in ash content. At eight weeks, the ash content ranged from 0.76% in potato stored in the charcoal cooling chamber to 0.78% in potato stored in the room. The ash content of potatoes were significantly different (p<0.05) in all the methods by the eighth week of storage.

The ash contents from this study were lower than the 0.88 to 1.10% ash content reported by Gikundi *et al*. (2021) in potato cultivars grown in Kenya. The differences from these results could be due to the difference in geographical location, cultural practices, and the variety of the potatoes (Omayio *et al*., 2016). Ash content indicates the presence of mineral elements in the food, and an increase in ash content will mean an increase in mineral content. This increase could be due to moisture loss in potato during storage as a consequence evaporation and transpiration processes, which then led to the concentration of the mineral elements in the potato. The availability and increased minerals in the potato during storage thus implies that individuals who consume the potato will have a reduced requirement for for the body’s mineral needs and this will ameliorate the threats of “hidden hunger”, which is a form of malnutrition caused by inadequate or absence of mineral elements in one’s diet (Baah *et al*., 2009).

**3.1.5 Crude Protein Content of Potato Tuber**

The crude protein of the control was 1.98%, and after two weeks of storage, the protein content increased to 2.03, 2.06, 2.01, and 2.06% in the pit, room, metal-in-block evaporative cooling system, and charcoal cooling chamber, respectively. The protein content of potato stored in the pit and metal-in-block evaporative cooling system were not significantly different (p<0.05), similarly, potato stored in the room and charcoal cooling chamber were not significantly different (p<0.05). After four weeks of storage, the crude protein content decreased and ranged from 1.57% in the room-stored potato to 1.83% in potato stored in pit. The crude protein content of potato in the metal-in-block evaporative cooling system and charcoal cooling chamber were not significantly different (p<0.05). By week six, the crude protein content ranged from 1.42% in potato stored in the pit, to 1.69% in potato stored in the charcoal cooling chamber. There were, however, no significant differences in the crude protein content of potato stored in the pit and charcoal cooling chamber. After eight weeks of storage, the crude protein content varied from 1.34% in the room-stored potato to 1.57% in potato stored in the metal-in-block evaporative cooling system, and the protein content in the metal-in-block evaporative cooling system was not significantly different (p<0.05) from that in the charcoal cooling chamber.

The crude protein content from this study were, however, comparable and within the range of 1.7 to 2.3% reported by Ogwuagu *et al*. (2019), and 1.63 to 1.76% in selected potato varieties reported by Gikundi *et al*. (2021). The decrease in the protein content from this research could be due to the proteolytic breakdown of protein in potato by enzymes inherent in the potato during storage, thereby reducing the quantity of protein in the potato. It could also be attributed to the sprouting process that might have depleted the proteins in the potato as several studies have reported that sprouting may deplete and reduce some nutrients in potatoes Gikundi *et al.* (2021) and Gumbo *et al.* (2021). Proteins are essential components of our food that perform numerous functions like repairing worn-out tissues, cell growth, and development and are made up of amino acids which are referred to as the building blocks of life.

**3.1.6 Carbohydrate Content of Potato Tuber**

Carbohydrates content revealed a significant increase with an increase in storage time. The carbohydrate content of the control sample was 13.23%, and this increased with an increase in storage time in all the storage methods. After two weeks of storage, the carbohydrates content of samples ranged from 16.77 to 18.73%. Potato stored in the room had the lowest carbohydrate content, while that in the charcoal cooling chamber had the highest. After four weeks of storage, the carbohydrate content increased further, and ranged from 19.23% in the room-stored potato to 20.80% in potato stored in the charcoal cooling chamber. By week six, the values of carbohydrates ranged from 26.14% in the pit-stored potato to 29.40% in potato stored in the charcoal cooling chamber, and potato stored in the charcoal cooling chamber varied significantly from all the others (p<0.05). After eight weeks of storage, the carbohydrates content ranged from 34.90% in potato stored in the metal-in-block evaporative cooling system to 37.61% in the room-stored potato. There were, however, significant differences (p<0.05) in carbohydrate content among all the storage methods in the eighth week of storage.

The carbohydrate contents from this research up to week six of storage were close to the range of 14 to 24% and 15.61 to 20.43% carbohydrate content reported by Ogwuagu *et al*. (2019) and Gikundi *et al*. (2021) respectively, however, after eight weeks of storage, the carbohydrate content in all the storage methods became higher than those reported in the literature. This increase in carbohydrate content could be due to the concentration of the potato content, as a result of moisture loss during storage. Carbohydrates in diets are important as they supply energy to the body and the values of carbohydrates content from this research indicates that consumers can obtain their daily recommended dietary allowances for carbohydrates by consuming the stored potato.

**3.2 Antinutrients Composition of Potato Tuber**

Table 2 depicts the antinutrient composition of potato in the different storage methods. Generally, the results revealed that the cyanide content decreased, while saponins, alkaloids, and tannins contents increased, with storage time. The phenols content recorded more increase in the room and charcoal cooling chamber storage methods during the periods of determination.

**3.2.1 Phenol Content of Potato Tuber**

The phenol content of potato without storage (the control) was 4.85 mgGAE/100g. The phenol content varied significantly in the second week of storage among the different methods from 3.13 to 5.62 mgGAE/100g, with potato stored in the room having the highest phenol content, while that stored in the pit had the lowest value. In the fourth week, significant differences (p<0.05) were found in the phenol content of potato in the different storage methods, and the values ranged from 2.85 mgGAE/100g in potato stored in the pit to 5.19 mgGAE/100g in potato stored in the room. In week six, the values of phenol content varied significantly (p<0.05) from 2.87 mgGAE/100g in potato stored in the pit, to 5.37 mgGAE/100g in potato stored in the charcoal cooling chamber. After eight weeks of storage, the phenol

Table 2: Antinutrient Content of Potato Tuber in the different Storage Methods

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | Phenol Content (mg/100g) | Cyanide Content (mg/100g) | Saponin Content (mg/100g) | Alkaloid Content (mg/100g) | Tannin Content (mg/100g) |
| Control | 4.85e±0.00 | 1.72a±0.01 | 5.73g±0.18 | 1.63g±0.04 | 1.22i±0.03 |
| After two weeks of storage | | | | | |
| PS2 | 3.13k±0.01 | 1.59b±0.01 | 6.34cde±0.15 | 1.75g±0.07 | 1.29h±0.01 |
| RS2 | 5.62a±0.01 | 1.37i±0.01 | 6.12f±0.04 | 1.64g±0.08 | 1.52g±0.03 |
| EC2 | 3.42j±0.01 | 1.45ef±0.02 | 6.35cde±0.07 | 1.73g±0.03 | 1.55g±0.03 |
| CC2 | 4.74f±0.01 | 1.31j±0.00 | 6.28ef±0.18 | 1.70g±0.03 | 1.49g±0.02 |
| After four weeks of storage | | | | | |
| PS4 | 2.85l±0.04 | 1.57bc±0.01 | 6.49cd±0.01 | 2.67e±0.15 | 1.49g±0.00 |
| RS4 | 5.19c±0.02 | 1.57bc±0.02 | 6.32de±0.04 | 1.97f±0.01 | 1.66ef±0.01 |
| EC4 | 3.37j±0.02 | 1.43fg±0.01 | 6.54bc±0.04 | 2.09f±0.01 | 1.63f±0.01 |
| CC4 | 5.02d±0.06 | 1.35i±0.01 | 6.38cde±0.04 | 2.06f±0.02 | 1.64ef±0.01 |
| After six weeks of storage | | | | | |
| PS6 | 2.87l±0.01 | 1.55c±0.01 | 6.79b±0.08 | 3.82a±0.06 | 1.70de±0.07 |
| RS6 | 4.66g±0.00 | 1.72a±0.01 | 6.41cde±0.04 | 2.53e±0.06 | 1.78c±0.04 |
| EC6 | 3.37j±0.00 | 1.46ef±0.01 | 6.72ab±0.05 | 3.18cd±0.11 | 1.75cd±0.01 |
| CC6 | 5.37b±0.01 | 1.40h±0.01 | 6.41cde±0.03 | 3.11d±0.06 | 1.77cd±0.02 |
| After eight weeks of storage | | | | | |
| RS8 | 4.25i±0.01 | 1.41gh±0.01 | 6.72ab±0.05 | 3.29c±0.06 | 1.93a±0.04 |
| EC8 | 4.54h±0.01 | 1.49d±0.01 | 6.91a±0.06 | 3.63b±0.04 | 1.86b±0.03 |
| CC8 | 5.56a±0.11 | 1.46d±0.01 | 6.81b±0.01 | 3.58b±0.05 | 1.81bc±0.04 |

Values are expressed as means ±SD of triplicate determinations. Means with different superscripts in the same column indicate significant differences (*P*< 0.05)

*Keys:*

*Control: Potato without storage*

*PS2, PS4, and PS6: Potato stored in pit for 2, 4, and 6 weeks respectively*

*RS2, RS4, RS6, and RS8: Potato stored in a room for 2, 4, 6, and 8 weeks respectively*

*EC2, EC4, EC6, and EC8: Potato stored in metal-in-block evaporative cooling system for 2, 4, 6, and 8 weeks respectively*

*CC2, CC4, CC6, and CC8: Potato stored in the charcoal cooling chamber for 2, 4, 6, and 8 weeks respectively*

content of potato in the various storage methods ranged from 4.25 mgGAE/100g in the room storage to 5.56 mgGAE/100g in potato stored in the charcoal cooling chamber. There were significant differences (p<0.05) in the phenol content among potato in the different storage methods.

Ndungutse *et al*. (2019) reported that the total phenol of potato cultivars in Kenya was 17.8 to 21.52mg GAE /100g FW, Akpe *et al*. (2021) reported 2.0 mg/100g in potato grown in Nigeria, while Abbasi *et al*. (2019) reported 93.58 to 253.24 mg/100g. These differences in phenol content could be attributed to factors such as varietal differences, cultural practices, and geographical location where the cropping was carried out (Tatarowska *et al*., 2019; Tatarowska *et al*., 2023). There was no regular pattern on how storage time and method affected the phenol content of potato, however, the presence of phenols is an indication that the potato could act as an antioxidant, anti-inflammatory, anti-clotting, immune enhancer, and, hormone modulator (Okwu & Omodamiro, 2005).

**3.2.2 Cyanide Content of Potato Tuber**

The cyanide content of the control sample was 1.72 mg/100g. The cyanide content decreased progressively during the storage. By week two of storage, the cyanide content varied from 1.31 to 1.59 mg/100g. The potato stored in the pit had the highest cyanide content, while that stored in the charcoal cooling chamber was the lowest. By week four, the potato stored in the pit and room had the highest cyanide content (1.57 mg/100g), while that stored in the charcoal cooling chamber had the lowest (1.35 mg/100g). By week six, the cyanide content ranged from 1.40 to 1.72 mg/100g, potato stored in the room had the highest cyanide content, while that stored in the charcoal cooling

chamber had the lowest. After eight weeks of storage, the cyanide content ranged from 1.41 mg/100g in potato stored in the room to 1.49 mg/100g in potato stored in the metal-in-block evaporative cooling system. The cyanide contents of the potato in the different storage methods were significantly different (P<0.05) during the period of evaluation.

Akpe *et al*. (2021) and Ezekiel *et al*. (2020) have reported 0.00 mg/100g cyanide in potato, however, reports of Ogbuagu *et al*. (2020) revealed 0.02% cyanogenic glycoside content in the raw potato. The results from this study regarding the presence of cyanide in potato are in agreement with the findings of Ogbuagu *et al*. (2020). Factors that could lead to the presence of cyanide in the potato from this study as opposed by other authors could be; the presence of cyanide in the soil where the crop was grown, or its proximity to a cassava farm, as it has been well documented that cassava possesses huge amount cyanide. Also, the increase in cyanide content in the room stored potato in the sixth week could be due to excessive moisture loss which led to the concentration of the potato's contents. There were however, no significant differences in the cyanide content of potato stored in the pit and room by the second week of storage, and those stored in the metal-in-block evaporative cooling system and charcoal cooling chamber after the eighth week of storage. The cyanide content from this study were low, and within the range of less than 50 mgHCN/kg being low in hydrogen cyanide based on Uchendu *et al*. (2013) classification, and can be regarded as non-toxic. Furthermore, common processing methods such as peeling, soaking, washing, cooking, etc. are known to reduce the quantity of cyanide. Therefore, consuming this stored potato will not pose any health threat to the end-users.

**3.2.3 Saponin Content of Potato**

The saponin content of the control sample (fresh potato tuber with storage) was 5.73 mg/100g. By week two of storage, the saponin content varied from 6.12 to 6.35 mg/100g, with potato stored in the room having the lowest saponin content, while that stored in the metal-in-block evaporative cooling system had the highest. By week four, the room stored potato had the lowest saponin content (6.32 mg/100g), while that stored in the metal-in-block evaporative cooling system was the highest (6.54 mg/100g). After six weeks of storage, the saponin content ranged from 6.41 mg/100g in potato stored in the room and charcoal cooling chamber to 6.79 mg/100g in the pit-stored potato. After eight weeks of storage, the saponin content ranged from 6.72 mg/100g in potato stored in the room to 6.91 mg/100g in the metal-in-block evaporative cooling system. There were significant differences (p<0.05) among potato in saponin content during each period of determination in the different storage methods.

Akpe *et al*. (2021) reported a saponin content of 4.0 mg/100g, while Ogbuagu *et al*. (2020) reported 8.09% saponin content in raw potato. The results from this study were within the range of saponin content reported by these authors. Saponin is an antinutritional agent which can have toxicological consequences. According to Sopido *et al*. (2000), some general characteristics of saponins are the ability to produce foams in aqueous solutions, hemolytic activity, cholesterol-binding capabilities, and bitterness. Additionally, these substances function as natural antibiotics, aiding the body in the battle against infections and microbial invasion. Because saponins naturally repel microorganisms, they are a suitable option for treating infections caused by yeast and fungi (Sopido *et al*., 2000).

**3.2.4 Alkaloid Content of Potato Tuber**

The alkaloid content of the control was 1.63 mg/100g. The alkaloid content increased during storage and by week two of storage, the alkaloid content varied from 1.64 to 1.75 mg/100g, potato stored in the pit had the highest alkaloid content, while that stored in the room had the lowest. By week four, the values of alkaloid content varied from 1.97 mg/100g in potato stored in the room, to 2.67 mg/100g in potato stored in pit. After six weeks of storage, the alkaloid content ranged from 2.53 to 3.82mg/100g. The potato stored in pit had the highest alkaloid content, while that stored in room was the lowest. By week eight, the alkaloid content varied from 3.29 mg/100g in potato stored in the room, to 3.63 mg/100g in potato stored in the metal-in-block evaporative cooling system. There were no significant differences (p<0.05) in alkaloid content among potato in the different storage methods with that in the control during the first two weeks of storage. It was however obvious that the alkaloid contents in all the storage methods increased progressively with an increase in the storage time.

The results from several authors revealed that the alkaloid content of potato is 2.17 mg/100g (Akpe *et al*., 2021), 14.17 to 22.35 mg/100g (Abbasi *et al*., 2019), and 4.46% (Ogbuagu *et al*., 2020). The findings from this study align with the reports of Akpe *et al*. (2021), and the relatively low levels of alkaloids could be attributed to the absence of “greening” in the potato during storage in all the storage methods. Greening is the manifestation of a high amount of glycoalkaloids in potato, which limits its utilization. The presence of alkaloids in potato suggests that they should not be consumed uncooked. Rather than their potential toxicity, the majority of alkaloids are known for their pharmaceutical benefits. On the other hand, high alkaloids in diets can lead to neurological problems and can cause gastrointestinal upset (Okaka *et al*., 1992).

**3.2.5 Tannin Content of Potato Tuber**

The tannin content of the potato without storage (control) was 1.22 mg/100g. The tannin content increased during storage in the different storage methods. By week two, the tannin content ranged from 1.29 mg/100g in the pit-stored potato to 1.55 mg/100g in potato stored in the metal-in-block evaporative cooling system. Potato stored in the pit was significantly different from that of the other methods in tannin content. By week four, the tannin content ranged from 1.49 to 1.66 mg/100g, potato stored in the pit had the lowest tannin content, while that stored in the room had the highest. By week six, the tannin content ranged from 1.70 mg/100g in potato stored in the pit to 1.78 mg/100g in potato stored in the room. By week eight, the tannin content ranged from 1.81 mg/100g in potato stored in the charcoal cooling chamber to 1.93 mg/100g in potato stored in pit, there were, however, significant differences (p<0.05) in tannin contents among potato in the different storage methods after weeks four, six, and eight.

The results from the work of Akpe *et al*. (2021) revealed that the tannin content of potato was 0.55 mg/100g; Ogbuagu *et al*. (2020) reported 0.07% tannins in the fresh potato; Ezekiel *et al*. (2020) reported 0.54% tannins content in potato cultivated in Adamawa State. The tannin contents from this research were higher than those reported by these researchers, and this could be due to the varietal differences, postharvest handling etc. Also difference in the quantity of tannin with time in the different storage methods could be due to the differences in storage conditions, and how the chemical constituents of the potato became concentrated with increase in moisture loss. Tannin concentration inhibits digestion and absorption by creating complexes with protein (in both substrate and enzyme), thereby lowering the nutritional value of foods (Osuntogun *et al*., 1989). Additionally, they bind to iron and hamper its bioavailability (Aletor & Adeogun, 1995). The tannin contents from this study were, however, relatively low and may not impair the absorption of nutrients contained in the potato.

1. **CONCLUSION**

This study concludes that the proximate composition indicated a significant increase in ash and carbohydrate, with decrease in the protein and moisture content during storage in all the methods. The metal-in-block evaporative cooling system and the charcoal cooling chamber performed better in nutrient retention. Antinutrient composition analysis showed significant increase in phenols, saponins, alkaloids, and tannins content during storage in all the storage methods, with a reduction in cyanide content. The charcoal cooling chamber was therefore recommended for adoption due to its nutrient retention and affordability. Further studies on the properties of flour produced from these stored potatoes should be carried out to augment the findings of this study. This could be of importance to individuals, industries and policy makers who wil require to store potatoes before processing various culinary potato products.

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1.

2.

3.

**References**

1. Liu, N., Zhao, R., Qiao, L., Zhang, Y., Li, M., Sun, H., *et al*. (2020). Growth stages classification of potato crop based on analysis of spectral response and variables optimization. ***Sensors***, *20*(14), 3995: 1-20 doi:10.3390/s20143995
2. FAOSTAT (2024). Food and Agricultural Organization of the United Nations. FAO Statistical Database. <http://www.potatopro.com>
3. Wijesinha-Bettoni, R & Mouillé, B. (2019). The contribution of potatoes to global food security, nutrition and healthy diets. ***American Journal of Potato Research,*** *96*(2):139-149.
4. Dereje, B. & Chibuzo, N. (2021). Nutritional composition and biochemical properties of *Solanum tuberosum*: In *Solanum tuberosum*: A Promising crop for starvation problem. IntechOpen. 1-12 doi:<http://dx.doi.org/10.5772/intechopen.98179>
5. Beals, K. A. (2018). Potatoes, nutrition and health. ***American Journal of Potato Research,*** *96*(315), 102-110.
6. Navarre, D. A., Brown, C. R. & Sathuvalli, V. R. (2019). Potato vitamins, minerals and phytonutrients from a plant biology perspective. ***American Journal of Potato Research,*** *96*(2), 111-126.
7. Devaux, A., Goffart, J. P., Kromann, P., Andrade, P. J., Polar, V. & Hareau, G. (2021). The potato of the future: opportunities and challenges in sustainable agri-food systems. ***Potato Research,*** *64*, 681–720
8. Tian, J., Chen, C., Ye, X. and Chen, S. (2016) Health benefits of the potato affected by domestic cooking: a review. ***Food Chemistry*** 202:165–175
9. Yang, Y., Achaerandio, I. & Pujola, M. (2016). Effect of the intensity of cooking methods on the nutritional and physical properties of potato tubers. ***Food Chemistry***, 197: 1301–1310.
10. Ikeyi, A. P. (2013). Isolation and Characterization of Bacteria Associated with Spoilt Irish Potato (*Solanum tuberosum*). ***The Experiment***. 12(4): 807-813
11. Kusur, A., Karic, A., Andrejas, M., & Alibasic, H. (2020). Change in the quantity of ascorbic acid after thermal processing of potato. Technologica Acta: ***Scientific/Professional Journal of Chemistry and Technology***, *13*(2), 1-4.
12. Ojo, F. T. (2013). Potato production in the tropics. M.Sc. project, University of Ibadan.
13. Ozturk, E. & Polat, T. (2016). The effect of long term storage on physical and chemical properties of potato. ***Turkey Journal of Field Crops,*** *21,* 218-223.
14. Gikundi, E. N., Sila, D. N., Orina, I. N. & Buzera, A. K. (2021). Physico-chemical properties of selected Irish potato varieties grown in Kenya. ***African Journal of Food Science,*** *15*(1), 10-19.
15. Gumbo, N., Magwaza, L. S. & Ngobese, N. Z. (2021). Evaluating ecologically acceptable sprout suppressants for enhancing dormancy and potato storability: a review. ***Plants,*** *10*(2307), 1–15. https://doi.org/10.339010112307
16. Senkumba, J., Kaaya, A., Atukwase, A. & Wasukira. A. (2017). Effect of storage conditions on the processing quality of different potato varieties grown in eastern Uganda: Technical report. Consultative Group on International Agricultural Research (CGIAR) Reasearch Program on Roots, Tubers and Bananas. 22-23
17. Jakubowski, T., & Królczyk, J. B. (2020). Method for the reduction of natural losses of potato tubers during their long-term storage. ***Sustainability*** *12*(3), 1048.
18. Jansky, S. H., Navarre, R. & Bamberg, J. (2019). Introduction to the Special Issue on the Nutritional Value of Potato. ***American Journal of Potato Research,*** *96*, 95–97.
19. Musita, C. N., Okoth, M. W. & Abong, G. O. (2019). Postharvest handling practices and perception of potato safety among potato traders in Nairobi, Kenya. ***International Journal of Food Science***, *2019*(2342619), 1–7.
20. AOAC. (2019). Official Method of Analysis Association of Analytical Chemist, 21st Edition, Washington DC.
21. Ooko, A. G. (2020). Phytochemicals in leaves and roots of selected kenyan orange fleshed sweet potato (OFSP) varieties. ***International Journal of Food Sciences***. *2020*(1), 1-11 Doi:10.1155/2020/3567972.
22. Obum-Nnadi, C. N., Amaechi, D., Ezenwa, C. M., Udeala, E., Nwokorie, K. S. & Ajima, M. (2022). Anti-bacterial, phytochemical analysis and blood pressure lowering effects of orange flesh sweet potatoes (*Ipomoea Batatas L.*). ***Current Research in Interdisciplinary Studies***, *1*(1), 9-21
23. Yamin (2021). Determination of total phenolic and flavonoid contents of Jackfruit peel and in vitro antiradical test. ***Food Research***. 5(1):84–90. DOI: 10.26656/fr.2017.5(1).350.
24. Mburu, F. W., Swaleh, S., & [Njue](https://scholar.google.com/citations?user=gYUNVCIAAAAJ&hl=en&oi=sra), W. (2012). Potential toxic levels of cyanide in cassava (Manihot esculenta Crantz) grown in Kenya. ***African Journal of Food Science***. 6: 416-420
25. Zhou, L., Mu, T., Ma, M., Zhang, R., Sun, Q. & Xu, Y. (2019). Nutritional evaluation of different cultivars of potatoes (*Solanum tuberosum* L.) from China by grey relational analysis (GRA) and its application in potato steamed bread making. ***Journal of Integrative Agriculture****, 18(1),* 231–245.
26. Ezekiel, T. W., Nuhu, N. D. & Nachana’a, T. (2020) .Phytochemical, elemental, proximate and anti- nitrients composition of Irish potato (*Solanum tuberosum*) obtained in Kwaja, Mubi Sourth Local Government Area of Adamawa State. ***International Journal of Innovative Science, Engineering & Technology***, *7*(7), 258-268.
27. Omayio, D. G., Abong, G. O. & Okoth, M. W. (2016) A Review of Occurrence of Glycoalkaloids in Potato and Potato Products. ***Current Research in Nutrition and Food Science,*** *4*(3), 195-202
28. Tatarowska, B., Milczarek, D. & Plich, J. (2023). The content of total carotenoids, vitamin c and antioxidant properties of 65 potato cultivars characterised under the European project ECOBREED. ***International Journal of Molecular Sciences*** *24*, 14-26.
29. Okache, T. A., Agomuo, J. K & Kaida, I. Z. (2020) Production and evaluation of breakfast cereals produced from finger millet, wheat, soybean, and peanut flour blend. ***Research Journal of Food Science and Quality Control,*** *6* (2), 9-19

Ugonna, C. U, Jolaoso, M. O. & Onwualu, A. P. (2013). A technical appraisal of potato value chain in Nigeria. ***International*** ***Research Journal of Agricultural Science and Soil Science***, *3*(8), 291-301.

1. Siddiqui, S., Ahmed, N., & Phogat, N. (2022). Potato starch as affected by varieties, storage treatments and conditions of tubers. IntechOpen, 1-15. Doi <http://dx.doi.org/10.5772/intechopen.101831>
2. Obomeghei, A. A., Olapade, A. A. & Akinoso, R. (2020). Evaluation of the Chemical Composition, Functional and Pasting Properties of Four Varieties of Nigerian Sweet Potato [*Ipomoea Batatas* L. (Lam.)] Flour. ***African Journal of Food and Agriculture***, *20*(3), 15764 – 15778
3. Baah, F. D., Maziya-Dixon, B., Asiedu, R., Oduro, I. & Ellis, W. O. (2009). Nutritional and biochemical compositeon of *D. alata* (*Dioscorea* spp.) tubers. ***Journal of Food Agriculture and Environment***, *7*(2), 373-378.
4. Ogbuagu, U., Igwe, C. U., Nwaogu, L. A., Airaodion, A. I. & Ogbuagu, E. O. (2020). Chemical Content and Antioxidant Potential of Aqueous Extract of Irish Potato Tubers Traditionally Used for Ulcer Treatment in Nigeria. ***International Research Journal of Gastroenterology and Hepatology*** *3*(1), 10 -18.
5. Ndungutse, V., Ngoda, P. M. N., Vasanthakaalam, H., Shakala, E. K.,& Faraj, A. K. (2019). Morphological and phytochemical composition of selected potato (*Solanum tuberosum L*.) cultivars grown in Rwanda. ***Annals of Food Science and Technology***, *20*(1), 393–401
6. Akpe, M. A., Ashishie, P. B., & Akonjor, O. A. (2021). Evaluation of some phytochemicals in raw and cooked *Ipomea batatas* (Lam), (Sweet Potato), *Solanum tuberosum* (Irish Potato) and *Dioscorea cayenensis* (Yellow Yam). ***Journal of Applied Science and Environmental Management***, *25*(9), 1563-1567
7. Abbasi, K. S., Qayyum, A., Mehmood, A., Mahmood, T., Khan, S. U., Liaquat, *et al.* (2019). Analysis of selected potato varieties and their functional assessment. ***Food Science and Technology***, *39*(2), 308-314.
8. Tatarowska, B., Milczarek, D. Wszelaczy´nska, E., Poberezny, J., Keutgen, N. Keutgen, A. J. and Flis, B. (2019). Carotenoids variability of potato tubers in relation to genotype, growing location and year. ***America Journal of Potato Research***, *96*, 493–504.
9. Okwu, D. E. & Omodamiro, O. D. (2005). Effects of hexane extract and phytochemical content of *Xylopia aethiopica* and *Ocimum gratissimum* on the uterus of guinea pig. ***Bio-research*** *3*(2), 40-44
10. Uchendu, N. O., Eze, S. O. O., Ugwu, O. P. C., Enechi, O. C. & Udeh, S. M. C. (2013). Characterization of different varieties of cassava starch for industrial utilization. ***Intentional Journal of Research and Reviews in Pharmacy and Applied Science***, *3*(3), 370-386
11. Sopido, O. A., Ahiniyi, J. A. & Ogunbanosu, J. U. (2000). Studies on certain characteristics of extracts of barke of pansinystalia macruceras (K. Schem.) Pierve Exbeille. ***Global Journal of Pure and Applied Science*** 6:83-87.
12. Okaka, J. C., Enoch, N. J. & Okaka, N. C. (1992). Human Nutrition. An Integrated Approach. Enugu State University of Technology Publication.
13. Osuntogun, B. A., Adewusi, S. R. A., Adewusi, A., Ogundiwin, J. O. & Nwasike, C. C. (1989). Effect of cultivar, steeping, and malting on tannin, total polyphenol, and cyanide content of Nigerian sorghum. ***Cereal Chemistry,*** *66*, 87-89.
14. Aletor, V. A. & Adeogun, O. A. (1995). Nutrient and antinutrient components of some tropical leafy vegetables. ***Food Chemistry***, 53, 375-379.