Global Journal of Science Frontier Research: C
Biological Science
Volume 15 Issue 2 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Nutritional Quality of Osmotically Dehydrated Catfish (*Clarias Garipinus*) and Beef as Influenced by Sodium Chloride Concentration

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Abstract- In this work, the influence of sodium chloride (solute) concentration on the nutritional quality of osmotically dehydrated Catfish and beef were evaluated, using vitamin C as quality marker. Results show that at 95% confidence interval, NaCl concentrations play significant role in the stability of vitamin C in both catfish muscle and beef during osmotic dehydration. The vitamin C value of catfish degraded from 20.5% to 88.76% for corresponding NaCl concentration levels of 10% to 90% respectively. For beef, 18.46% to 69.23% reduction of vitamin C was recorded for respective 10% to 90% NaCl concentration. It is therefore advised that if sodium chloride must be used as solute in the osmotic dehydration of the above agricultural products, then, the dehydrated products must be fortified with adequate vitamin C before consumption.

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GJSFR-C Classification : FOR Code: 069999

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I. Introduction

Nutritional losses have been found to accompany virtually every agricultural processing activity. These processing activities includes drying, washing, size reduction, cold storage, blanching, sterilization etc, and the effect of these activities on finished product quality, ultimately, determines the usefulness and commercial viability of that unit operation.

Drying (either oven, sun or osmotic) amongst them is one of the worst unit operations were nutritional losses are encountered and reported. It is indeed, accompanied by loss of volatiles, proteins, vitamins, aroma, texture and changes in colour. Thus, to investigate the nutritional losses during processing, scientist and food engineers have considered vitamin C as a nutrient quality index or marker during processing and storage of foods (Fennema, 1977; Tarade et al, 2007; Abioye et al, 2013).

Vitamin C, otherwise called ascorbic acid, is an important component of food with a broad biological activity relevant to human health. It is an antioxidant and the recommended daily allowance (RDA) for ascorbic acid is 75mg for women and 90mg for men. It is a white, crystalline, odourless and water-soluble compound (Andrea et al, 2006). Vitamin C supports the absorption of iron and the formation of collagen and is often added to foods not only as a nutrient to make up for processing losses, but is added to prevent the browning of fresh and canned fruits and vegetables, the acidification of fish and meat (Andrea et al, 2006; Kirby et al, 1996). This has led several scientists to investigate the degradation potentials of vitamin C in various agricultural and food products during processing and storage (Gordon and Samaniego, 1990; Vikran et al, 2005; Rao et al, 1981; Kajihausa et al, 2010; Hand et al, 2005). It is water-soluble and in water readily oxidizes first to dehydroascorbic acid, then to diketogulonic, oxalic, and threonic acids (Andrea et al, 2006). The first reaction is known to be reversible, but the subsequent ones are not. Therefore the content of vitamin C in agricultural products and foods can decrease during food preparation, preservation and storage.

Beef and catfish (*Clarias garipinus*) are the most commonly available and widely consumed sources of animal and fish proteins in developing countries like Nigeria. However, smoke-drying is the commonest means of preservation with its attendant high cost of firewoods(energy), and nutrient losses. In contemporary food technology, the focus is to conserve energy, reduce cost, improve quality and maximize retention of nutrients in both processing and storage. It is therefore appropriate to try other means of preservation such as osmotic dehydration.

Osmotic dehydration is an important complementary treatment and food preservation method in the preservation of foods. It presents some benefits which includes reduction of damage of heat to flavour, colour, decrease in energy cost, increase in shelf-life, retention of aroma etc (Alakali et al, 2006; Torres et al, 2006; Moazzam, 2012). In osmotic dehydration, the food product is immersed in osmotic solution such as salts, alcohols, sugars etc. However, there is dearth of information on the nutritional quality of osmotically dehydrated catfish and beef in sodium chloride solution. Therefore, the objective of this study is to investigate the effect of sodium chloride concentration on the nutritional quality of osmotically dehydrated catfish muscle and beef using vitamin C as quality marker.

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II. Materials and Methods

a) Sample Preparation

Three matured market-sized catfish (*Clarias garipinus*) weighing 1.5kg each and 5kg of beef were purchased from the Tombia Junction Market in Bayelsa State, Nigeria in August, 2014. They were taken immediately in plastic basins to the Food Processing Laboratory of the Niger Delta University and eviscerated and prepared for osmotic dehydration and vitamin C content experimentation. 32 samples of 5g each were cut-out from each of the specimen for replication at each sodium chloride concentration level.

b) Apparatus Used

The apparatus used were 250ml beakers, a camry digital balance, 250ml conical flasks, 200ml measuring cylinder, kitchen knife, 100ml beakers, 50ml burette with stand, glass stirring rod, mortar and pestle and a convective oven (Venticell, MMM, Medcener, Germany).

c) Chemicals and Reagents Used

The chemicals used includes; vitamin C tablets (Ascorbic acid), 5 x 10^{-2} M Potassium Iodate solution, 1.0M HCl solution, 0.6M Potassium iodide solution, starch indicator solution (Freshly prepared) and cheese cloth

d) Solute Concentrations

Nine (9) different concentration levels of the sodium chloride (NaCl) solution were obtained in the following ratios;

Sample Code	% Solution Concentration	
F_1	10% NaCl	+ 90% H_2O
F_2	20% NaCl	+ 80% H_2O
F_3	30% NaCl	+ 70% H_2O
F_4	40% NaCl	+ 60% H_2O
F_5	50% NaCl	+ 50% H_2O
F_6	60% NaCl	+ 40% H_2O
F_7	70% NaCl	+ 30% H_2O
F_8	80% NaCl	+ 20% H_2O
F_9	90% NaCl	+ 10% H_2O

The samples were then immersed in the different osmotic solutions (% NaCl + % H_2O) at room temperature of 25^{0}C for a period of 5 hours. After 5 hrs, samples were withdrawn from the solution, blotted with absorbent paper and sent in cellophane bags for vitamin C analysis in the Chemistry Laboratory of the Niger Delta University, Bayelsa State. This was replicated thrice for each specimen at the various sodium chloride concentration levels.

e) Procedure

0.5g of vitamin C tablets were weighed and transferred into a 250ml conical flask and 150ml of distilled water added. With the aid of a glass stirring rod, the tablets were brought into solution. 5ml of 1M HCl was added to assist the dissolution process. 10ml of 0.6 KI solutions was then added, followed by 2 drops of freshly prepared starch indicator solution.

A burette was filled with 0.05M Potassium iodide (0.05M KIO_3) solution and the solution was titrated against the vitamin C solution to a permanent bluish – purple colour. The titre volume was noted.

5g of the fish/beef sample at each concentration levels were weighed and crushed in a mortar and pestled until it became properly grinded. 100ml of distilled water was then added to wash off the pestle and mortar into a 250ml beaker and boiled on the hot plate for about 15 minutes. The stock was then cooled and strained through the cheese cloth. The filtrate was transferred in a measuring cylinder and made up to 150ml with extra distilled water. The solution was then placed in a 250ml conical flask, 5ml of 1.0M HCl, 10ml of 0.6M KI solution and 4 drops of freshly prepared starch indicator added. The burette was then filled to the 'O' mark with the Potassium iodate solution. The titration was carried out in the same manner as in the case of vitamin C. This was repeated for the fresh catfish/beef and dehydrated samples from all NaCl concentrations using the formula

$$\frac{0.5g}{Vol.of\ titrant\ of\ tablet} = \frac{mg\ of\ Vitamin\ C}{Vol\ of\ titrant\ of\ fish/meat} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

III. Results and Discussions

The moisture loss information for both catfish and lean beef during the osmotic dehydration as influenced by solute (NaCl) concentration and immersion time are presented in the respective figures and tables below.

a) Catfish

Figure 1 shows the graphical behavior of moisture loss as dictated by immersion time and solute concentration. At F9, it is obvious that moisture loss ranged from 13.73% to 47.36% at 5 min and 5 hrs of immersion respectively. However, there was no moisture loss for the first 25 min for F1 but increased to 7.04% at 45 min of immersion and remained constant till the end of 5 hrs. This could be credited to the low osmotic pressure as presented by the low solute (NaCl) concentration. A closer look at the data shows that F7 is the best concentration level, as it yielded 56.0% moisture removal after 5 hrs of dehydration. The findings here agree with the works of Milica et al (2013) on fish and Anoar et al (2005) on Carica Papaya. An analysis of variance conducted on the data is presented in Table 1 and results show that, at 95% confidence level, significant difference exists between the mean values of percent moisture loss, thereby indicating that solute (NaCl) concentration and immersion time are vital to the osmotic dehydration of catfish muscle.

Figure 1 : Effect of NaCl concentration and immersion time on moisture loss

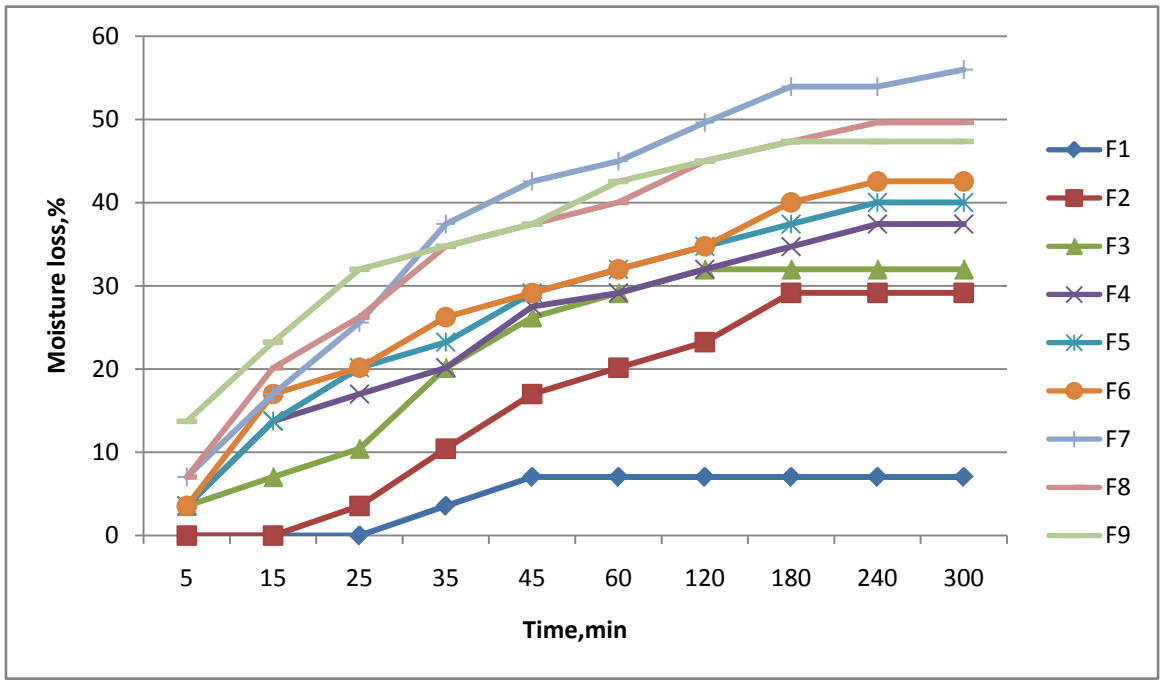


Table 1 : One-Way Anova on effect of NaCl concentration and immersion time on moisture loss

Source	SS	DF	MS	Prob	F-ratio	F- critical
Between group	4407.6321	1	4407.6321	0.0000	38.7074	4.6001
Within group	1594.1886	14	113.8706			
Total	6001.8207	15				

b) Catfish Vitamin C Analyses

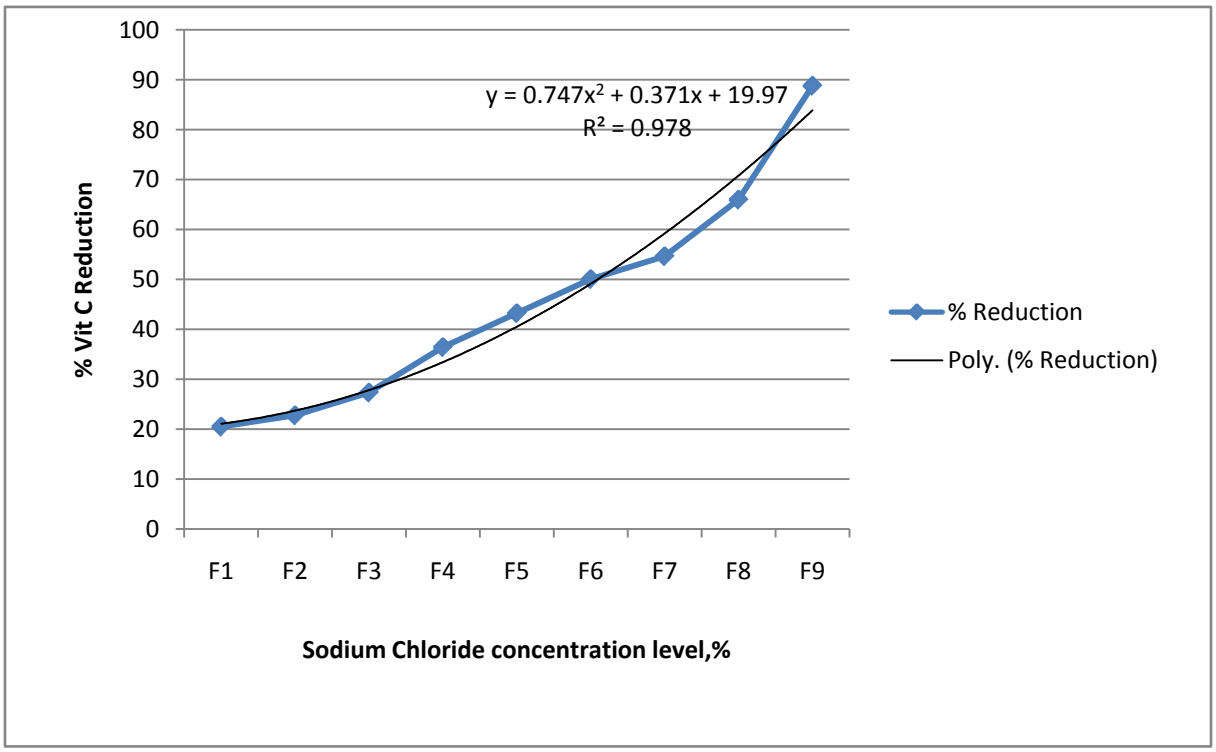
Furthermore, an analysis of vitamin C content of the fresh catfish muscle gave 97.83mg of vitamin C. This value is higher than the recommended daily allowance of 75mg for women and 90mg for men. However, the degradation of vitamin C in catfish muscle after 5 hrs of osmotic dehydration in NaCl solution is indicated in Table 2.

Table 2 : Degradation of vitamin C (mg/5g) at different NaCl concentration levels after 5 hrs of dehydration

Sample Code	% NaCl Conc.	Vitamin C (mg/5g) ± SD	% Reduction
F1	10% NaCl + 90% H_2O	77.78 ± 1.02	20.50
F2	20% NaCl + 80% H_2O	75.56 ± 0.23	22.76
F3	30% NaCl + 70% H_2O	71.10 ± 0.01	27.32
F4	40% NaCl + 60% H_2O	62.20 ± 0.05	36.42
F5	50% NaCl + 50% H_2O	55.56 ±0.35	43.21
F6	60% NaCl + 40% H_2O	48.88 ± 0.69	50.04
F7	70% NaCl + 30% H_2O	44.40 ± 0.81	54.62
F8	80% NaCl + 20% H_2O	33.30 ± 1.20	65.96
F9	90% NaCl + 10% H_2O	11.00 ± 0.07	88.76

Table 2 shows that, generally, as solute (NaCl) concentration increases, vitamin C content decreased. Specifically, vitamin C content decreased from 77.78mg to 11.00mg for a corresponding solute concentration change from F1 to F9 respectively. This quality degradation is an indication, that NaCl should never be used in making hypertonic solutions for osmotic dehydration of catfish muscles as it tempered seriously, with the nutritional value of the fish. These results agree with the findings of Saito et al (2009) and, Danijela et al (2013) on pork and Anoar et al (2006) on Papaye. It is important to note here that, if NaCl must be used as solute in the osmotic dehydration of catfish muscle, the final product must be fortified with vitamin C before consumption. This implies that solute (NaCl) concentration plays a major role in degrading the biological value of catfish in the osmotic process. Figure 2 reports the percent reduction of vitamin C as against change of solute concentration and it shows that percentage reduction of vitamin C ranged between 20.50% to 88.76% for solute (NaCl) concentration of F1 and F9 respectively.

Figure 2 : Relationship between NaCl concentration and vitamin C reduction



c) Beef moisture loss

Figure 3 shows the relationship between moisture loss and solute (NaCl) concentration and immersion time. Results reveal that, generally, moisture loss increases positively with increase in immersion time for beef also. At 5 min of immersion, no moisture loss was recorded, but moisture loss increased to 32.0% after 5hrs of experimentation in F9. For F1, instead of the beef muscle becoming dehydrated, it rather absorbed more moisture. This, perhaps, is due to the low osmotic pressure exhibited by the hypertonic solution (10% NaCl). It could also be interpreted as the beef muscle having more NaCl content than it is in the hypertonic solution, hence, the reverse osmosis. Anova (Table 3) indicated that significant difference exist between the mean values of percent moisture loss during the dehydration process at 95% level of probabilty. It is obvious; therefore, that solute (NaCl) concentration and immersion time influences the osmotic dehydration process of beef using NaCl as solute.

Figure 3 : Effect of NaCl concentration and immersion time on moisture loss

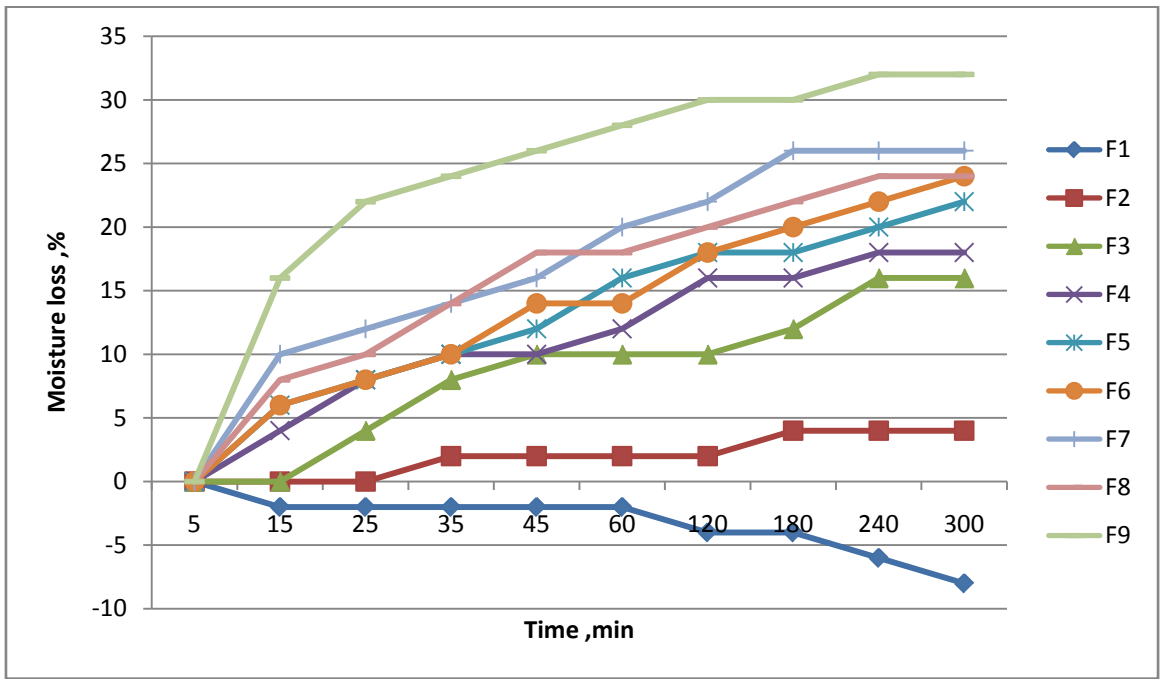


Table 3 : One-Way Anova on effect of NaCl concentration and immersion time on moisture loss

Source	SS	DF	MS	Prob	-ratio	F-critical
Between group	441.000	1	441.000	0.0498	4.6101	4.6101
Within group	1339.000	14	95.643			
Total	1780.000	15				

d) Beef Vitamin C Analysis

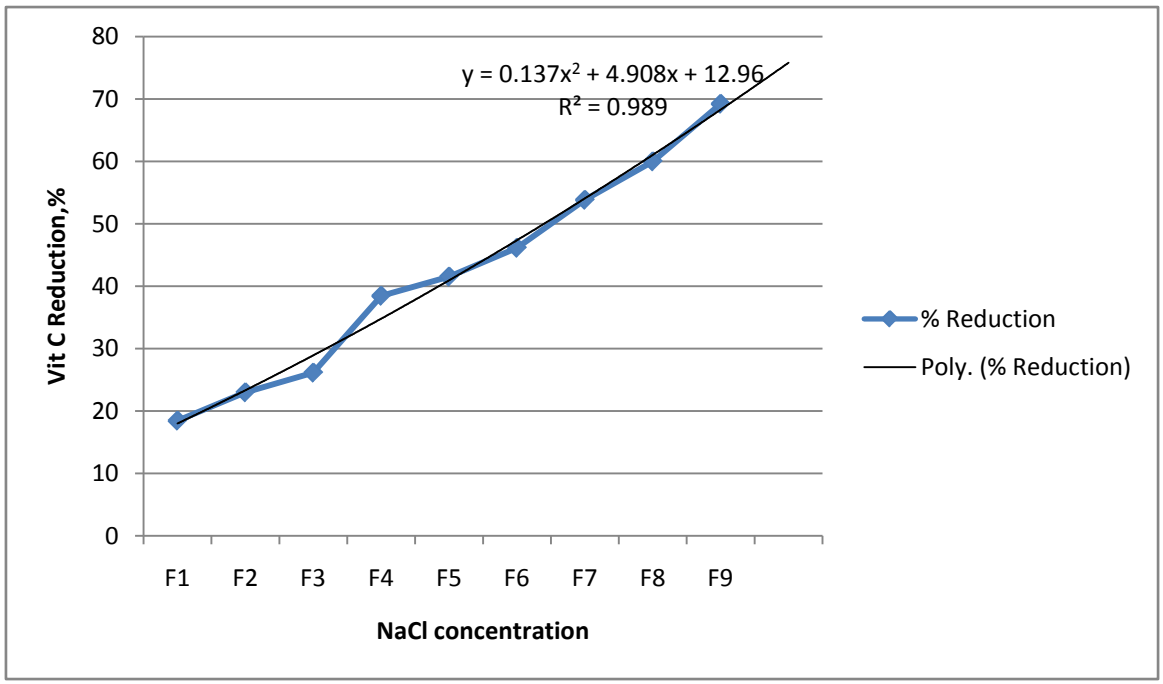
A comprehensive analysis of vitamin C content of fresh beef gave 141.30mg as against the recommended daily allowance of 90mg for men and 75mg for women. However, Table 5 shows a steady decline of vitamin C content as concentration of solute (NaCl) increases in the hypertonic solution. Vitamin C value decreased from 115.22mg to 43.48mg at corresponding increase of solute (NaCl) concentration from 10% to 90% respectively after 5hrs of immersion. It is, however, pertinent to note that, solute (NaCl) concentration levels of 10% to 30% are acceptable, as the dehydrated beef contains vitamin C levels above the recommended daily allowance (90mg – 75mg). Results presented here concur with those of Saito et al (2009) on beef and Danijela et al (2013) on pork.

Table 4 : Degradation of vitamin C (mg/5g) at different NaCl concentration levels

Sample Code	% NaCl Conc.	Average Vitamin C (mg/5g) ± SD	% Reduction
F1	10% NaCl + 90% H_2O	115.22 ±0.12	18.46
F2	20% NaCl + 80% H_2O	108.80 ±0.34	23.00
F3	30% NaCl + 70% H_2O	104.35 ±0.63	26.15
F4	40% NaCl + 60% H_2O	86.96 ± 1.04	38.46
F5	50% NaCl + 50% H_2O	82.96 ±0.87	41.54
F6	60% NaCl + 40% H_2O	76.09 ±0.72	46.15
F7	70% NaCl + 30% H_2O	65.22 ±1.08	53.84
F8	80% NaCl + 20% H_2O	56.52 ±0.39	60.00
F9	90% NaCl + 10% H_2O	43.48 ±1.20	69.23

The effect of solute (NaCl) concentration on vitamin C values as shown in Table 5 shows that significant difference exists between mean vitamin C values at various solute concentration levels. Therefore, serious attention must be paid to the solute (NaCl) concentration level when osmotic dehydration of beef is considered. Again Figure 6 shows the percent reduction of vitamin C values as solute concentration increases and yielded a polynomial relationship. At F1 and 5hrs after dehydration, 18.46% of vitamin C was degraded but increased to 69.23% at F9. These results agree with that of Filipovic et al (2012) on Pork meat and Abioye et al (2013) on baobab drink.

Figure 4 : Relationship between NaCl concentration and %Vitamin C reduction



IV. Conclusion

The effect of solute (NaCl) concentration on the vitamin C content of catfish and beef were studied. Average vitamin C values were found to decrease as solute (NaCl) concentration was increased. For catfish, percent reduction of vitamin C ranged from 20.5% to 88.76%, while for beef, percent reduction ranged from 18.46% to 69.23%. Results obtained here shows that, if nutritional quality is a priority, then NaCl should never be used as a solute in the osmotic dehydration of catfish muscle. However, for beef, 10% to 30% NaCl solution is acceptable as solute in the osmotic dehydration process. This is because the dehydrated beef from this concentration levels still retains acceptable levels of vitamin C content.

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