Preservative Efficacy of Aqueous and Ethanolic Extracts of Leek (*Allium ampeloprasum* L.) on Soybean Daddawa- A Condiment

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Abstract: **- Previous studies showed that lipid peroxidation is a key factor in soybean daddawa deterioration and *Alliums* are rich in antioxidants. In the present study, the preservative efficacies of aqueous and ethanolic extracts of Leek (*Allium ampeloprasum* L.) on stored soybean daddawa compared to Sodium Chloride (NaCl) was investigated. Soybean (*Glycine max* (L). Merr.)seeds fermented into soybean daddawa was preserved with both extracts (at 3, 5 and 7% concentration) and NaCl (at the concentrations of 0, 3 and 5%). The samples stored at 30 ± 2^0C for up to 14 days were analysed for peroxide value (POV), free fatty acid (FFA), pH, titratable acidity (TTA), water absorption capacity (WAC) and fat absorption capacity (FAC). Solvent used in extraction did not have significant (P>0.05) effect on all the storage indices. Extracts of Leek significantly (P<0.05) lowered the POV, FFA and TTA generated in stored daddawa. The pH of all the stored soybean daddawa samples did not change significantly (P>0.05), except those treated with ethanolic extract which reduced pH values from 8.08 - 8.60 to 5.70 – 6.70. Both tested extracts lowered the WAC significantly (P<0.05) while the FAC of treated soybeandaddawa was not significantly affected compared to those treated with NaCl. Results of the present study suggest better antioxidant activities of leek extract over NaCl which is commonly employed in soybean daddawa preservation. This advantage coupled with the medicinal value of leek will probably qualify it as a virile alternative for soybean ddadawa preservation.**

Keywords: **Antioxidant, condiment, Leek, NaCl, peroxidation preservation and soybean daddawa.**

I. INTRODUCTION

Spices and condiments are an important part of human history and nutrition and have played an importantrole in the development of most cultures around the world(Garcıa-Casal et. al. 2016). In West Africa many*Bacillus* fermented legume products are used as condiments and sources of dietary protein and minerals. The prominent ones include *Dawadawa/Daddawa* and *Ogiri* (Adedeji et al., 2017), Soybean daddawa (Popoola and Akueshi, 1985, Omafuvbe et al., 2000; Kolapo et al., 2007 a,b) and *Ugba* (Okorie and Olasupo (2013).

In Nigeria, the use of soybean (*Glycine max*) seed as an alternative to locust bean (*Parkiabiglobosa*) seed is also seen as a way of incorporating soybean protein into local diets. However, the popularity of soybean daddawa is marred by the perception that it is prone to faster deterioration than locust bean daddawa at the end of the fermentation period (Obatolu*et al*. 1998;Popoola et al. 2007). Documented reports have indicated that higher level of lipid peroxidation in soybean daddawa compared to locust bean daddawa is responsible for faster deterioration of soybean daddawa (Kolapo and Sanni, 2007; Kolapo et al. 2007a). In addition, the microorganisms that fermented soybean seeds to soybean daddawa later turned destructive by causing spoilage of the product during storage (Kolapo and Sanni, 2006). However, attempts have been made to extend the shelf life of locust bean daddawa (Ikenebomeh, 1989) and soybean daddawa (Omafuvbe, 1994) by adding sodium chloride salt (1%) as a preservativebut the effect of this practice on the lipid peroxidation of stored daddawa has not been documented.

Traditionally, salt (sodium chloride) has been viewed as a food preservative that enhances human health by killing or limiting growth of foodborne pathogens and spoilage organisms. However, in recent decades, with increasing consumption of many different processed foods containing high levels of sodium, the perception of dietary salt has evolved to a point where it is now considered, by some, to be a potential health threat (Doyle and Glass, 2010). It is incontrovertible that sodium is an essential nutrient with important functions in regulating extracellular fluid volume and the active transport of molecules across cell membranes. However, recent estimates from around the world showthat over 95% ofmen and over 75% ofwomen exceed the recommended daily tolerable upper intake of sodium(Doyle and Glass, 2010).. Since these high levels of dietary sodium are associated with a high prevalence of hypertension, prehypertension and, possibly, other adverse effects on health, many national and international health organizations recommend that sodium intake be significantly decreased

Herbs and spices are naturally rich in antioxidants and thus could be used to arrest lipid peroxidation, a key biochemical factor in soybean deterioration. In this regard, dichloromethane extract of ginger (*Zingiberofficiniale*) has been shown to be effective in arresting lipid peroxidation and microbial proliferation in stored soybean daddawa, thus extending its shelf life (Kolapo et al., 2007 b)..Similarly, higher antioxidant activity in terms of free radical scavenging activity of leek extracts have been attributed to its rich phenolics and flavonoids content (Mladenovic et al. 2011; Abdel-Salam et al. 2014). As part of efforts to finding panacea to storage problem of soybean daddawa using substances that pose no health threat, the present study therefore investigated the possibility of using ethanolic and aqueous extracts of Leek (*Allium ampeloprasum* L.) to arrest lipid peroxidation in stored soybean daddawa. The influence of the treatments on functional properties of stored daddawa was also evaluated.

II. MATERIALS AND METHODS

A. Collection of Seeds and Soybean Daddwa Preparation

The Soybean seeds of variety TGX 1440-2E used for the present work were obtained from the Institute of Agricultural Research and Training, Ibadan. Nigeria. Soybean daddawa was prepared according to the method of Popoola and Akueshi (1985) as described by Omafuvbeet. al. (2000).

B. Leek Samples and Preparation of Extracts.

Leek (*A. ampeloprasum* L.) samples were purchased from a local market in Ibadan, Nigeria. The samples were sorted to remove stones and dirt, washed and air dried. Both ethanolic and aqueous extract of the samples were obtained using the method reported by Irkin and Korukluoglu (2007).

C. Application of Leek Extracts to Soybean Daddawa.

Soybean daddawa samples (10g) containing 3, 5 and 7% (v/w) of both ethanolic and aqueous extracts of Leek were prepared separately in sterile container. Positive controls containing 3 and 5% common salt (NaCl) (w/w) and a negative control containing 0% salt and extract were equally set up. All samples of each treatment were prepared in triplicates and stored at ambient temperature (30±2^{0}C) for two weeks and the various analyses were done at two days interval.

D. Measurement of Antioxidant Activity

The effectiveness of the extracts of Leek as an antioxidant in stored soybean daddawa was tested by the determination of Peroxide value (POV) and Free Fatty Acid (FFA) contents of soybean daddawa kept at ambient temperature. The POV (meqkg^{-1}) of samples was measured by titration with 0.1M sodium thiosulphate solution using starch as indicator (AOAC, 1990) while the FFA content (expressed as % oleic acid) was estimated using an alkali titration method (AOAC, 1990). All determinations were carried out in triplicates and mean values were calculated. The experiments were repeated three times and the average of the various determinations were reported as the final values.

E. pH and Titratable Acidity Determination

The pH and titratable acidity (expressed as lactic acid equivalent) of the preserved, stored soybeandaddawa were determined as previously described by Ikenebomeh (1989).

F. Measurement of Functional Properties

The fat and water absorption capacity of the samples were determined using the centrifugation method previously described by Sosulkiet. al. (1976). All determinations were carried out in triplicates and mean values were calculated.

G. Statistical Analysis

Data obtained were expressed as means. The statistical significance of differences was assessed using analysis of variance. A two-tailed P value of less than 0.05 was considered to be statistically significant. Values that were significantly different were separated using Duncan Multiple Range test using SPSS for windows Verson 11.0 statistical package.

III. RESULTS AND DISCUSSION

A drastic and progressive increase in peroxide value (POV) was recorded for both positive (NaCl treated) and negative (no preservative) controls with increasing storage time; with the values for negative control being significantly ($P<0.05$) higher. The POV of soybean daddawa treated with extracts of Leek was significantly ($P<0.05$) lower than those of positive control while the type of solvent used for extraction and concentration of the extract used for preservation did not exhibit significant ($P>0.05$) effect on the lipid stability of stored soybean daddawa (Table 1). The initial trend of increase in peroxide values of unpreserved daddawa obtained in the present study is somewhat similar to earlier reports on soybean daddawa(Popoola et. al., 2007; Kolapo and Sanni, 2007; Kolapo et al. 2007a) and soymilk (Iwe, 1991).

Since an increase in POV is a good predictor of fat deterioration (Zia-ur-Rehman et. al., 2003); lower POV obtained in leek extract preserved samples is an indication that such preserved daddawa samples were more resistant to lipid peroxidation compared topositive (NaCl treated) and negative (no preservative) controls.Previous reports have documented both enzymic and non-enzymic antioxidant potentials of Leek (Lau 1989; Numagami 1996; Geng and Lau 1997, Stajner and Varga 2003; Abdel-Salam et al. 2014).The anti-peroxidation effect of leek extract in stored soybean daddawa observed in the present study could be attributed to the antioxidant elements reported to be present in Leek.

Free Fatty Acid (FFA) content of untreated sample and positive control increased progressively with time of storage while a corresponding decrease was recorded for samples treated with Leek extract. The FFA values of samples treated with natural preservatives were significantly ($P<0.05$) lower compared to the values obtained for both positive and negative controls. It appeared that solvent used in extraction as well as extract concentration did not have any significant effect ($P>0.05$) on the amount of FFA generated in the stored soybean daddawa (Table 2).

Lipid oxidation is an important factor influencing quality and acceptability of food products (Hunt et. al., 1999).

Table 1

Effect of aqueous and ethanolic extracts of Leek on Peroxide value! of stored soybean daddawa

Storage Time(Day)	Common salt (NaCl)					
	0%	3%	5%			
0	3.92 ± 0.28^{f}	3.70 ± 0.14^{e}	3.90 ± 0.99^{e}			
2	5.20 ± 0.00^{e}	5.60 ± 0.01^{d}	5.30 ± 0.14^{d}			
4	5.00 ± 0.85^{e}	6.78 ± 0.01^{c}	5.40 ± 0.70^{d}			
6	5.70 ± 0.42^{de}	7.00 ± 0.98^{bc}	7.33 ± 0.04^{c}			
8	7.00 ± 1.70^{d}	8.00 ± 0.57^{bc}	8.20 ± 0.83^{b}			
10	10.30 ± 0.27^{c}	8.20 ± 0.13^{b}	8.30 ± 0.56^{b}			
12	13.23 ± 0.09^{b}	8.30 ± 0.23^{b}	8.34 ± 0.04^{b}			
14	17.00 ± 0.85^{a}	12.20 ±0.28^{a}	11.53 ±0.01^{a}			
Storage Time(Day)	Leek extract (Aqueous extract)			Leek extract (Ethanolic extract)		
	3%	5%	7%	3%	5%	7%
0	3.30 ± 0.06^{e}	3.37 ± 0.01^{e}	3.33 ± 0.14^{e}	3.30 ± 0.06^{d}	3.38 ± 0.01^{e}	3.20 ± 0.14^{e}
2	6.80 ± 0.23^{a}	7.00 ± 0.03^{a}	6.80 ± 0.28^{a}	6.20 ± 0.13^{a}	6.21 ± 0.03^{a}	6.60 ± 0.28^{a}
4	6.10 ± 0.03^{b}	6.10 ± 0.79^{ab}	5.91 ± 0.34^{ab}	6.10 ± 0.03^{a}	6.10 ± 0.79^{ab}	5.90 ± 0.34^{ab}
6	6.00 ± 0.13^{b}	5.87 ± 0.02^{b}	5.88 ± 0.05^{b}	6.03 ± 0.14^{ab}	5.77 ± 0.00^{b}	5.82 ± 0.04^{b}
8	5.61 ± 0.13^{c}	5.61 ± 0.04^{b}	5.11 ± 0.03^{c}	5.60 ± 0.03^{b}	5.71 ± 0.04^{b}	5.71 ± 0.03^{b}
10	5.33 ± 0.14^{c}	5.40 ± 0.05^{c}	4.98 ± 0.13^{c}	5.30 ± 0.14^{b}	5.02 ± 0.05^{c}	5.00 ± 0.01^{c}
12	4.87 ± 0.05^{d}	4.72 ± 0.14^{d}	4.68 ± 0.04^{d}	4.97 ± 0.05^{c}	4.72 ± 0.14^{d}	4.68 ± 0.00^{d}
14	4.50 ± 0.51^{d}	4.53 ± 0.03^{d}	4.50 ± 0.04^{d}	4.67 ± 0.51^{c}	4.50 ± 0.26^{d}	4.66 ± 0.05^{d}

Values are means ± SD (n=3). Values in the same column with different superscripts are significantly different ($p < .05$). !Peroxide value in meqkg^{-1}

Table 2

Effect of aqueous and ethanolic extracts of Leek on Free Fatty Acid† of stored soybean daddawa

Storage Time(Day)	Common salt (NaCl)					
	0%	3%	5%			
0	0.019±0.004^{e}	0.018 ± 0.003^{de}	0.019 ± 0.001^{ef}			
2	0.024±0.004^{e}	0.022 ± 0.001^{d}	0.021 ± 0.009^{def}			
4	0.036±0.005^{d}	0.029 ± 0.04^{c}	0.029 ± 0.003^{de}			
6	0.39±0.002^{cd}	0.032 ± 0.004^{bc}	0.031 ± 0.004^{de}			
8	0.045±0.001^{c}	0.038 ± 0.004^{b}	0.038 ± 0.006^{cd}			
10	0.058±0.006^{ab}	0.041 ± 0.003^{ab}	0.039 ± 0.004^{bc}			
12	0.061±0.003^{ab}	0.043 ± 0.000^{a}	0.042 ± 0.001^{b}			
14	0.068±0.001^{a}	0.045 ± 0.004^{a}	0.043 ± 0.001^{a}			
Storage Time(Day)	Leek extract (Aqueous)			Leek extract (Ethanolic)		
	3%	5%	7%	3%	5%	7%
0	0.021 ± 0.005^{a}	0.020 ±0.001^{a}	0.020 ± 0.000^{a}	0.020 ± 0.005^{a}	0.020 ± 0.001^{a}	0.020 ± 0.001^{a}
2	0.018 ± 0.002^{ab}	0.015 ± 0.007^{ab}	0.015 ± 0.006^{ab}	0.020 ± 0.002^{a}	0.015 ± 0.001^{b}	0.015 ± 0.000^{b}
4	0.010 ± 0.000^{c}	0.011 ± 0.000^{b}	0.010 ± 0.000^{b}	0.015 ± 0.003^{ab}	0.010 ± 0.000^{c}	0.012 ± 0.001^{bc}
6	0.010 ± 0.001^{c}	0.010 ± 0.000^{b}	0.010 ± 0.000^{b}	0.015 ± 0.001^{ab}	0.010 ± 0.000^{c}	0.010 ± 0.001^{c}
8	0.010 ± 0.000^{c}	0.010 ± 0.000^{b}	0.010 ± 0.001^{b}	0.010 ± 0.000^{b}	0.010 ± 0.000^{c}	0.010 ± 0.001^{c}
10	0.010 ± 0.002^{c}	0.010 ± 0.000^{b}	0.010 ± 0.000^{b}	0.010 ± 0.002^{b}	0.010 ± 0.000^{c}	0.010 ± 0.000^{c}
12	0.010± 0.002^{c}	0.005 ± 0.003^{c}	0.005 ± 0.001^{c}	0.010± 0.002^{b}	0.010 ± 0.001^{c}	0.009 ± 0.000^{c}
14	0.010 ± 0.000^{c}	0.005 ± 0.003^{c}	0.005 ± 0.000^{c}	0.010 ± 0.000^{b}	0.007 ± 0.001^{c}	0.007 ± 0.000^{c}

Values are means ± SD (n=3). Values in the same column with different superscripts are significantly different ($p < .05$).†Free Fatty Acid as % oleic acid

The formation of organic acids and free fatty acid is an initial step in fat oxidation/deterioration, development of rancidity and off-flavour in fatty foods (Sattar and Demen, 1973). The increase in the amount of products of fat deterioration with storage in the control samples observed in the present study is in agreement with previous reports on stored soybean daddawa (Popoola et. al., 2007; Kolapo and Sanni, 2007) and stored canned tuna in brine (fish product) (Siriamornpun et. al., 2008).

In the present study, the formation of fat deterioration products viz FFA and Peroxides were effectively controlled by the addition of leek extracts. Details of the compounds of the extract of Leek which give it antioxidant properties observed in the present study is not known at this stage. However, various antioxidant compounds reported to be present in Leek include organo-sulphur compounds derived from decomposition of allicin, phenolics, saponins, vitamin C, anthocyanins, quercetin and kaempferol (Hedger and Lister, 2007,Abdel-Salam et al. 2014). These compounds would be most probably responsible for the observed reduction of lipid oxidation in samples treated with Leek extracts.

Some studies have reported that an increasing salt concentration accelerated the rate of POV and FFA generation in fish product stored under somewhat special condition of 4^0C (Aubgbourg and Ughano, 2002; Yanar et. al. 2006; Eboh et. al, 2006). Results of the present study on soybean daddawa stored at ambient temperature of 30 ± 2^0C indicate otherwise but it is noticeable that the quantity of peroxidation products increased with storage time but the quantity was lower compared to the negative control. This is an indication that peroxidative activity was significantly higher in NaCl treated samples compared with those treated with Leek extracts. The implication of this is that the traditional use of NaCl in prolonging the shelf life of daddawa does not guarantee oxidative stability of the innate lipid. However, the use of natural antioxidant such as the one investigated in the present study is potent enough to stem the lipid peroxidation tide in stored soybean daddawa.

In all the stored samples, pH increased steadily with days of storage except in the stored soybean daddawa samples that were treated with ethanolic extract of leek in which their pH decreased with storage days (Table 3). There was no significant difference (P>0.05) between the pH of stored samples treated with aqueous extracts of Leek and those of positive and negative controls. However, ethanolic extract had significant (P<0.05) pH lowering effect on stored soybean daddawa samples.. Within each treatment, preservative concentration had no significant effect (P>0.05) on the pH of stored soybean daddawa.

It has been observed in previous reports (Popoola et. al. 2007; Kolapo and Sanni 2007) that the observed pH increase with storage time in soybean daddawa is similar to the reported trend for the fermentation of soybean and locust bean daddawa (Ikenebomeh et al. 1986; Oyeyiola 1988; Sarka et. al. 1993; Omafuvbe et. al. 2000;). Increasing pH during fermentation has been attributed to proteolytic activities and release of ammonia by microorganisms involved in fermentation. The similar pH increase in stored soybean daddawa with storage time also possibly indicates continuous, post processing activity of the fermenting microorganisms (Popoola et. al. 2007; Kolapo et. al. 2007a). Oven drying of fresh soybean daddawa cause a shift from alkaline to acidic pH, and it was suggested that the driving out of ammonia during oven drying process may have been responsible for this (Kolapo, 2008).

Table 3
Effect of aqueous and ethanolic extracts of Leek on pH of stored soybean daddawa

Storage Time(Day)	Common salt (NaCl)		
	0%	3%	5%
0	8.26 ± 0.01^{d}	8.04 ± 0.00^{g}	8.13 ± 0.01^{e}
2	8.45 ± 0.01^{c}	8.39 ± 0.01^{f}	8.21 ± 0.01^{d}
4	8.45 ± 0.01^{c}	8.46 ± 0.01^{e}	8.36 ± 0.02^{c}
6	8.50 ± 0.00^{c}	8.51 ± 0.01^{d}	8.33 ± 0.04^{c}
8	8.59 ± 004^{b}	8.52 ± 0.02^{d}	8.44 ± 0.01^{b}
10	8.65 ± 0.01^{b}	8.59 ± 0.02^{c}	8.48 ± 0.03^{ab}
12	8.64 ± 0.09^{b}	8.67 ± 0.01^{b}	8.50 ± 0.04^{a}
14	8.76 ± 0.01^{a}	8.72 ± 0.02^{a}	8.53 ± 0.01^{a}

Storage Time(Day)	Leek extract (Aqueous)			Leek extract (Ethanolic)		
	3%	5%	7%	3%	5%	7%
0	7.94 ± 0.01^{e}	8.34 ± 0.10^{c}	8.10 ± 0.00^{e}	8.60 ± 0.06^{a}	8.38 ± 0.01^{a}	8.08 ± 0.01^{a}
2	7.69 ± 0.01^{f}	8.36 ± 0.01^{c}	8.39 ± 0.11^{d}	8.47 ± 0.01^{a}	8.34 ± 0.03^{a}	8.08 ± 0.01^{a}
4	8.17 ± 0.01^{d}	8.43 ± 0.15^{abc}	8.47 ± 0.05^{cd}	8.44 ± 0.03^{a}	6.23 ± 0.79^{b}	5.88 ± 0.02^{b}
6	8.21 ± 0.00^{d}	8.51 ± 0.06^{abc}	8.54 ± 0.02^{bc}	8.33 ± 0.14^{ab}	5.77 ± 0.00^{c}	5.82 ± 0.04^{c}
8	8.34 ± 0.03^{c}	8.53 ± 0.02^{abc}	8.60 ± 0.01^{ab}	8.26 ± 0.03^{ab}	5.76 ± 0.01^{c}	5.71 ± 0.00^{d}
10	8.44 ± 0.08^{b}	8.56 ± 0.06^{ab}	8.63 ± 0.07^{ab}	8.24 ± 0.01^{ab}	5.72 ± 0.05^{de}	5.67 ± 0.00^{e}
12	8.47 ± 0.02^{b}	8.58 ± 0.04^{a}	8.67 ± 0.02^{a}	7.97 ± 0.05^{b}	5.72 ± 0.01^{d}	5.68 ± 0.00^{de}
14	8.57 ± 0.01^{a}	8.61 ± 0.13^{a}	8.68 ± 0.04^{a}	6.71 ± 0.51^{c}	5.70 ± 0.06^{de}	5.66 ± 0.00^{de}

Values are means ± SD (n=3). Values in the same column with different superscripts are significantly different ($p < .05$).

The observed pH decrease in stored soybean daddawa treated with ethanol extracts of leek in the present study might be possibly indicating that continuous production of ammonia was inhibited in such samples, or that compounds that scavenge alkaline products were extracted with the use of ethanol.

The titratable acidity (TTA) of stored soybean daddawa increased progressively with days of storage in the positive and negative controls as well as in all the treated samples (Table 4). TTA values of daddawa treated with leek extracts were significantly lower (P<0.05) than the positive and negative control samples. Within the positive control treatment, concentration of the NaCl used had a significant (P<0.05) effect on the overall TTA values. Increased concentration of NaCl resulted in a correspondingly lower TTA values in stored soybean daddawa. However, in samples treated with ethanolic extract, an opposite trend was observed in which higher concentration of preservative resulted into a corresponding higher TTA values.

The trend of an increased TTA with storage time obtained in the present study compares favourably with those obtained in stored Nigerian packed fruit juices and local beverages (Dosumu et. al., 2007) and stored soybean daddawa (Popoola et. al. 2007; Kolapo et. al. 2007a). In those previous studies it was opined that increased TTA in stored soybean daddawa reflects the post processing carbohydrate metabolism of microorganisms associated with spoilage. Results from the present study may be further strengthening this position, as higher concentration of NaCl (a known antimicrobial agent) resulted in lower values of recorded TTA in samples so treated.However, the increased TTA values in samples preserved with ethanolic extract may be attributable to wide arrays of organic acid that might have been extracted by ethanol. *Allium* used in the present study is known to be composite of many compounds such as vitamin C (ascorbic acid), phenolic and saponin compounds (Hedges and Lister, 2007).

Table 4

Effect of aqueous and ethanolic extract of Leek on titratable acidity of stored soybean daddawa

Storage Time(Day)	Common salt (NaCl)					
	0%	3%	5%			
0	0.017±0.002^{e}	0.030 ± 0.005^{c}	0.024 ±0.001^{e}			
2	0.025±0.014^{de}	0.038 ± 0.001^{bc}	0.025 ± 0.009 ^{de}			
4	0.029±0.005^{de}	0.051 ± 0.021^{b}	0.026 ± 0.009^{de}			
6	0.042±0.012^{cde}	0.052 ± 0.004^{b}	0.035 ±0.004^{cde}			
8	0.045±0.012^{cd}	0.052 ± 0.004^{b}	0.038 ± 0.006^{cd}			
10	0.057±0.004^{bc}	0.058 ± 0.003^{ab}	0.041 ± 0.004^{c}			
12	0.076±0.018^{ab}	0.073 ± 0.000^{a}	0.055 ± 0.001^{b}			
14	0.092±0.004^{a}	0.078 ± 0.004^{a}	0.069 ± 0.001^{a}			
Storage Time(Day)	Leek extract (Aqueous)			Leek extract (Ethanolic)		
	3%	5%	7%	3%	5%	7%
0	0.024 ± 0.007^{d}	0.015± 0.001^{d}	0.020 ± 0.001^{c}	0.014 ± 0.007^{de}	0.030 ± 0.004^{c}	0.026 ± 0.011^{c}
2	0.028 ± 0.000^{cd}	0.019 ± 0.004^{cd}	0.023 ± 0.005^{c}	0.025 ± 0.012^{cd}	0.033 ± 0.005^{c}	0.027 ± 0.012^{c}
4	0.034 ± 0.007^{bcd}	0.033 ± 0.003^{bc}	0.029 ± 0.005^{bc}	0.032 ± 0.000^{c}	0.034 ± 0.008^{c}	0.039 ± 0.001^{bc}
6	0.036 ± 0.011^{bcd}	0.035 ± 0.012^{bc}	0.030 ± 0.002^{bc}	0.034 ± 0.007^{bc}	0.034 ± 0.003^{c}	0.040 ± 0.005^{bc}
8	0.044 ± 0.007^{abc}	0.037 ± 0.004^{b}	0.032 ± 0.006^{bc}	0.048 ± 0.015^{ab}	0.043 ± 0.000^{bc}	0.041 ± 0.002^{bc}
10	0.047 ± 0.002^{ab}	0.037 ± 0.003^{a}	0.032 ± 0.001^{bc}	0.053 ± 0.008^{ab}	0.052 ± 0.006^{ab}	0.045 ± 0.018^{bc}
12	0.048± 0.008^{ab}	0.040 ± 0.009^{a}	0.039 ± 0.006^{ab}	0.055± 0.003^{a}	0.056 ± 0.001^{ab}	0.061 ± 0.000^{ab}
14	0.056 ± 0.005^{a}	0.043 ± 0.011^{a}	0.043 ± 0.006^{a}	0.058 ± 0.002^{a}	0.062 ± 0.009^{a}	0.070 ± 0.009^{a}

Values are means ± SD (n=3). Values in the same column with different superscripts are significantly different (p < .05).

These innates compounds may have contributed to recorded acidity of daddawa treated with the extract of these *Alliums*.

A gradual decrease was observed in water absorption capacity (WAC) of stored soybean daddawa with storage days. In this regard, there was no significant difference (P>0.05) between daddawa sample that was treated with NaCl and natural preservatives. Addition of natural preservatives resulted into a significant (P<0.05) reduction in WAC with increasing storage days. Solvent used in extraction, as well as the preservative concentration had no significant (P>0.05) effect on the ability of various extracts in modifying WAC of the treated samples (Table 5).WAC is an indication of a product to associate with water in conditions where water is limiting (Giami, 1993). Fermentation does not affect WAC in legumes (Giami and Bekahem, 1992) while an observed decreased WAC in stored soybean daddawa may be implying that even in wet form, less water is available for microbial activities (Popoola et al., 2007). The recorded higher WAC lowering ability of Leek extract in the present work could therefore contribute to restricted microbial activity in daddawa samples preserved with leek extracts.

Table 5
Effect of aqueous and ethanolic extracts of Leek on water absorption capacity of stored soybean daddawa

Storage Time(Day)	Common salt (NaCl)					
	0%	3%	5%			
0	240 ± 6^{a}	220 ± 0^{a}	225 ± 4^{a}			
2	210 ± 8^{b}	216 ± 3^{a}	212 ± 5^{a}			
4	190 ± 3^{c}	200 ± 4^{b}	197 ± 3^{b}			
6	185 ± 2^{c}	185 ± 7^{bc}	180 ± 0^{c}			
8	180 ± 6^{cd}	180 ± 0^{bc}	170 ± 4^{d}			
10	170 ± 1^{d}	180 ± 3^{c}	170 ± 2^{d}			
12	150 ± 8^{e}	160 ± 2^{d}	150 ± 5^{e}			
14	150 ± 5^{e}	155 ± 4^{d}	150 ± 2^{e}			
Storage Time(Day)	Leek extract (Aqueous)			Leek extract (Ethanolic)		
	0%	3%	5%	3%	5%	7%
0	225 ± 3^{a}	225 ± 2^{a}	220 ± 3^{a}	223 ± 3^{a}	225 ± 2^{a}	220 ± 4^{a}
2	212 ± 3^{b}	215 ± 3^{ab}	200 ± 3^{b}	209 ± 3^{b}	215 ± 1^{b}	211 ± 3^{a}
4	202 ± 3^{c}	190 ± 1^{c}	190 ± 0^{c}	200 ± 3^{c}	189 ± 1^{c}	185 ± 7^{b}
6	185 ± 1^{d}	184 ± 2^{c}	185 ± 1^{c}	185 ± 2^{d}	175 ± 2^{d}	175 ± 2^{b}
8	170 ± 1^{e}	162 ± 1^{d}	160 ± 3^{d}	170 ± 0^{e}	160 ± 0^{e}	162 ± 3^{c}
10	160 ± 2^{e}	155 ± 3^{d}	150 ± 5^{de}	163 ± 1^{e}	150 ± 0^{f}	153 ± 2^{cd}
12	150 ± 1^{f}	149 ± 3^{de}	144 ± 2^{e}	155 ± 3^{f}	150 ± 4^{f}	140 ± 1^{d}
14	140 ± 7^{f}	143 ± 2^{e}	134 ± 3^{f}	140 ± 3^{g}	148 ± 2^{f}	135 ± 2^{d}

Values are means ± SD (*n*=3). Values in the same column with different superscripts are significantly different ($p < .05$).

Fat absorption capacity (FAC) of the stored samples decreased with storage time. There was no significant (P>0.05) difference between FAC values of positive and negative control and those samples treated with leek extracts. Both extracting solvent and preservative concentration did not have significant modifying effect on FAC values of treated, stored soybandaddawa (Table 6). FAC could be attributed to the physical entrapment of oils which is related to number of non-polar side chains on the proteins that bind hydrocarbon chains of fatty acids. Fat acts as flavour retainer and increase mouth feel of foods (Kinsella, 1976). Result from the present study is indicating that the use of leek extracts to arrest lipid peroxidation in stored soybean daddawa will not negatively affect the functional properties of such treated daddawa.

IV. CONCLUSION

Results of the present study suggest better antioxidant activities of leek extract over sodium chloride salt which is commonly employed in soybean daddawa preservation. In addition, it reduced the water absorption capacity of the stored daddawa, a feature that is directly related to amount of water available for microbial activities. These observed advantages of leek extracts coupled with the medicinal value of leek will probably qualify it as a virile alternative for soybean ddadawa preservation especially now that there are great global concerns on regulating/reducing dietary salt intake.

Table 6
Effect of aqueous and ethanolic extracts of Leek on Fat absorption capacity of stored soybean daddawa

Storage Time(Day)	Common salt (NaCl)					
	0%	3%	5%			
0	1.1 ± 0.1^{a}	1.2 ± 0.1^{a}	1.2 ± 0.0^{a}			
2	0.9 ± 0.0^{a}	1.1 ± 0.0^{a}	0.9 ± 0.0^{b}			
4	0.9 ± 0.1^{a}	1.0 ± 0.0^{a}	0.9 ± 0.2^{ab}			
6	1.0 ± 0.0^{a}	0.8 ± 0.2^{ab}	0.8 ± 0.2^{bc}			
8	0.8 ± 0.2^{ab}	0.8 ± 0.1^{b}	0.6 ± 0.1^{c}			
10	0.7 ± 0.0^{b}	0.9 ± 0.1^{ab}	0.7 ± 0.0^{b}			
12	0.6 ± 0.0^{b}	0.7 ± 0.1^{b}	0.8 ± 0.1^{b}			
14	0.7 ± 0.1^{b}	0.8 ± 0.1^{ab}	0.6 ± 0.1^{c}			
Storage Time(Day)	Leek extract (Aqueous)			Leek extract (Ethanolic)		
	3%	5%	7%	3%	5%	7%
0	1.1 ± 0.0^{a}	1.0 ± 0.1^{a}	1.0 ± 0.0^{a}	1.0 ± 0.1^{a}	1.0 ± 0.2^{a}	1.0 ± 0.0^{a}
2	1.0 ± 0.1^{a}	0.9 ± 0.0^{a}	0.9 ± 0.0^{a}	1.0 ± 0.0^{a}	1.0 ± 0.0^{a}	0.8 ± 0.0^{b}
4	0.9 ± 0.0^{a}	0.9 ± 0.1^{ab}	0.9 ± 0.0^{a}	0.9 ± 0.0^{a}	0.9 ± 0.1^{ab}	0.9 ± 0.1^{ab}

6	0.8 ± 0.1^{ab}	0.8 ± 0.1^{ab}	0.8 ± 0.2^{abc}	0.8 ± 0.2^{ab}	0.8 ± 0.0^{b}	0.8 ± 0.1^{ab}
8	0.8 ± 0.0^{b}	0.8 ± 0.0^{b}	0.8 ± 0.1^{ab}	0.8 ± 0.0^{ab}	0.7 ± 0.0^{bc}	0.8 ± 0.0^{ab}
10	0.9 ± 0.0^{a}	0.7 ± 0.2^{abc}	0.7 ± 0.1^{bc}	0.9 ± 0.1^{ab}	0.7 ± 0.2^{abc}	0.9 ± 0.2^{ab}
12	0.7 ± 0.0^{c}	0.8 ± 0.1^{ab}	0.7 ± 0.1^{bc}	0.6 ± 0.0^{c}	0.8 ± 0.1^{ab}	0.8 ± 0.1^{ab}
14	0.7 ± 0.1^{bc}	0.6 ± 0.1^{c}	0.7 ± 0.2^{abc}	0.6 ± 0.1^{c}	0.7 ± 0.1^{bc}	0.7 ± 0.1^{bc}

Values are means ± SD (n=3). Values in the same column with different superscripts are significantly different ($p < .05$

REFERENCES

[1]. Abdel-Salam, A.F., Shahenda M.E. and Jehan B.A. (2014). Antimicrobial and antioxidant activities of red onion, garlic and leek in sausage.*African Journal of Microbiology. Research* 8:2574-2582

[2]. Adedeji, B.S., O.T. Ezeokolib, C.N. Ezekiel, A.O. Obadinaa, Y.M. Somorin. M. Sulyokd, R,A. Adelekeb, B. Warth, C.C. Nwangburukah. A.M. Omemui, O.B. Oyewolea.andKrska, R. (2017). Bacterial species and mycotoxin contamination associated with locust bean,melon and their fermented products in south-western Nigeria. *International Journal of Food Microbiology* 258: 73–80.

[3]. AOAC (1990) Official Methods of Analysis 15thEdn. Association of Official Analytical Chemist. Washington DC.

[4]. Aubgbourg S and Ugliano M. (2002). Effect of brine pre-treatment on lipid stability of frozen horse mackerel (Trachurustrachurus).*European.Food Research Technology*. 215:91-95

[5]. Dosumu O.O., Oluwaniyi O.O., Awolola G.V. and Okunola M.O. (2009). Stability studies and Mineral concentration of Some Nigerian packed Fruit Juices, Concentrate and Local Beverages. *Advances in Natural and Applied Sciences.* 3(1):22-36

[6]. Doyle, M. E. and Glass, K.A. (2010). Sodium Reduction and Its Effect on Food Safety, Food Quality and Human Health.*Comprehensive Reviews in Food Science and Food Safety*. 9: 44-56

[7]. Eboh L, Mwpba H.D. and Ekpo M.B.(2006). Heavy metal contaminants and processing effects on the composition, storage stability and fatty acid profiles of five common commercially available fish species in Oron Local Government, Nigeria.*Food Chemistry*. 97:490-497

[8]. Garcıa-Casal, M. N. Pena-Rosas, J. P. and Gomez-Malave H. (2016) Sauces, spices, and condiments: definitions, potential benefits, consumption patterns, and global markets. *Annal of the.New York Academy of Science*. 1379: 3–16. doi: 10.1111/nyas.13045

[9]. Geng, Z and Lau B.H.S. (1997). Aged Leek extract modulates glutathione redox cycle and superoxide dismutase activity in vascular endothelial cells. Phytotherapy.Research. 11:54-56

[10]. Giami, S.Y.(1993) Effect of Processing on the proximate composition and functional properties of cowpea (Vigniaunguiculata) flour.*Food Chemistry*. 47:153

[11]. Giami, S.Y. and Bekeham, D.A. (1992). proximate composition and functional properties of raw and processed full fat fluted pumpkin (Telferiaoccidentalis) seed flour. *Journal ofScienceFood andAgriculture* 59:32

[12]. Hedger, L.J. and Lister, C.E.(2007). The nutritional attributes of Allium species. Crop and Food Research Confidential Report No 1814. New Zealand Institute for Crop and Food Research Limited. Christchurch. pp44.

[13]. Hunt, M.C., Sorheim, O. and Slinde E. (1999). Colour and heat denaturation of myoglobin forms in ground beef.*Journal of Food Science*. 64:847-851

[14]. Ikenebomeh, M.J.; Kok, R. and Ingram, J.M. (1986). Processing and fermentation of theAfrican Locust Bean (*Parkiafilicoidea*Welw) to produce Dawadawa.*Journal of Science Food and Agriculture*37: 273-283

[15]. Ikenebomeh, M.J. (1989). The influence of salt and temperature on natural fermentation of African locust bean. *International. Journal of Food. Microbiology*. 8: 133-139

[16]. Iwe, M.O. (1991). Pattern of spoilage of soymilk: Influence of preparation methods and storage conditions.*Nigerian.Food.Journal*.9:92-104.

[17]. Irkin, R. and Korukluoglu, M. (2007). Control of Aspergillusniger with Leek, onion and leek extracts. *African Journal Biotechnology*. 6(4):384-387

[18]. Kinsella, J.E. (1976). Functional Properties of proteins in foods- A survey.Critical.Review in Food Scence and Nutrition.**7(3**): 219

[19]. Kolapo, A.L. (2008). Microbiological, deterioration and preservative studies on soybean daddawa-A condiment. MSc Thesis. University of Agricuture, Abeokuta. Nigeria. 108pp.

[20]. Kolapo, A.L. and Sanni, M.O. (2006). Microbiology of soyiru spoilage.*International Journal of Food and AgriculturalResearch*.3(2):188-196

[21]. Kolapo, A.L. and Sanni, M.O. (2007). Biochemical changes of soyiru (fermented soybean) with storage. *Agricuture and Food Science Journal of Ghana*.6:471-483

[22]. Kolapo, A.L., T.O.S. Popoola, M.O. and Sanni, M.O (2007a). Evaluation of Biochemical Deterioration of Locust bean Daddawa and Soybean Daddawa- Two Nigerian Condiments. *American Journal of Food Technology*. 2(5): 440-445

[23]. Kolapo, A.L.,.Popoola, T.O.S; Sanni, M.O.andAfolabi, R.O. (2007b).Preservation of soybean Daddawa condiment with Dichloromethane Extract of Ginger.*Research. Journal of .Microbiology*. 2(3): 254-259

[24]. Lau, B.H.S. (1989). Detoxifying, radio-protective and phagocyte-enhancing effects of Leek.*International.Clinical.Nutrition. Review*.9:27-31

[25]. Mladenovic J.D., Maskovic P.Z., Pavlovic R.M. and Radovanovic B.C. (2011). Antioxidant activity of ultrasonic extracts of leek Allium porrum L. *Hemijska Industrija* 65: 473-477

[26]. Numagami, Y. (1996). Attenuation of rat ischemic brain damage by aged Leek extracts: a possible protecting mechanism as antioxidants. *Neurochemistry.International*. 29:135-143

[27]. Obatolu, V.A.; Osho, S,M. and Uwagbuete, A.C. (1998). Comparative Physicochemial properties of fermented soybean and Locust bean. In: Ferris R.S.B (ed). Post- Harvest Technology and Commodity Marketing.IITA.Ibadan. pp163-168

[28]. Okorie C.P. and Olasupo,N. A.(2013) Controlled fermentation and preservation of UGBA –an indigenous Nigerian fermented food. SpringerPlus 2:470. http://www.springerplus.com/content/2/1/470

[29]. Omafuvbe, B.O. (1994). Natural fermentation of soy-bean (*Glycine max*) with added salt for soy-daddawa production.*World Journal of Microbiology and Biotechnology* 10: 497-480

[30]. Omafuvbe B.O, Shonukan, O.O. and Abiose, S.H. (2000). Microbiological and Biochemical changes in the traditional fermentation of soybean daddawa – a Nigerian Food Condiment.*Food Microbiology* 17, 469-474.

[31]. Oyeyiola, G.P (1988) Microbiology of the fermentation of 'Irupete' and 'Iruworo' obtained from local producers. *MIRCEN Journal of Applied Microbiology.and Biotechnology*. 4; 439-455.

[32]. Popoola, T.O.S and Akueshi, C.O (1985). Microorganisms associated with the fermentation of soybean for the production of Soybean `Daddawa' (A condiment). *Nigerian Food Journal*. 2: 194-196

[33]. Popoola, T.O.S; Kolapo A.L. and Afolabi O.R (2007) Biochemical deterioration of soybean daddawa- a condiment. *Journal of Food, Agriculture andEnvironment.***5**(1):67-70

[34]. Sarkar, P.K.; Cook, P.E. and Owens, J.C (1993). *Bacillus* Fermentation of Soybean.*World Journal.of Microbiology. and Biotechnology*.9: 295-299

[35]. Sattar, D. and Demen, J.M. (1973). Effect of packaging material on light induced quality deterioration of milk. *Journal of Canning Science. Technology Alim*entarus.6: 170-174

[36]. Siriamornpun, S., Yang, L. Kubola, J. and Li, D. (2008).Changes of Omega-3 Fatty acid content and lipid composition in canned Tuna during 12-month storge.*Journal of Food Lipids* 15: 164-175

[37]. Sosulki, F.; Humbert, E.S. and Bui, K. (1976). Functional Properties of Rape seed Flours, concentrates and Isolates. *Journal of Food Science*.41: 1349-1352

[38]. Stajner, D. and Varga, I.S. (2003). An evaluation of the antioxidant abilities of *Allium*species.*ActaBiologicaSzegediensis*. 47(1-4):103-106

[39]. Yanar, Y. Celik, M and Akamca, E. (2006). Effects of brine concentration on shelf-life of hot-smoked tilapia (oreochromisniloticus) stored at 4^0C. *Food Chemistry*. 97:244-247

[40]. Zia-ur-Rehman, Salariya, A.M and Habib F.(2003). Antioxidant activity of ginger extract in Sunflower oil. *Journal of Science Food and Agriculture*. 83: 624-629