Global Journal of Engineering and Technology Advances
eISSN: 2582-5003
Cross Ref DOI: 10.30574/gjeta
Journal homepage: https://gjeta.com/

(RESEARCH ARTICLE)

Check for updates

Performance evaluation of a low-cost cold storage system using animal products

Fawziyyah Uthman [1], Jelili Aremu Oyedokun [2,*], Kamaldeen Taiwo Sule [3], Elizabeth Ayodele Onipede [1] and Imran Olaitan Oyedokun [4]

[1] *Department of Agricultural and Bio-Environmental Engineering, Kwara State Polytechnic, Ilorin, Nigeria.*
[2] *Department of Engineering and Scientific Services, National Centre for Agricultural Mechanization, Ilorin, Nigeria.*
[3] *Department of Electrical and Electronics Engineering, Kwara State Polytechnic, Ilorin, Nigeria.*
[4] *Department of Preliminary and General Studies, Federal College of Horticulture, Dadin-kowa Gombe, Nigeria.*

Global Journal of Engineering and Technology Advances, 2023, 16(03), 192–199

Publication history: Received on 08 August 2023; revised on 19 September 2023; accepted on 22 September 2023

Article DOI: https://doi.org/10.30574/gjeta.2023.16.3.0191

Abstract

Animal products such as chicken, fish and beef are highly perishable and easily deteriorate thus, requires proper storage to maintain their quality and shelf life. It is known that shelf life of chilled fresh animal products can be extended by various packaging solution such as vacuum or modified atmosphere packaging. However, a freshness of chilled meat is strongly influence by temperature. The storage system incorporated temperature control. This provides insights into the performance and effectiveness of the low-cost storage system for animal products by evaluating temperature stability. The findings of this study will contribute to a sustainable and affordable storage system that will minimize animal product losses as well improve the quality. This research work deals with the performance evaluation of a low cost smart storage system, the smart storage system allows to be setting to a desired temperature within the range of 55 °C to – 17 °C with a capacity of 20 kg. The animal products (chicken, catfish and beef) was frozen with the temperature of 0 °C with two-hour interval record taken for 16 hours for each of the products in pieces and whole, while the DE frozen was carried out for 12 hours with an interval of two hours record taken. The result of the products in wholes was compared with the pieces during the frozen and DE frozen. It was revealed that chicken in whole and pieces weight reduced after 16 hours of frozen by 0.06% and 3.9% respectively, catfish in whole and pieces weight increase after 16 hours of frozen by 0.11% each and beef in whole and pieces weight reduced after 16 hours of frozen by 0.09% and 2.87% respectively while chicken in whole and pieces weight increase after 12 hours of DE frozen by 0.06% and 0.26% respectively, catfish in whole and pieces weight increase after 12 hours of DE frozen by 0.23% and 0.57% respectively and beef in whole and pieces weight reduced after 12 hours of DE frozen by 1.11% and 3.39% respectively. The storage was found to be suitable for the selected animal products and highly recommended for small and middle scale animal frozen sellers or producers.

Keywords: Low-cost storage system; Shelf-life extension; Animal product; Post-harvest losses; Frozen

1. Introduction

Foods are organic substances which are consumed for nutritional purposes. Foods are plant or animal origin and contain moisture, protein, lipid, carbohydrate, minerals, and other organic substances. Foods undergo spoilage due to microbial, chemical, or physical actions. Nutritional values, color, texture, and edibility of foods are susceptible to spoilage (Rahman, 2007). Animal products are required to be preserved to retain their quality for longer period of time. Food preservation is defined as the processes or techniques undertaken in order to maintain internal and external factors which may cause food spoilage (Balarabe *et al*., 2016). Animal products includes meat, milk, fish, skin/hide that are processed into other by products for human consumption. There is the need for awareness campaigns to consumers and entrepreneurs that engage in the handling and processing of these products. Methods of preserving animal products

*Corresponding author: Oyedokun J.A

include the use of high temperature (canning), low temperature (freezing), drying (sun drying, smoking, use of radiation and chemical preservatives) (Balarabe *et al.,* 2016).

Nigeria is one of the leading countries in production of agricultural products, comprising plant and animal products. presently, the demand for food of a growing population is a major global problem, and that is more than a third of food is lost or wasted in post-harvest agricultural operations. Reducing the waste after harvest, especially in developing countries, can be a sustainable solution to increase food availability, reduce pressure on natural resources, eliminate hunger, and improve farmers' living conditions (Barbara, 2019). Storage is the act of keeping the quality of agricultural materials and preventing them from deterioration for a specific period of time beyond their normal shelf life (Oyedokun *et al.,* 2022). However, controlled atmosphere storage system is the general classification that includes all forms of storage that have device for monitoring and controlling the environmental factors such as temperature and relative humidity. However, the freshness of chilled meat is strongly influence by temperature. Inadequate storage, distribution and retail temperatures can lead to a significant reduction in shelf life and early spoilage of meat, catfish, chicken and cat fish (Fabunmi *et al*., 2015). Microbial cross-contamination usually occur during slaughtering, evisceration and dressing operations, especially on the surface of meat, via contact with equipment, handlers, clothes, objects etc. Meat, chicken and catfish are particularly favorable substrate for the growth of micro-organisms due to its chemical compositions including proteins, lipids and water. The lipid content of meat, catfish, and chicken also make them very sensitive to oxidation (the reaction of oxygen with fatty acids) and subsequent production of peroxides. The breakdown products of the peroxides produce the characteristics objectionable odor and flavor of rancid meat, chicken and cat fish. Rahman (2014) revealed that refrigeration is a typical controlled atmosphere system that can operate at below atmospheric temperature. Refrigeration is the process of removing heat from a place where it is not wanted and transferring that heat to a place where it makes little or no difference). Cold storage generally embarks on a continual extraction of heat from its body whose temperature is already below its surrounding temperature. This refrigeration heritably is the only means of preserving original freshness of food products (Rahman, 2014). Lack of storage facilities is one of the major challenges facing perishable produces in Nigeria and result in higher postharvest losses. Temperature plays an important role in postharvest handling of perishable product since it affects mostly enzymatic reaction in harvested produce. Postharvest losses are not only a function of waste of food, but they also represent a corresponding waste of human effort, farm input, live hoods, investment and scarce resources. One of the instantaneous ways of assuring good quality of animal products is the use of a cold storage systems. Cold storage involves keeping foods beneath ambient conditions and above freezing temperature, normally between −2 °C to 16 °C. Elimination of heat energy from foodstuffs through cryogenic systems or the mechanical refrigeration process depresses the temperature of the product. Preservation of food at low temperature includes two different processes i.e. chilling and freezing. Chilling comprises the use of temperature between 0 °C to 8 °C, whereas freezing involves the use of temperatures lower than the freezing point, normally below −18 °C. The preserving action of the process of freezing is due to the low temperature as well as due to the low water activity created by the transformation of water to ice (Kaale *et al.,* 2011). Storing these animal products at low temperature has been reported to inhibit the growth of microorganism, chemical and enzymatic reaction (Pal, 2014). Microorganisms are spoilage agents and consists of bacterial, yeast and molds. However, low temperature does not destroy these spoilage agents as does high temperature, but greatly reduces their activities, providing a practical way of preserving perishable foods in their natural state which otherwise is not possible through heating. Cold preservation is an excellent way to store agricultural materials it prevent the growth of micro-organisms and other chemical changes that causes deterioration (Fabunmi *et al.,* 2015).

2. Material and Methods

2.1. Materials

Animal products used for this study (Chicken, Catfish and Beef) were purchased from Obbo road and Kulende markets respectively in Ilorin West Local Government Area of Kwara State, Nigeria.

2.2. Methods

2.2.1. Sample Preparation

The animal products (Chicken, Catfish and Beef) were degutted, washed and allowed to drain for two (2) minutes, salted, weighed and packaged in a cellophane bag for storage

2.2.2. Experimental procedure

The experiment was carryout at no load and at load, temperature reading of the cold storage system were measured for the period of two (2) hours at no load in order to ascertain its working condition before loading with the selected products.

The animal products were weighed before storage and then re weighed after two (2) hours for sixteen (16) hours during frozen and interval of two (2) hours for twelve (12) hours during DE frozen. Figure 1a and 1b show the pictures of the cold storage and when packaged with the animal products.

Figure 1a Cold storage with packaged products

Figure 1b Cold storage

3. Results and Discussions

The results obtained from the experiment is presented in tables 1 -3 and figures 2-8. The selected animal products were in whole and piece forms when stored. It was kept for sixteen (16) hours and weighed after every two (2) hours interval. The DE for the animal products are kept for twelve (12) hours and re weighed after two (2) hours.

Table 1 Result of the weight recorded for frozen of Chicken, Catfish and Beef in whole and pieces Form

S/No.	Time (Hr.)	Chicken Weights (g)		Catfish Weights (g)		Beef Weights (g)	
		Whole	Pieces	Whole	Pieces	Whole	Pieces
1	0	1815	1312	870	876	1174	1186
2	2	1814	1273	875	876	1172	1184
3	4	1816	1268	874	876	1171	1180
4	6	1818	1263	873	876	1175	1162
5	8	1817	1264	872	875	1174	1161
6	10	1814	1265	872	877	1173	1158
7	12	1817	1264	871	876	1187	1155
8	14	1816	1262	871	877	1172	1152
9	16	1816	1261	871	877	1173	1152

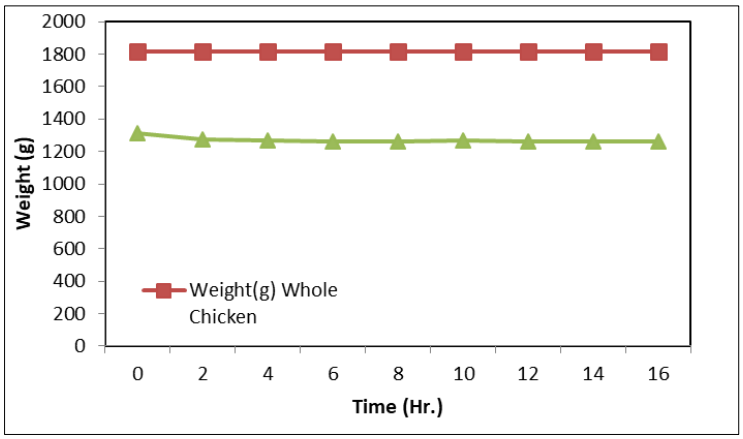

Figure 2 Graph of frozen Chicken weight (g) against Time (Hr.)

3.1. Discussions on the frozen of Chicken

The weight of the whole chicken when kept in the cold storage increases from 1816 g to 1815 g which is equivalent to 1 g, representing 0.06% while the pieces chicken decreases from of 1261 g to 1312 g, an equivalent of 51 g representing 3.9%. The results are revealed that chicken frozen in whole and pieces gives better results as shown in figure 2.

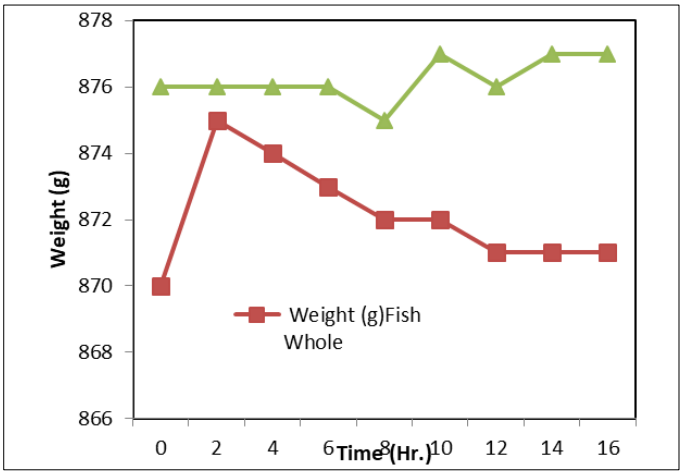

Figure 3 Graph of frozen Catfish weight (g) against Time (Hr.)

3.2. Discussions on the frozen of Catfish

The weight of the whole catfish when kept in the cold storage increases from 871 g to 870 g which is equivalent to 1 g, representing 0.11% while the pieces catfish increases from of 877 g to 876 g, an equivalent of 1 g representing 0.11%. The results are revealed that catfish frozen in whole and pieces gives better results as shown in figure 3.

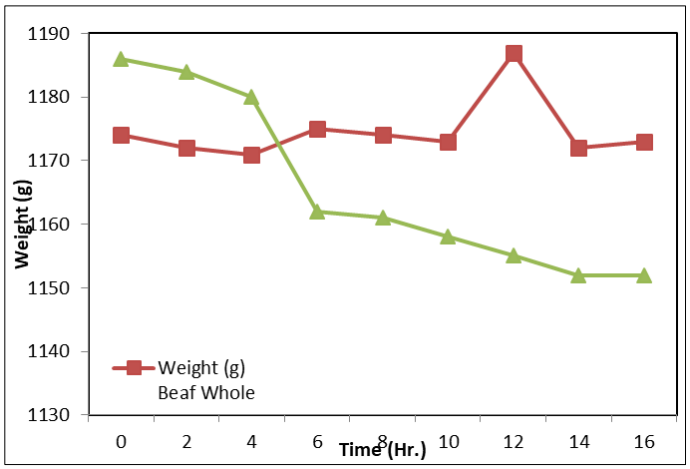

Figure 4 Graph of frozen beef weight (g) against Time (Hr.)

3.3. Discussions on the frozen of Beef

The weight of the whole frozen beef when kept in the cold storage decreases from 1173 g to 1174 g which is equivalent to 1 g, representing 0.09% while the pieces beef also decreases from of 1152 g to1186 g, an equivalent of 34 g representing 2.87%. The results revealed that whole frozen beef gives better result than when it is in pieces form as shown in figure 4.

Table 2 Result of the weight recorded for DE frozen of Chicken, Catfish and Beef in whole and pieces Form

S/No.	Time (Hr.)	Chicken Weights (g)		Catfish Weights (g)		Beef Weights (g)	
		Whole	Pieces	Whole	Pieces	Whole	Pieces
1	0	1816	1261	872	877	1173	1152
2	2	1818	1265	878	877	1177	1148
3	4	1818	1264	876	880	1176	1146
4	6	1818	1268	876	879	1174	1122
5	8	1817	1265	874	879	1162	1115
6	10	1817	1264	874	882	1160	1112
7	12	1817	1264	874	882	1160	1113

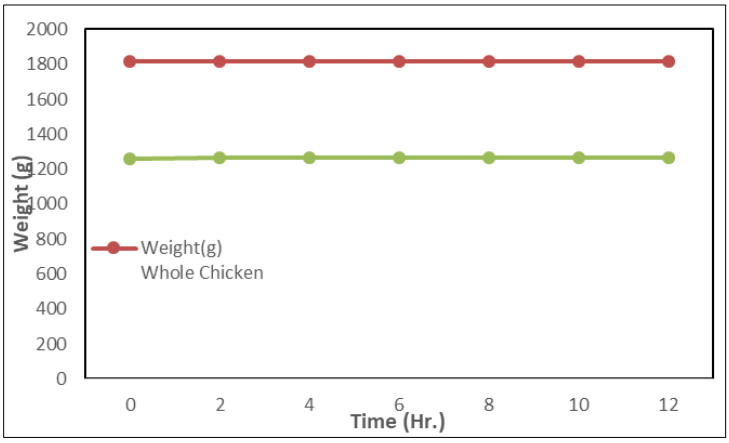

Figure 5 Graph of DE frozen Chicken weight (g) against Time (Hr.)

3.4. Discussions on the DE frozen of Chicken

The weight of the whole DE froze chicken when kept in cold storage increases from 1817 g to 1816 g which is equivalent to 1 g, representing 0.06% while the pieces chicken increases from of 1261 g to 1264 g, an equivalent of 3 g representing 0.24%. The results show that chicken DE frozen in whole gives better results than in pieces as shown in figure 5.

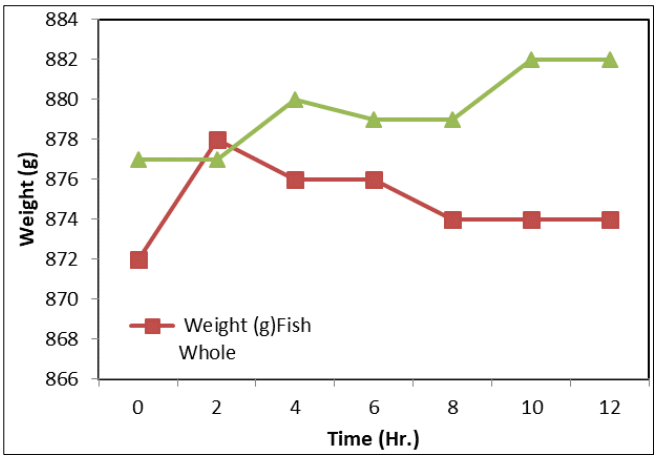

Figure 6 Graph of DE frozen Catfish weight (g) against Time (Hr.)

3.5. Discussions on the DE frozen of Catfish

The weight of the whole DE frozen catfish when kept in the cold storage increases from 874 g to 872 g which is equivalent to 2 g, representing 0.23% while the pieces catfish also increases from of 882 g to 877 g, an equivalent of 5 g representing 0.57%. The results show that fish DE froze in whole gives better results than in pieces as shown in figure 6.

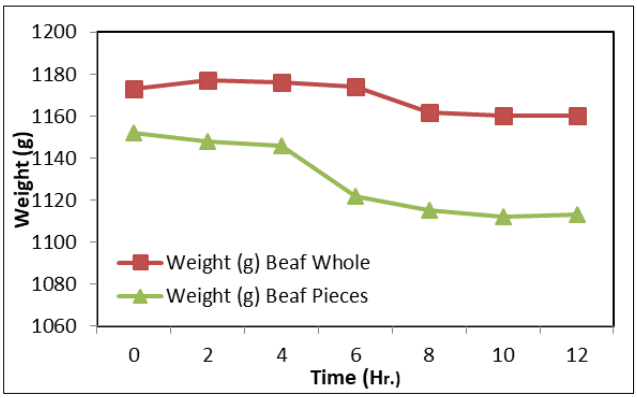

Figure 7 Graph of DE frozen beef weight (g) against Time (Hr.)

3.6. Discussions on the DE frozen of Beef

The weight of the whole DE frozen beef when kept in the cold storage decreases from 1160 g to 1173 g which is equivalent to 13 g, representing 1.11% while the pieces beef also decreases from of 1113 g to 1152 g, an equivalent of 39 g representing 3.39%. The results show that beef DE froze in whole gives better results than in pieces as shown in figure 7.

Table 3 Cooling Storage Temperature at no-load and at load

S/No	Time (Minutes)	Temperature at no load (°C)	Temperature at load (°C)
1	0	32.1	31.1
2	10	25	25.1
3	20	0.85	20.7
4	30	-0.9	16.2
5	40	-3.7	13.1
6	50	-5.2	10
7	60	-6.2	8.2
8	70	-6.8	6.7
9	80	-7.2	5.1
10	90	-7.3	3.7
11	100	-7.4	2.8
12	110	-7.4	1.8
13	120	-7.4	1

The following can be deduced from the table 3 and figure 8

i. The maximum the cooling storage at no load is -7.4°C
ii. It takes the cooling system 100 minutes to attain the maximum cooling level of the storage system
iii. The ambient temperature of the cooling system is 32.1°C

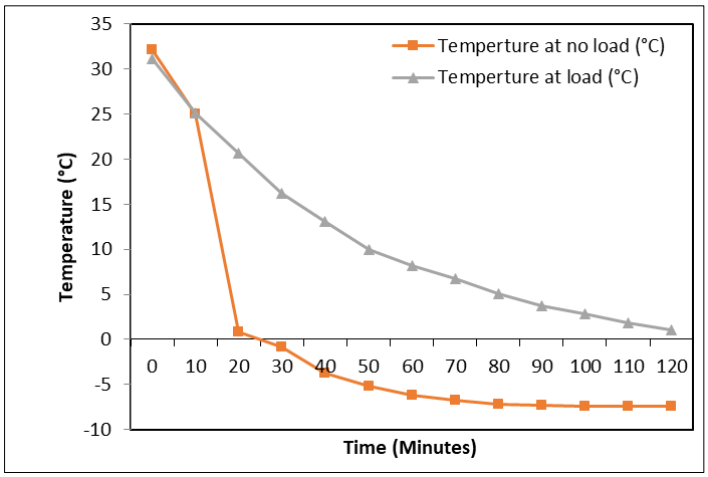

Figure 8 Graph of the Cooling Storage temperature at no-load and at load against Time

4. Conclusion

Assessment of a cost-effective cold storage system utilizing animal products underscores the significance of innovative solutions in preserving perishable items. Through this evaluation, it becomes evidence that advancements in storage technology can bridge the gap between limited resources and optimal preservation contributing to reduced waste and improved access to animal-derived products. While challenges may arise in terms of scalability and environmental impact, the research demonstrates the potential for such system to enhance food security and economic viability, making strides towards a sustainable and efficient cold storage system.

Compliance with ethical standards

Acknowledgements

We acknowledge our indebtedness and deepest sense of gratitude to all members of staff, Institute of Technology, Kwara State Polytechnic, Ilorin, National Centre for Agricultural Mechanization, Ilorin and Federal College of Horticulture, Dadin-kowa Gombe, Nigeria.

Disclosure of conflict of interest

We hereby declared there is no conflict of interest.

References

[1] Balarabe, S., Doma, U.D., Kalla, D.J,U. and Zahraddeen, D., 2016. Animal Products and Handling: A Caution for Consumers and Entrepreneurs Nigerian Journal of Animal Science.2016 Vol. (1) Pp. 266 – 274

[2] Barbara, Sawicka, 2019. Post-harvest Losses of Agricultural Produce, Department of Plant Production Technology and Commodities Science, Faculty of Agro bioengineering, University of Life Sciences in Lublin, Lublin.

[3] Fabunmi O.A, Osunde Z.D, Alabadan B.A. and Jigam A.A., 2015. Influence of moisture content and temperature interaction on mechanical properties of DESMA (Novella pentadesma) SEED. Journal of Advance Food Science Technology, Vol. 2, Pp.81–85.

[4] Kaale, L. D., Eikevik, T. M., Rustad, T. and Kolsaker, K., 2011. Super chilling of food: A review. Journal of Food Engineering, 107(2), pp. 141-146

[5] Oyedokun J.A., N.O. Oladipo, M.K. Bello, O.M. Odeseye, and O.A. Ogunjirin; 2022. Design and Fabrication of NCAM Multi-crop Dryer, Global Scientific Journal Vol. 10, Issue 3, Pp. 2081-2091

[6] Pal, M, 2014. Preservation of various foods. Ph.D. Lecture Note, Addis Ababa University, College of Veterinary Medicine and Agriculture, DebreZeit, Ethiopia. Pp.1-11.

[7] Rahman, MS. (2007). Handbook of food preservation. 2nd ed. Food science and technology. Boca Raton: CRC Press; (eds).

[8] Rahman, R. (2014). Food preservation. http://en.banglapedia.org/index. php? title=Food_ Preservation.