EVALUATION OF NUTRIENTS RETENTION OF PERISHABLE FOODS USING THE PRINCIPLE OF FREEZE-DRYING, SABON-GARI, KADUNA STATE. NIGERIA.

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Abstract: Nigeria, an agriculture-based country lacks adequate preservation facilities to store perishable food for longer shelf live and maintaining its quality (unaltered), leading to huge wastages and losses for farmers. The research aims to investigate the nutrients retention capability of freeze dried perishable materials over conventional methods of drying. Samples of fresh Tomatoes, Strawberries, Apples, Beef and Spinach were collected, dried using the 3 selected methods of drying (direct sun, Solar and freeze drying) and analyzed to investigate their nutrients loss after drying. The results shows that freeze drying method recorded the lowest nutrients loss of 29 -0.5%, the method is hygienic, takes shorter time and little colour and shape variations in the dried products, Solar drying method recorded nutrients loss of 67 – 7.75%, although it was relatively hygienic, it took longer processing time (several days) and led to significant colour and shape variations. The direct sun drying method resulted in the highest nutrient loss, ranging from 93.07 – 10.48%, the process is unhygienic, time-consuming and significantly changed the colour and shape of the dried products. The findings strongly suggest that freeze drying is the most effective method for retaining nutrients in perishable products, making it a viable solution for prolonging shelf life and preserving the quality of agricultural produce in Nigeria. Implementing the freeze drying method could reduce food wastage, support farmers, and enhance food security in Nigeria.

Keywords: Freeze drying, Nutrients retention, Perishable food , Solar drying, Sun drying

INTRODUCTION

The basic need of man is food, man and animals need to eat to survive, grow and stay healthy and strong. Man engaged in agricultural activities in an effort to produce food, these activities result into production of food items for local and commercial consumption (Patel & Pikal, 2019). However, African farmers, Nigeria and Northern states encounter challenges of preservation and storage of agricultural products when produced in abundance. In period of abundance harvest, lack of adequate preservation facilities of food produces, especially fruits and vegetables, leads to a lot of wastages of this produce. These problems, discourages farmers as their efforts are wasted and incur losses (Muhammed *et. al.*, 2017)

Freeze drying is a process of drying product by sublimation, under low temperature and reduced pressures (Adams *et al.*, 2015). It has wide application in different fields, such as food, pharmaceuticals, manufacturing (Adams *et al.*, 2015). The earliest known instance of freeze drying dates back to 1890 when Altmann carried out a procedure involving organ parts, and using Gaede;s novel contribution to technology, the diffusion pump. Gersh constructed an efficient vacuum system for preparing historical samples through freeze drying in 1913 (Ter, 2019). When substances undergo freeze-drying treatment it’s done for the

purposes of achieving long lasting quality without changes upon adding water during restoration; however, reaching this result also depends significantly on correct packaging and storage.

The principle of Freeze drying has a wide range of applications which includes; pharmaceuticals and biotechnology, food and agriculture-based industries, chemical synthesis, bio-separation, nanotechnology, as recovery method for water damaged documents and books, bacteriology and high altitudes environment and advanced ceramics process (Vecchio, 2010).

Muhammed *et al.* (2017) conducted research that demonstrated the effectiveness of freeze drying in preserving nutrients in various perishable food items such as fruits, vegetables and meat. Their findings showed that freeze drying recorded the lowest nutrients loss compared to other drying methods.

Traditional methods of drying like sun drying and solar drying have been extensively used in developing countries like Nigeria because of their simplicity and low-cost nature. Smith and Johnson (2016) and Rahman *et al.* (2018) pointed the drawbacks of these methods, including significant nutrients losses, unhygienic processing conditions and longer drying time.

Studies by Chen *et al,* (2019) and Gupta and Mishra (2020) explored the economic viability and benefits of implementing freeze drying facilities in developing countries. These researches indicates that the preservation of perishable food through freeze drying has the potential to reduce food wastage and also enhance food security and improve the farmer's income.

Adoption of freeze-drying technology in some regions such as Latin America and Southeast Asia, has shown promising results in preserving the nutritional value and sensory qualities of dried products (Garcia *et al.,* 2021; Nguyen and Le, 2022).

Drying in Nigeria

Drying is a process of removing moisture from substance with the sole aim of preserving it for future use. Drying removes moisture which prevents the growth of microorganisms and prevents vegetables and other farm produce from spoilage. Moisture is removed to a safe level that does not alter some important qualities of the commodity. Northern Nigeria farmers use traditional sun drying and smoking methods for drying most of the agricultural and perishable produce. These old drying methods have a lot of disadvantages and problems associated with them, these includes lacks of controllability on the drying conditions, the drying process is very slow and are usually interrupted by unfavourable weather conditions, it also needs constant supervision of the process since the produce have to be protected from predators and rain. Under open sun drying the chances for contamination due to dust, dirt and insect infestation are high. Similarly, solar dryers are effective than direct sun drying in terms of contamination but also poses a lot of nutrients losses, large colour & shape variations and is less effective in seasons with low sunlight (cold/harmattan season) (Heriquez *et. al*, 2012).

So, it is important to investigate an improved technology like freeze drying to maintain the quality and thereby solve the problem of traditional sun drying and wastage of agricultural produce.

High rate of nutrients content lost in perishable material and subsequent degradable changes in their nutrients value during opened conventional drying under sun. In this way, it is assumed that the water

content of the perishable materials in the form of vapour can easily be evaporated without destroying the nutrients contents as in the case of other conventional drying processes such as direct sun drying and solar drying (Semirames, 2019).

MATERIALS AND METHODS

Materials

Fresh samples Tomatoes, Strawberries, Apples, Beef and Spinach were sourced from Modern Sabon Gari market, Kaduna State in order to ensure representative of the samples. A freeze dryer, solar dryer and trays were used to dry the samples.

Sampling Techniques

In this research purposive sampling technique is employed to select samples of perishable food items and specific drying methods for analysis. This technique allow us to focus on specific perishable food items and drying methods that are widely consumed and critical to the food preservation challenges faced in Nigeria.

Selection of perishable food items

We purposively selected 5 perishable food items: Tomatoes, Strawberries, Apples, Beef and Spinach. These items were selected based on their popularity, nutritional significance and susceptibility to nutrient loss during drying process.

Selection of drying methods

Direct sun drying, Solar drying and freeze drying were specifically selected due to their relevance to food preservation practices in Nigeria. Direct sun drying and solar drying represent the traditional methods often used in the absence of advanced preservation facilities, while freeze drying represents the modern method of drying.

Methods

Sample collection/Preparation

Samples of Tomatoes, Strawberries, Apples, beef and Spinach were cleaned and washed with water, then cut into slices to increase surface area. The samples were divided into four (4) lots for direct sun drying, Solar drying, freeze drying and fresh samples (to serve as control and reference sample).

Sun Drying Method

Samples were put in trays (each sample in separate tray) for sun drying experiments (Figure 1a). These trays were put under direct sun and are taken into a room during night when there is no sunlight. The sun drying was usually between 10:00 to 6:00 pm.



Fig. 1: Samples in a tray sprayed for sun drying

Freeze Drying Method

Samples were freeze dried in a LGJ-12 freeze dryer developed by Biejing Songyuanhuaxing Technology Develop Co. Ltd. The frozen samples slices were immediately transferred to the drying chamber of freeze drier. Lastly, sample were packed in sealed bags and stored until characterization.



Fig. 2: Freeze dryer containing samples

Solar Drying Method

Samples were placed in a dryer made up of an insulated box constructed with a wood. The surface is covered with transparent single layered sheet. The inside is coloured black in order to absorb solar radiation. The temperature is raised and the inside air gets warm and these removes moisture from the samples in the trays inside the box. The plywood and other insulating objects prevent virtually all contaminants from getting into the sample.



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Fig. 3: Samples in a solar dryer

Analyses

Proximate Analysis

1. Moisture content (AOAC 1980)

Plastic dishes were dried in an oven to100^{o}C. Then later cooled in a desiccator and is weighed as (W_1). Placed 2 grams of the grounded (powder) sample in the weighed moisture dish and weighed as (W_2). Keep the sample in an oven for about 3 hours, then cooled and weighed W3

% of moisture: $\frac{w_2-w_3}{w_2-w_1} \times 100$ (1)

2. Ash content

Cleaned and dried crucible are weighed W1. Also, placed two grams of the grounded (powder) in the crucibles and record the weight as W_2. Transferred the sample to Murffle Furnace and heat to about 550°C, the cooled and weighed W3.

% of Ash: $\frac{w_3-w_1}{w_2-w_1} \times 100$ (2)

3. Determination of Fibre

Put 2 grams of sample in a 1.2ml of H2SO4 and boiled for 30 minutes. Transfer and boiled the residue to a beaker of 1.2ml of NaOH. The residue is then washed with hot water and dried and weighed C2, after then heat to 550 ^{O}C in a furnace and weighed C3.

% of Fibre was calculated as: $\frac{c_2-c_3}{w} \times 100$ (3)

4. Lipids/Fat

- Dried 250ml boiling flask and allowed to cool
- Weighed an empty filter paper as W1
- Weighed 2 grams of sample in a filter paper as W2
- Filled N-hexane into a boiling flask
- Assemble the Soxhlet apparatus and allowed refluxing for 8 hours
- Removed sample and transferred to oven
- From oven transferred to desiccator and allowed to cool and weighed as W3

% of Fat was calculated as: $\frac{w_3-w_1}{w_2-w_1} \times 100$ (4)

1. Protein

Digestion:

I.
II. Weighed 2 grams of sample to Kjeldahl flask
III. Add Cu catalyst into 15ml conc. H2SO4
IV. Heat in fume cupboard until it turns green.
V. Cooled and washed with water down black particles at the neck of the flask
VI. Digest into 100ml distilled water

Distillation:

- Markham apparatus was steamed for 15 minutes
- Placed Conical flask containing 10ml Boric indicator under condenser.
- 10ml of the digest was pipetted into the body of the apparatus through funnel
- Then washed down with distilled water then by 10ml 40% NaOH solution.
- Steamed through NH4SO4 for about 7 minutes.

2. Determination of Carbohydrate (CHO) (Pearson 1976)

= 100 - (%moisture + % Ash + % Protein + % Fat)

2.4 Chemical Analysis

Perchloric Acid Digestion (Wet Oxidation) of plant Materials for P, Ca, Mg, Fe, Mn, Zn, and Cu

Ground sample (oven-dry, 60°C) was weight (0.5 to 1.0g) into a 125-ml Erlenmeyer flask. 4ml of perchloric acid, 25ml conc. HNO3 and 2 ml conc. H2SO4 were added under a fume hood. These were heated slowly on a hot plate under perchloric acid fume hood until the appearance of dense white fumes, distilled water were added and boiled for half a minutes on the same plate. Finally, cooled and filtered with a wash bottle into a 100 ml volumetric flask. Filled up to mark with distilled water (Whatman No. 42 filter paper, 9 cm) (A.M Maritza. 2012). The solution was stored for colorimetry (P and Fe determination) and Atomic absorption spectrometry(Mg, Ca and Zn determination).

RESULTS

Experimental results

Table 1: Proximate compositions of fresh samples

SAMPLES	MOISTURE (%)	ASH (%)	CARBOHYDRATE (%)	PROTEIN (%)	LIPID (%)	CRUDE FIBRE (%)
TOMATOE	95.2	0.02	89.03	0.70	2	8.2
APPLE	85.05	0.50	13.55	0.30	0.40	0.02
SPINACH	11.05	9.01	7.52	58.80	11.04	6.04
BEEP	68.19	0.92	0.02	21.50	6.75	0.03
STRAWBERRY	88.6	11.27	5.76	0.89	4.78	0.03

Table 2: Mineral compositions of fresh samples

SAMPLES	K (mg/100)	Fe	Ca	Mg	Zn
TOMATOE	26.15	1.40	17.43	32.50	0.57
APPLE	26.15	1.40	17.43	32.50	0.57
SPINACH	16.85	43.47	61.19	27.51	3.73
BEEP	388	2.84	43.5	38.5	2.67
STRAWBERRY	1.93	19.27	118.13	0.15	1.40

Table 3: Minerals compositions of dried samples

SAMPLES	Sun dried Sample						Solar dried Sample						Freeze dried Sample					
	Soduim	Potassium	Calcium	Magnisium	Phosphorus	Iron	Sodium	Potassium	Calcium	Magnesium	Phosphorus	Iron	Sodium	Potassium	Calcium	Magnesium	Phosphorus	Iron
Tomatoes	0.5	0.09	0.1	0.15	0	0.5	1.78	0.75	0.09	0.19	0	1.78	1.88	1.29	0.15	0.19	0	1.88
Apple	20.2	1	10.3	20.5	0.23	20.2	22.45	0.98	13.67	26.45	0.45	22.45	25.9	1.2	15.45	30.19	0.49	25.9
Spinach	8.4	20.4	39.8	13.67	1.99	8.4	10.98	39.9	51.78	23.45	3.02	10.98	16.23	43	60.89	25.56	3.24	16.23
Beep	298	2.05	39	28.34	2.19	298	358	2.45	39.78	33.45	2.45	358	379	2.56	42.98	37.65	2.58	379
Strawberry	0.54	8.36	59	0.05	0.5	0.54	0.98	12.8	68	0.1	0.9	0.98	1.89	18.45	100	0.13	1.2	1.89

Nutrients Variation (loss)

The table below the nutrients variations of each drying methods employed in this research i.e the sun, solar and freeze drying methods.

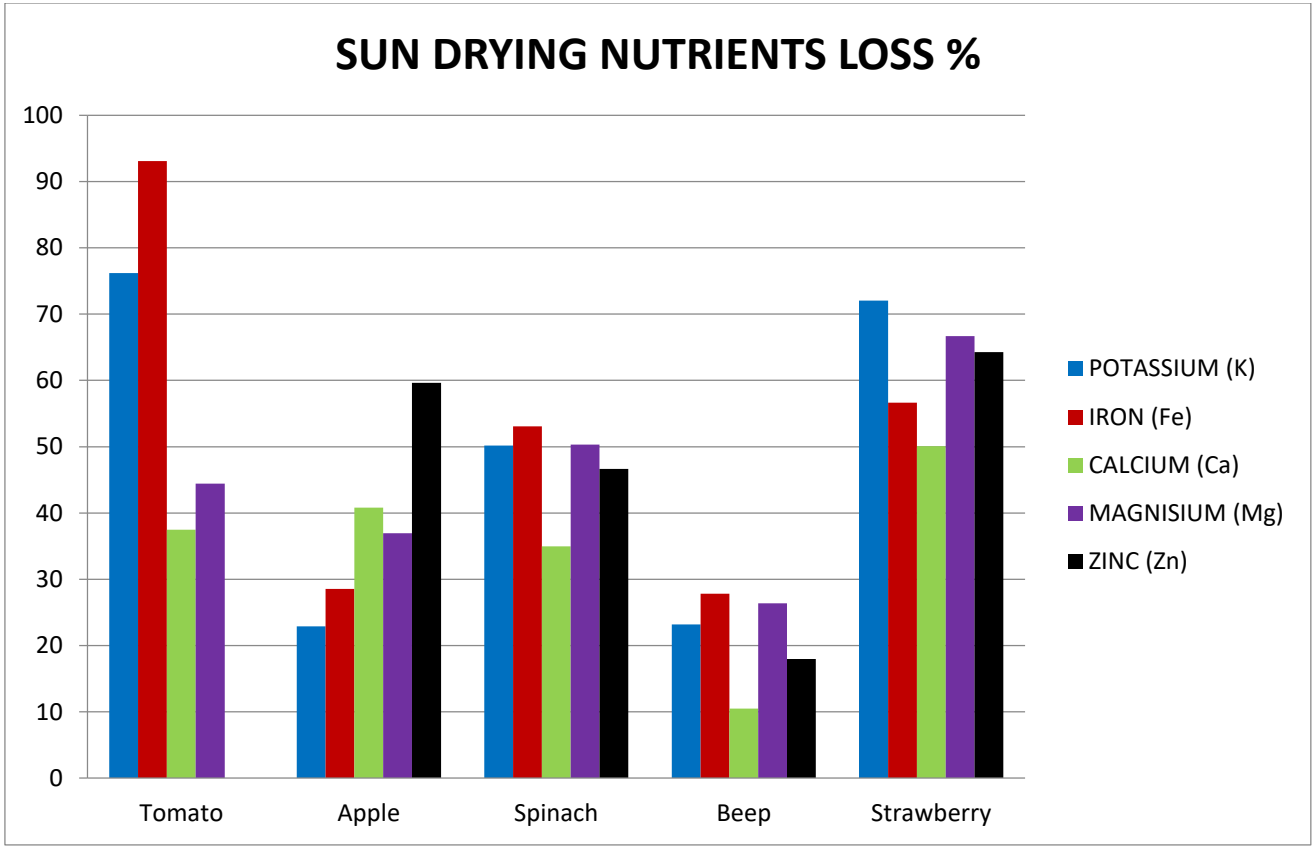

Fig. 4: Sun drying nutrients loss

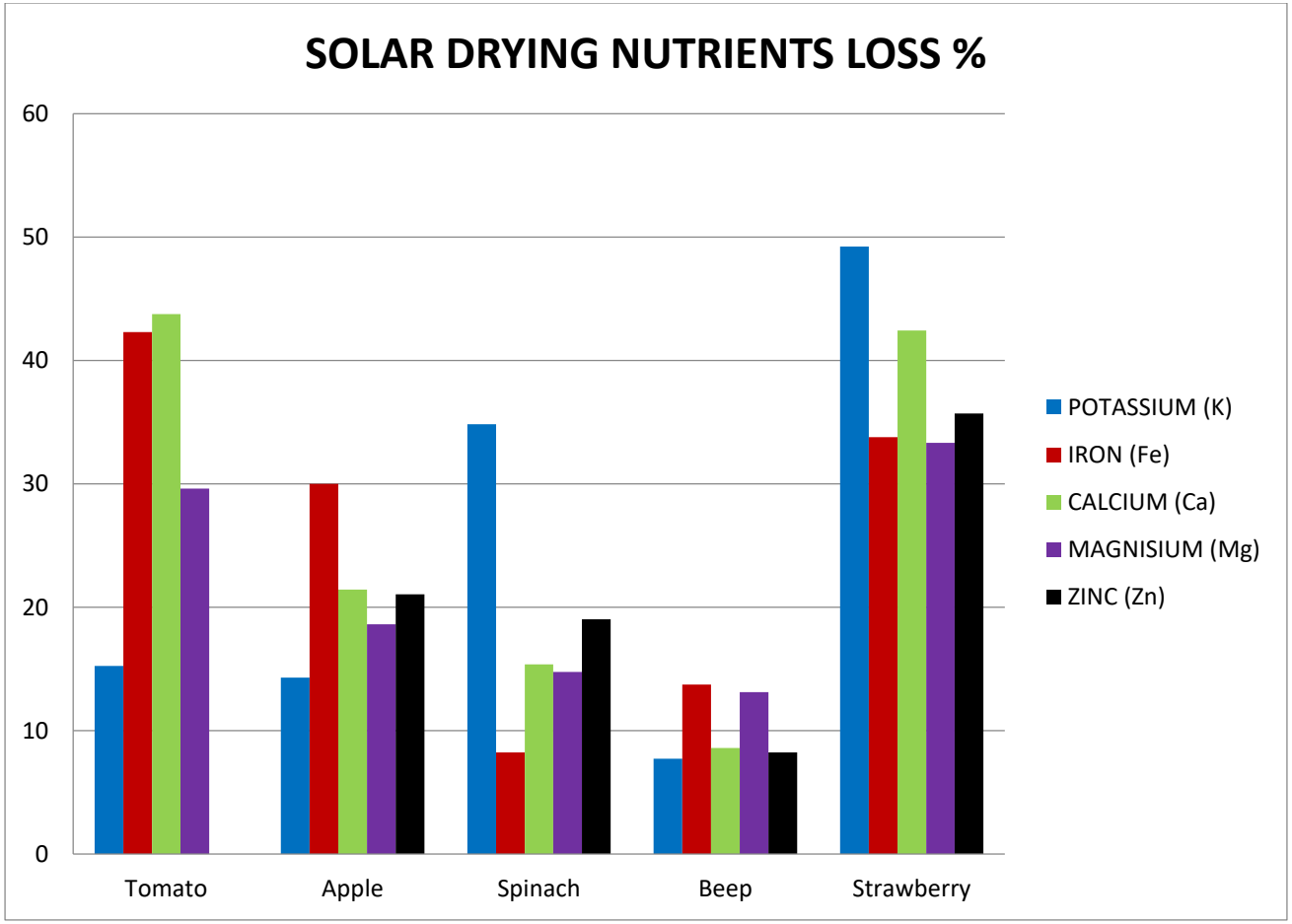

Fig. 5: Solar drying nutrients loss

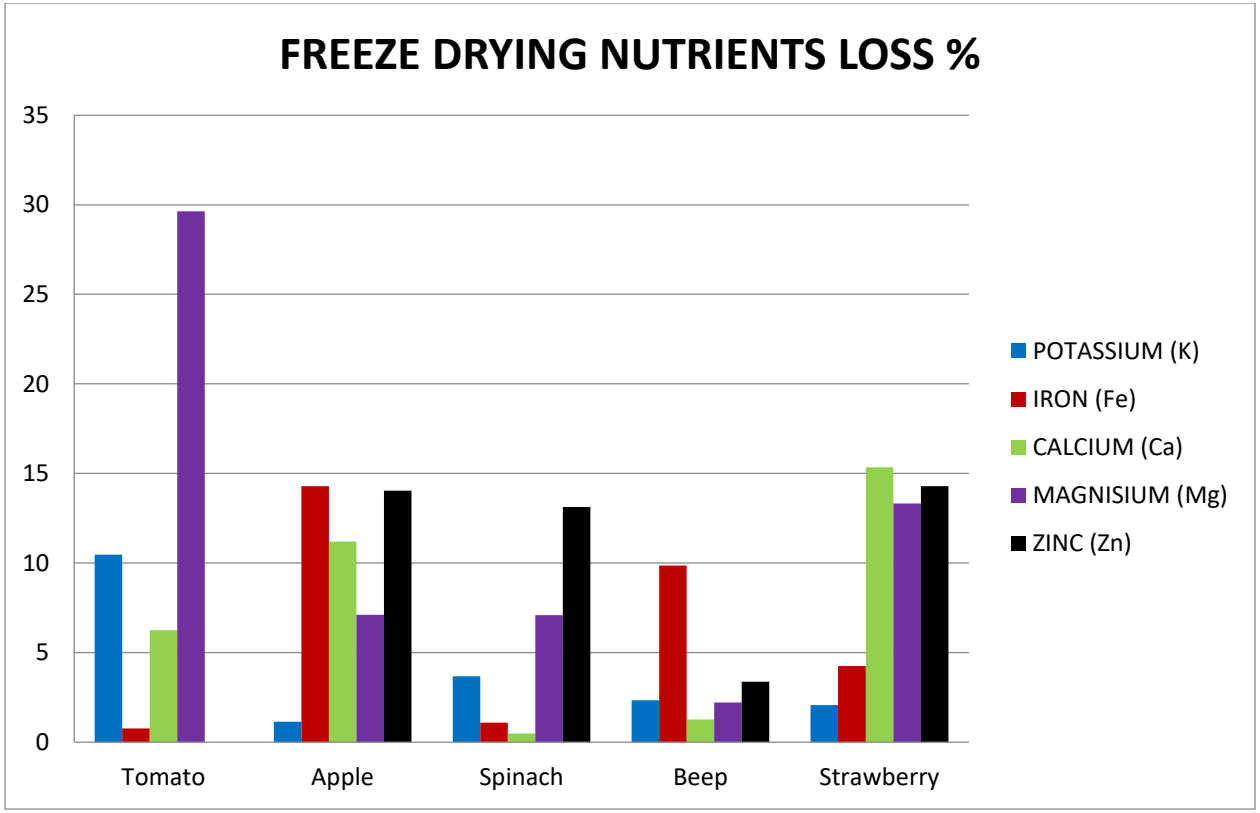

Fig. 6: Freeze drying nutrients loss

Table 4: Nutrients Variation of dried samples

SAMPLES	δ (%)						δ^* (%)						δ^{**} (%)					
	Sodium	Potassium	Calcium	Magnesium	Phosphorus	Iron	Sodium	Potassium	Calcium	Magnesium	Phosphorus	Iron	Sodium	Potassium	Calcium	Magnesium	Phosphorus	Iron
Tomatoes	76.19	93.077	37.5	44	0	15.2	42	43.8	30	0	10.48	0.77	6.3	29.6296	0	76.19	93.077	37.5
Strawberries	22.901	28.571	40.8046	37	59.6	14.3	30	21.4	19	21.053	1.145	14.3	11	7.10769	14	22.901	28.571	40.8046
Apples	50.148	53.071	34.9567	50	46.6	34.8	8.2	15.4	15	19.035	3.68	1.08	0.5	7.08833	13.1	50.148	53.071	34.9567
Beef	23.206	27.817	10.4755	26	18	7.74	14	8.61	13	8.2397	2.332	9.86	1.3	2.20779	3.37	23.206	27.817	10.4755
Spinach	72.021	56.617	50.055	67	64.3	49.2	34	42.4	33	35.714	2.073	4.26	15	13.3333	14.3	72.021	56.617	50.055

$$\text{Sun dried nutrient Variation } (\boldsymbol{\delta}) = \frac{Fresh\ Sample - Sun\ Dried}{Fresh\ Sample} \times 100$$

$$\text{Solar dried nutrient Variation } (\boldsymbol{\delta}^*) = \frac{Fresh\ Sample - Sun\ Dried}{Fresh\ Sample} \times 100$$

$$\text{Freeze dried nutrient Variation } (\boldsymbol{\delta}^{**}) = \frac{Fresh\ Sample - Sun\ Dried}{Fresh\ Sample} \times 100$$

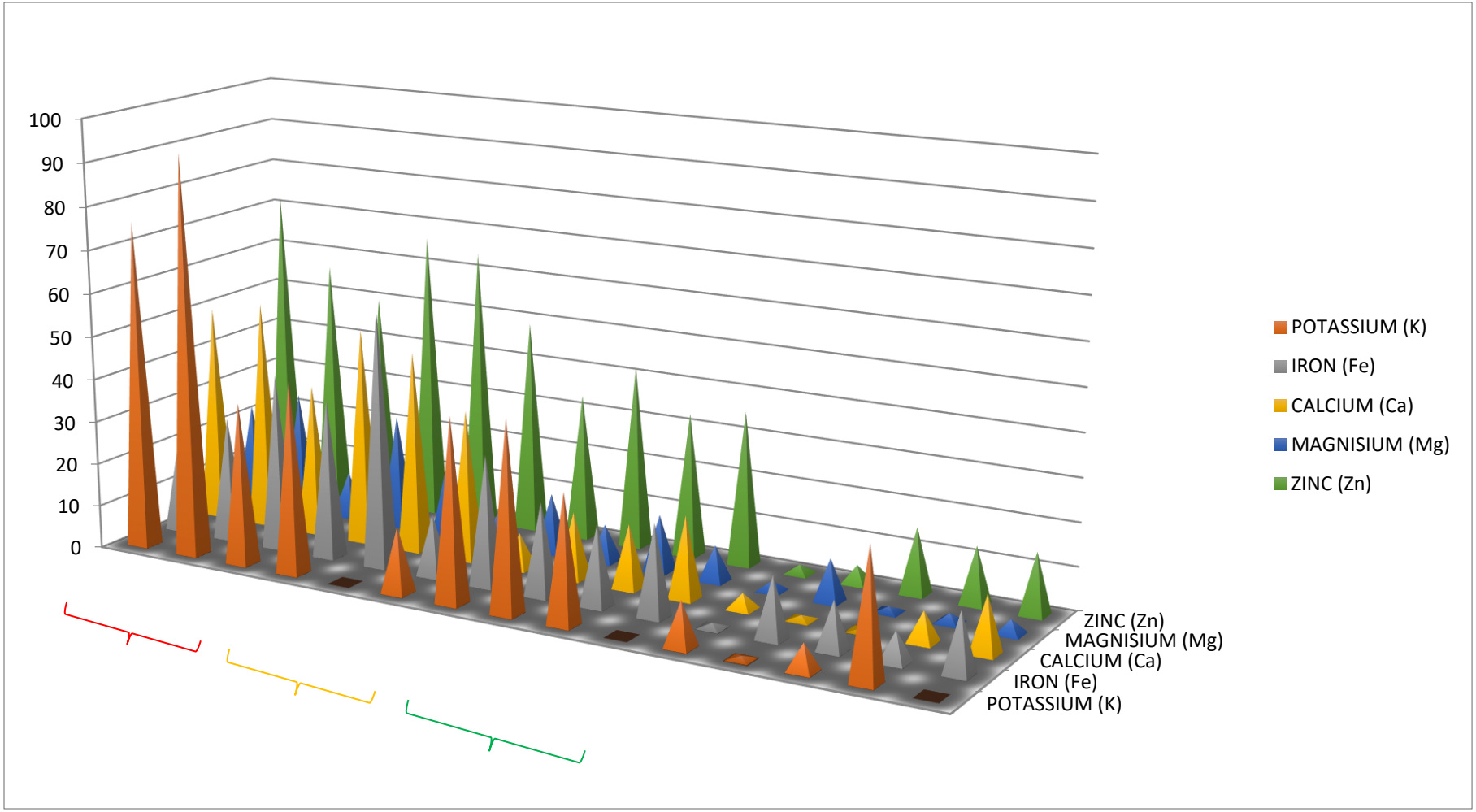

Fig. 7: Nutrients variations of the three drying methods

4.0 DISCUSSION

One of the most common methods of preserving perishable foods is drying. Drying had undergone series of improvement over the years with significant developments to make the process effective and hygienic (Kumar *et al.*, 2015). This work investigates the nutrients retention of three selected drying methods (direct sun, solar and freeze drying) by comparing the nutrients variations of the three drying methods. Direct sun drying been the old, traditional and most used methods of drying perishable foods in Nigeria especially northern Nigeria recorded the highest nutrients variation (nutrients loss) of 93.077% - 10.4755%, the method also recorded high colour loss and high contamination from foreign materials as it is subjected to direct sun without any shield and takes a longer time before it gets dried (7 days in this research). Solar drying; an improved sun drying where perishable foods are put in a constructed box made of materials to increase the flow of sun/heat radiation recorded a nutrients variation (nutrients loss) of the range 67% - 7.74%, this method is very hygienic as there were no contamination and recorded slight colour changes, it takes lesser time than direct sun drying (5 days). A modern drying method (freeze drying) majorly adopted by food and pharmaceutical industries to dry delicate medical cells/tissues recorded the lowest nutrients variations (nutrients loss) of 29% - 0.5%, the method is hygienic and takes time usually 24 hours.

5.0 CONCLUSION AND RECOMMENDATIONS

The nutrient variations (nutrients loss) of some drying methods as the most important quality parameter of dried perishable foods was investigated. The results showed that the freeze-drying method is the most effective method of drying perishable foods as it recorded the lowest nutrients loss (29-0.5%), the method is hygienic and takes not more than 24 hours to dried sample, followed by the solar drying method with nutrient loss of 67 – 7.74%, though the method is a little bit hygienic but it takes longer time of at least 5days. Direct sun drying recorded the highest nutrients loss and the process is completely unhygienic and takes much longer time than the other methods. The principle of freeze drying if fully harnessed and our local fabricators puts in effort to produce them locally (as foreign freeze dryers are expensive) in our locality (northern Nigeria in particular) will end losses incurred by perishable farmers and will boost our economy and above all create a lot of works to the teaming youths. The study recommends that implementing the freeze drying method could reduce food wastage, support farmers, and enhance food security in Nigeria

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