NUTRITIONAL RESPONSE OF OKRA TO VARIOUS PACKAGING MATERIALS AND CHEMICAL PICKLING AGENTS

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ABSTRACT

The research is focused at determining the nutritional response of Okra when pickling is carried out using different antimicrobial liquids (vinegar, olive oil, and groundnut oil) and packaging materials (glass jar, plastic and stainless steel), as well as make a comparism when spices (garlic, ginger, mixture of garlic and ginger) are added as well as control (no treatment). The okra variety used was purchased from IITA (variety 47-4), based on NIHORT classification. Groundnut oil was extracted using a hydraulic press, and the physico-chemical properties of the groundnut oil was determined in the laboratory. The other antimicrobial liquids were purchased from a grocery store. The relative humidity and temperature of the storage environment was determined three times daily (8:00 a.m, 12:00 p.m, and 5:00 a.m.) for a period of 7 days. The nutritional content of okra such as crude fibre, calcium, vitamin A and vitamin C were determined at the end of the experiment. The mean result of crude fibre, calcium, vitamin C and vitamin A from okra samples after pickling showed that vitamin C of okra stored in stainless steel was significantly higher (36.06 mg/100g) than those of glass (35.02 mg/100g) and plastics (36.03 mg/100g).The mean calcium content of okra stored in plastic (80.730%) was significantly higher than those stored in glass (80.320%) and stainless steel (80.010%) respectively. Crude fibre of stored okra (3.24%) using groundnut oil was higher compared to when vinegar and olive oil were used respectively.

Keywords: Pickling, okra, vinegar, groundnut oil, calcium, protein

INTRODUCTION

Pickling or salting is a method of fermenting food to extend its shelf life. It can be considered as one of the oldest preservation method of food. The pickling process consists of lowering the pH due to conversion of sugar to acid by microorganisms present that are lactic acid bacteria and they naturally present in the surface of vegetable. The salt also plays an important role in fermentation by drowning out water and nutrients from vegetable and become lactic substrates for lactic acid bacteria growth. As the lactic acid grows, sugar will be converted to lactic acid and drop the pH to make the condition become acidic and inhibit the growth of pathogens and other non-acidic tolerant microorganisms especially aerobic spoilage microorganisms that can lead to spoilage. Pickling means increasing the acidity of a product so that food poisoning organisms, such as Clostridium botulinum do not grow and produce toxin. This may be done through a fermentation process and/or by the direct addition of an acid ingredient, such as vinegar or lemon juice or any other antimicrobial liquid. With either method, follow a reliable recipe to ensure proper acidification (Reynolds *et al* 2006).

Pickling also delay the enzymes activity on vegetable in terms in terms of softening vegetable tissues. The acidity and salinity of solution, temperature of fermentation, and oxygen content determine what kind of microorganisms dominant, and thus affect the flavour of end product. Pickling with the help of vinegar and oil has been practice from time immemorial in this country. If these preservatives are used in proper proportions the pickles can be retained for 10-15 years without vegetables and fruits in pickled form began as a household art, at present, most of the world's supply of pickles is produced in commercial plants. Any vegetables or fruit may be pickled. Pickling is the process of preserving food by anaerobic fermentation in brineor vinegar. The resulting food is called a pickle. This procedure gives the food an interesting twist in flavour. (Chou,2012).

However, some vegetables used in pickling are very heat sensitive and quality indicators such as colour and texture are usually degraded to a large extent during thermal treatment (Lau *et al*., 2000). Therefore, some pickled vegetables such as fresh pack pickles are produced without heat processing (Miller and Wehner, 1989).Nutrient change always occur when food are pickled. The exact nutrient changes depend on the composition of the pickling agent, the length of time you allow the food to be soaked in the pickling agent. Quick pickles are usually soaked for a short time (several days at most) in a highly acidic solution (usually involving vinegar).

Most of the helpful nutrient losses during the pickling process are usually water soluble nutrients, including vitamins that get leached into the pickling solution. The need to study the pickling of okra under different pickling agent and spices so as to reduce nutrient loss and deficiency disease is imperative. This research is to look into the nutritional response of okra when pickled with different chemical pickling agents.

MATERIALS AND METHODS

Preparation of Spices Fresh ginger that is firm and smooth to touch was used. It was kept at spoilage. In modern days pickles are prepared with salt, oil, vinegar, mixture of salt and spices (Srivastava *et al.,* 2002) .Pickling is an age-old method for preserving vegetables and fruits. The manufacture of pickles, relishes, and condiments has become one of the most important food industries. Although the preservation of room temperature, away from foods that could take away its flavour. They were peeled before use and incorporated into the container. 13g rhizome of ginger was used for this research work. Garlic was peeled before use, sliced and incorporated into the container. This involves peeling the outer layer of the garlic before incorporating it in the packaging material used. 13g of garlic was used for this research work.

Preparation of Antimicrobial Fluid

Vinegar, (5% acetic acid) a clear, colourless vinegar with a mellow aroma and a tart acid flavour was used for this experiment. 250ml of undiluted vinegar with 5% acetic acid was used for this experiment (Binsted *et al.,* 1962). Olive oil is a natural preservative that prevents spoilage by isolating the food from air, providing a seal that can delay oxidation, deterioration and moulding. Olive oil was incorporated into the packaging materials used, with a mixture of the spices used (ginger, garlic, mixture ginger and garlic) as well as the control. 250ml of olive oil was used for this research work.Attrition mill was used to reduce the size of the groundnut seed, thereby increasing the surface area and enhance the efficiency of oil extraction. The milled groundnut was fed into the cylinder of the hydraulic press. The maximum size the cylinder can accommodate is 3kg**.** The fed groundnut was then heated for 10 minutes at a temperature of 70^{o}C to increase extraction efficiency. Pressure was applied to the heated groundnut sample to bring about leaching of the groundnut oil from the seeds. The extracted oil was then collected, followed by laboratory analysis.



Figure 1: Hydraulic press for oil extraction   Figure 2 : pH meter   Figure 3: Experiment set up

Measurement of Parameters
The following parameters were measured during the course of the experiment.

Temperature and Relative Humidity
The temperature and the relative humidity of the storage environment were taken three times daily at 8:00 a.m, 12:00 p.m and 6:00 p.m respectively using thermometer and hygrometer.

Nutritional Analysis
The nutritional analysis of Okra with various chemical pickling agents was carried out at the chemistry laboratory in the University of Ilorin. The nutritional values and moisture content were determined in the laboratory. The nutritional parameters determined were vitamin C using AOAC (1995) method of analysis, Vitamin A, Calcium and Crude fibre were also determined.

pH Measurement
The pH was measured using a pH meter. The pH was measured four times during the course of the experiment. A pH range of 3.5 – 4.6 is needed for pickling process to be most effective.

Statistical Analysis
The effect of pickling agents and spices on the nutritional values of Okra in different packaging materials were investigated using A two-way analysis of variance (ANOVA) at $P \leq 0.05$ and the level of the significant means were further evaluated using Duncan's New Multiple Range Test (DNMRT).

RESULTS AND DISCUSSION
The design layout, summary of statistics of data generated and and analysis of variance test on Tables 1, 2 and 3 respectively show the effect of the measured parameters on the nutritional qualities of stored okra. The test shows that stored okra using the three selected materials (stainless, glass and plastic), the three selected pickling agents and the two spices had significantly different vitamin C content, vitamin A content, crude fibre, and calcium at 5% level. Also the interactions between study parameters were also significant at 5%.Based on packaging materials used, the value of vitamin C was high in stainless steel (33.4%) ,compared to glass and plastics. Vitamin A content was highest in plastic (33.4%), with no significant changes in those stored in glass and stainless steel respectively. Crude fibre was observed to have the highest value when okra was stored in plastic (33.4%), with no significant difference when stored in glass and stainless steel respectively .Based on the packaging materials used, and the pickling agent used, vitamin C has the highest value when stored in stainless steel, using vinegar as a pickling agent (33.5%).Vitamin A has the highest value when stored in stainless steel, using groundnut oil as a pickling agent. (33.4%). Crude fibre has the highest value when stored in plastic, using groundnut oil as a pickling agent. (33.8%).

Based on packaging material used, the value of vitamin C using ginger as spice, stored in stainless steel ranges between 35.813(mg/100g) – 35.853(mg/100g),the value of vitamin C using garlic as spice, stored in stainless steel ranges between 35.843 (mg/100g) – 36.073 (mg/100g).When glass was used as a packaging material, the value of vitamin C using ginger as spice ranges between 35.857(mg/100g) – 36.063(mg/100g),the value of vitamin C using garlic as a spice ranges between 35.947(mg/100g) – 36.043 (mg/100g).When plastic was used as a packaging material, the value of vitamin C using ginger as a spice ranges between 35.960 (mg/100g) – 36.127 (mg/100g),the value of vitamin using garlic as a spice ranges between 35.810 (mg/100g) – 36.027 (mg/100g).

The value of vitamin A stored in stainless steel using ginger as a spice ranges between 12.060 (mg/100g) – 12.270 (mg/100g), the value of vitamin A stored in stainless steel, using garlic as a spice ranges between 12.013 (mg/100g) – 12.270 (mg/100g).When glass was used as a packaging material, the value of vitamin A, using ginger as spice ranges between 12.040 (mg/100g) – 12.300 (mg/100g),when garlic was used a spice, the value of vitamin A ranged between 12.190 (mg/100g) – 12.263 (mg/100g).When plastic was used as a packaging material, the value of vitamin A ranges 12.063 (mg/100g) – 12.347 (mg/100g), when garlic was used as a spice, the value of vitamin A ranges between 12.027 (mg/100g) – 12.317(mg/100g).When stainless steel was used as a packaging material, the value of crude fibre using ginger as a spice ranges between 3.407% – 3.463%.the value of crude fibre, using garlic as a spice ranged between 3.467% – 3.503%.When glass was used as a packaging material, the value of crude fibre, using ginger as a spice ranged between 3.157% – 3.240%.when garlic was used as a spice, the value ranged between 2.890% – 3.130%.When plastic was used as a packaging material, the value of crude fibre, using ginger as a packaging material ranged between 2.947% – 3.1853%,when garlic was used as a spice, the value of crude fibre ranged between 2.820% – 3.150%.When stainless steel was used as a packaging material, the value of calcium using ginger as a spice ranged between 80.450% – 80.480%,when garlic was used as a spice, the value of calcium ranged between 80.457% – 80.563%.When glass was used as a packaging material, the value of calcium, using ginger as a spice ranged between 80.383% – 80.597%,when garlic was used as a spice, the value of calcium ranged between 80.413% – 80.597%.When plastic was used as a packaging material, the value of calcium, using ginger as a spice ranged between 80.530% – 80.633%,when garlic was used as a spice, the value of calcium ranged between 80.420% – 80.540%,when a mixture of both garlic and ginger the value of calcium ranged between 80.503% – 80.567%,when no spice was added (control), the value of calcium ranged between 80.717% – 80.777%.

Table 1 : Design layout for possible treatment combination

Possible Combination	**Spices**	**Materials**		
		M1	**M2**	**M3**
	S1	M1P1S1	M2P1S1	M3P1S1
	S2	M1P1S2	M2P1S2	M3P1S2
P1	S3	M1P1S3	M2P1S3	M3P1S3
	S4	M1P1S4	M2P1S4	M3P1S4
	S1	M1P2S1	M2P2S1	M3P2S1
	S2	M1P2S2	M2P2S2	M3P2S2
P2	S3	M1P2S3	M2P2S3	M3P2S3
	S4	M1P2S4	M2P2S4	M3P2S4
	S1	M1P3S1	M2P3S1	M3P3S1
	S2	M1P3S2	M2P3S2	M3P3S2
P3	S3	M1P3S3	M2P3S3	M3P3S3
	S4	M1P3S4	M2P3S4	M3P3S4

Materials (M1 = Stainless, M2 = Glass Jar, M3 = Plastic), Pickling Agent (P1 = Olive oil, P2 = Vegetable Oil, P3 = Vinegar), and Spices (S1= Ginger, S2 =Garlic, S3 = Mixture, S4 = No Spice

Table 2: Summary statistics of the data generated

Materials	Pickling Agent	Spices	Vitamin C (mg/100g)	Vitamin A (mg/100g)	Crude Fibre	calcium
Stainless	Olive Oil	1	35.833	12.220	3.433	80.450
		2	36.073	12.270	3.467	80.563
		3	35.863	12.057	3.477	80.507
		4	36.130	12.500	3.107	80.757
	Groundnut Oil	1	35.813	12.270	3.407	80.457
		2	35.843	12.013	3.483	80.457
		3	36.017	12.277	3.427	80.563
		4	36.203	12.573	3.203	80.777
	Vinegar	1	35.853	12.060	3.463	80.480
		2	35.973	12.083	3.503	80.497
		3	36.853	12.070	3.433	80.517
		4	36.213	12.563	3.403	80.760
Glass	Olive Oil	1	36.063	12.300	3.157	80.597
		2	36.043	12.253	2.890	80.597
		3	36.057	12.250	3.203	80.473
		4	36.100	12.367	3.423	80.740
	Groundnut Oil	1	36.030	12.180	3.190	80.597
		2	36.050	12.263	2.960	80.487
		3	36.050	12.190	3.177	80.583
		4	36.100	12.320	3.443	80.723
	Vinegar	1	35.857	12.040	3.240	80.383
		2	35.947	12.190	3.130	80.413
		3	35.820	12.210	3.200	80.470
		4	36.120	12.390	3.207	80.723
Plastic	Olive Oil	1	36.067	12.207	2.947	80.550
		2	36.027	12.170	2.857	80.540
		3	36.047	12.200	2.810	80.533
		4	36.187	12.443	3.403	80.777
	Groundnut Oil	1	36.127	12.347	3.157	80.633
		2	35.850	12.027	3.050	80.507
		3	36.027	12.170	2.820	80.567
		4	36.200	12.510	3.580	80.760
	Vinegar	1	35.960	12.063	3.183	80.530
		2	35.810	12.317	3.150	80.420
		3	35.867	12.253	2.873	80.503
		4	36.203	12.460	3.477	80.717

Table 3: Multivariate analysis of variance for measured parameters

Source	Dependent Variable	Sum of Squares	Df	Mean Square	F	Sig.
	Crude Fibre	1.648	2	0.824	458.936	0.000*
	Calcium	0.011	2	0.005	2.641	0.078*
	Vitamin C	0.025	2	0.012	18.169	0.000*
M	Vitamin A	0.007	2	0.004	6.579	0.002*
	Crude Fibre	0.154	2	0.077	42.836	0.000*
	Calcium	0.078	2	0.039	19.487	0.000*
	Vitamin C	0.005	2	0.003	3.71	0.029*
P	Vitamin A	0.041	2	0.02	36.041	0.000*
	Crude Fibre	0.718	3	0.239	133.313	0.000*
	Calcium	1.123	3	0.374	187.179	0.000*
	Vitamin C	0.793	3	0.264	389.95	0.000*
S	Vitamin A	1.535	3	0.512	901.757	0.000*
	Crude Fibre	0.097	4	0.024	13.481	0.000*
	Calcium	0.042	4	0.011	5.274	0.001*
	Vitamin C	0.723	4	0.181	266.788	0.000*
MP	Vitamin A	0.057	4	0.014	25.306	0.000*
	Crude Fibre	2.25	6	0.375	208.877	0.000*
	Calcium	0.054	6	0.009	4.469	0.001*
	Vitamin C	0.731	6	0.122	179.665	0.000*
MS	Vitamin A	0.251	6	0.042	73.757	0.000*
	Crude Fibre	0.118	6	0.02	10.954	0.000*
	Calcium	0.072	6	0.012	5.979	0.000*
	Vitamin C	0.353	6	0.059	86.829	0.000*
SP	Vitamin A	0.298	6	0.05	87.44	0.000*
	Crude Fibre	0.275	12	0.023	12.766	0.000*
	Calcium	0.054	12	0.004	2.24	0.018*
	Vitamin C	1.102	12	0.092	135.478	0.000*
MPS	Vitamin A	0.271	12	0.023	39.825	0.000*
	Crude Fibre	0.129	72	0.002		
	Calcium	0.144	72	0.002		
	Vitamin C	0.049	72	0.001		
Error	Vitamin A	0.041	72	0.001		
	Crude Fibre	1133.176	108			
	Calcium	701128.2	108			
	Vitamin C	140247.7	108			
Total	Vitamin A	16214.89	108			

The new Duncan multiple range test on Table 4 shows the different mean values of vitamin A of the stored okra in the materials. The result shows that vitamin C of stored okra in stainless was significantly higher (36.06 mg/100g) than those of glass (35.02 mg/100g) and plastics (36.03 mg/100g) irrespective of the pickling agent and or spice used for preservation of the okra. Vitamin A content of the stored okra however was significantly higher in plastic than in glass and stainless irrespective of the pickling agent and or spice used. Similarly, the mean calcium content of the stored okra in plastic was 80.586% which was significantly higher than the calcium value of 80.566% and 80.565% observed in glass and stainless respectively. Crude fibre was significantly higher in stainless than in glass and plastic respectively. Glass and plastic have relatively the same crude fibre. Crude fibre of stored okra (3.24) using groundnut oil as pickling agent was significantly higher than the crude fibre of stored okra (3.272) using vinegar and olive oil respectively. For calcium, however, olive and ground oil improve the calcium content of stored okra slightly above that of vinegar as pickling agent. Vitamins A and C were similarly the same with slightly higher values for groundnut oil as pickling agent. Spice was seen to play some role in altering the nutritional qualities of the stored okra using the selected materials and pickling agent. Ginger reduces slightly the crude fibre of the stored okra while garlic reduces it significantly from 3.36 to 3.166. Similarly the mixture of the two spices also reduces the crude fibre of the stored okra significantly.

Table 4: Multiple comparison using the new duncan range test

	Materials	Crude Fibre	Calcium	Vitamin C	Vitamin A
	Stainless	3.401a	80.565a	36.056	12.246
Materials	Glass	3.185b	80.566	36.020	12.246
	Plastic	3.109b	80.586	36.031	12.264
	Olive Oil	3.181a	80.590	36.041	12.270
Pickling Agent	Groundnut Oil	3.241b	80.593	36.026	12.262
	Vinegar	3.272b	80.534	36.040	12.225
	Ginger	3.242a	80.520	35.956	12.187
	Garlic	3.166b	80.498	35.957	12.176
Spices	Mixture	3.158b	80.524	36.067	12.186
	No Spice	3.361c	80.748	36.162	12.459

The chemical composition of okra pickles varies to a little bit depending on the media at which okra are processing (Hosain *et al.,*2010). Generally, it was observed that the two spices use reduce the crude fibre of the stored okra. This conclusion is consistent for calcium, vitamin A and vitamin C of the stored okra under storage condition pickling agent as used for this research work. The value obtained for vitamin C are less or similar to that obtained by Zaman *et al.* (2006) and Nwofia *et al.* (2012) in papaya pickles

Figure 4 shows the graphical illustrations of vitamin C content of the various spices (ginger, garlic, mixture and no spice) along the three pickling agent for all the three materials used for the storage. The result shows that highest value of vitamin C was observed in stainless steel,using vinegar as pickling agent spiced with a mixture of ginger and garlic. Figure 5 shows the graphical illustrations of vitamin A content of the various spices (ginger, garlic, mixture and no spice) along the three pickling agent for all the three materials used for the storage. The result shows that highest value of vitamin A (12.573 mg/100g) was observed in stainless steel, using groundnut oil as pickling agent with no spice (control). Figure 6 shows the graphical illustrations of Crude fibre content of the various spices (ginger, garlic, mixture and no spice) along the three pickling agent for all the three materials used for the storage. The result shows that highest value of Crude fibre (3.580) was observed in plastic, using groundnut oil as pickling agent with no spice (control). Figure 7 shows the graphical illustrations of the Calcium content of the various spices (ginger, garlic, mixture and no spice) along the three pickling agent for all the three materials used for the storage. The result shows that highest value of Calcium (80.777) was observed in stainless steel as a packaging material, groundnut oil as pickling agent with no spice (control),similar value was recorded when plastic was used as a packaging material, olive oil as pickling agent, with no spice (control).

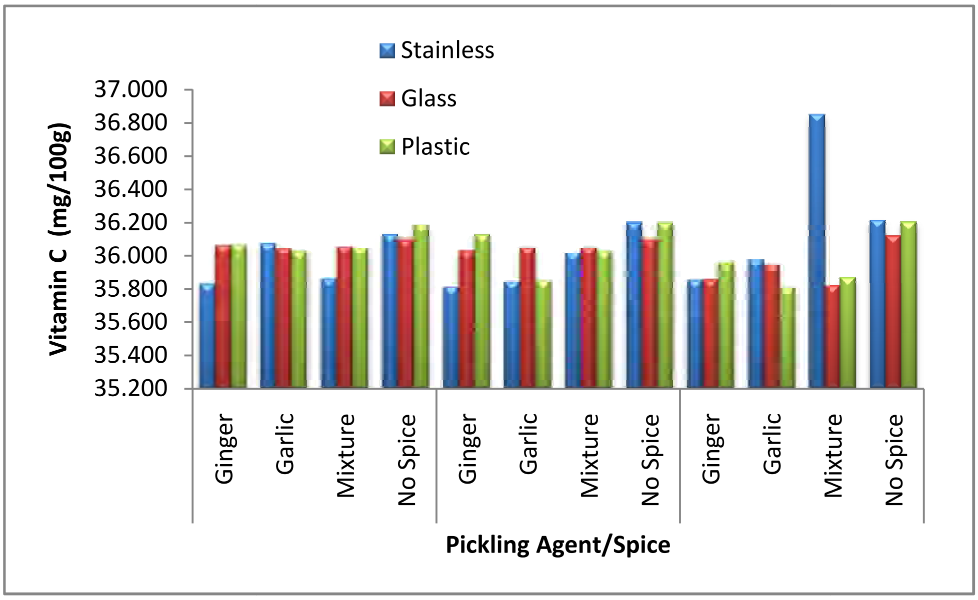

Figure 4: Graphical Illustration of the Vitamin C in Various Pickling Agent and Spice

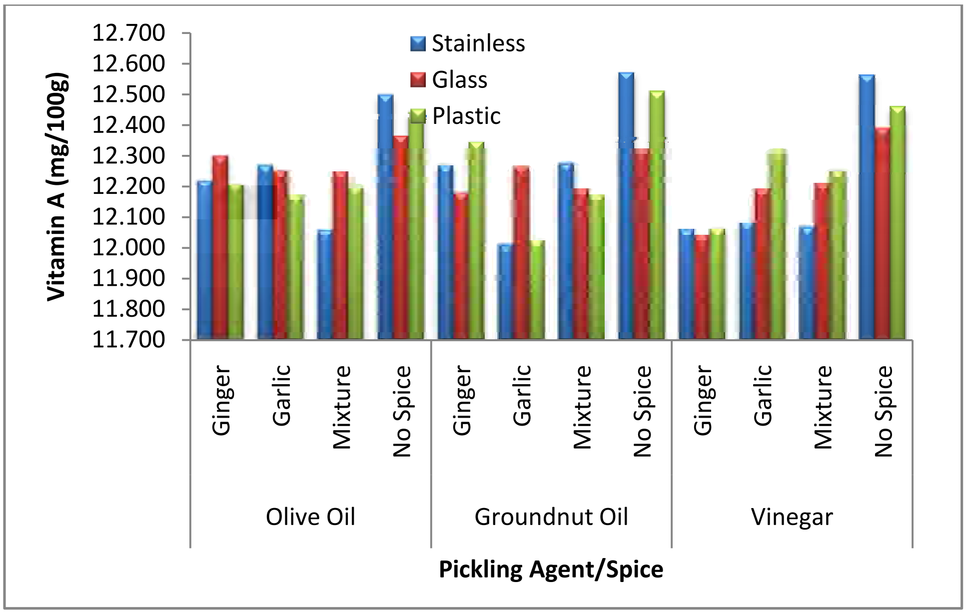

Figure 5: Graphical Illustration of the Vitamin A in Various Pickling Agent and Spice

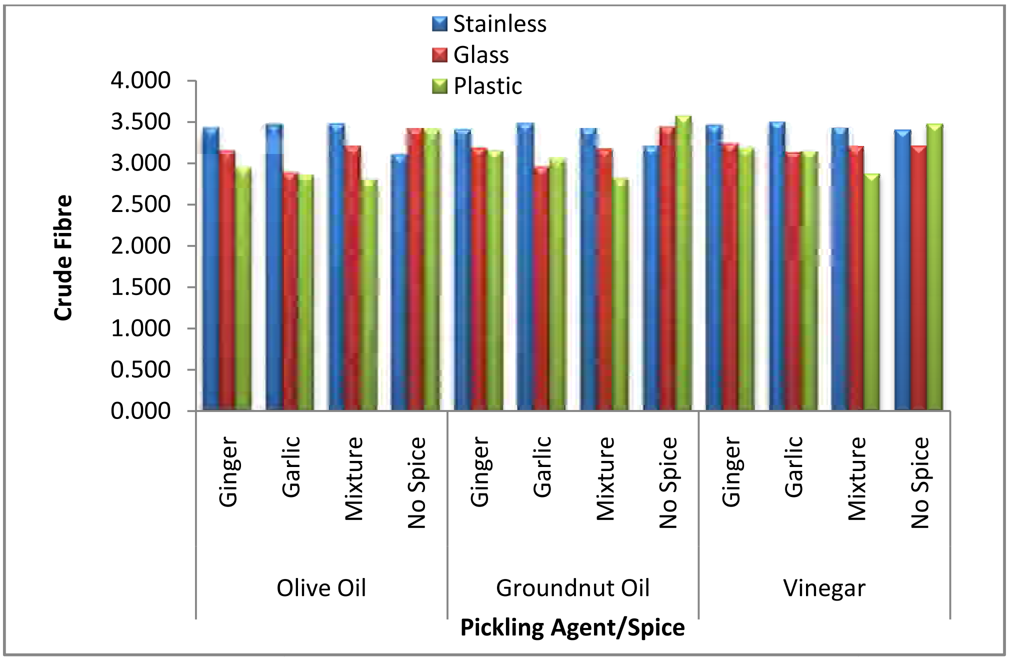

Figure 6: Graphical Illustration of the Crude Fibre in Various Pickling Agent and Spice

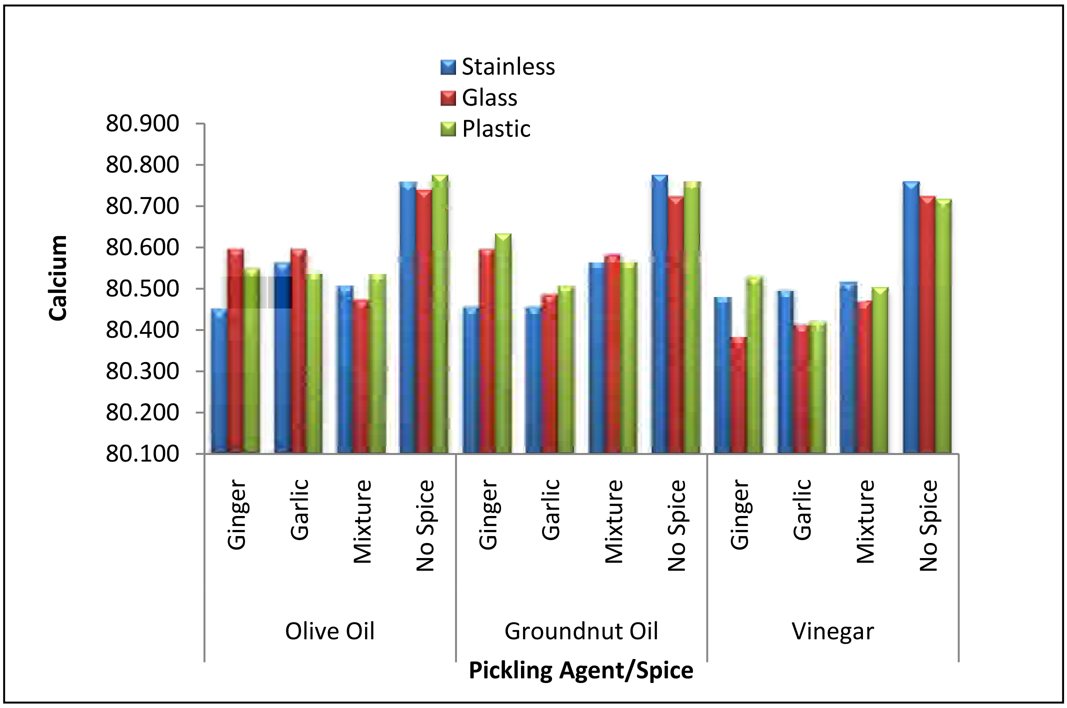

Figure 7: Graphical Illustration of the Calcium in Various Pickling Agent and Spice

CONCLUSSION

From the result of the analysis carried out, it was observed that the nutritional analysis of the pickled okra varied depending on the packaging materials used, as well as the spices used. The vitamin C of okra stored in stainless steel was higher, compared to those stored in glass and plastic jars. The value of vitamin C of stored okra is higher in plastic than in other packaging materials. The calcium value of okra stored was higher compared to other packaging materials. The value of crude fibre was also higher in stainless steel than in other packaging materials. For pickles rich in calcium, crude fibre, vitamin

A, and vitamin C, stainless steel should be used for packaging them.

Testing the nutritional compositions of pickled vegetables using different materials, microbila liquids and spices is relatively new area of research. However, it is important to know that all the three conditions of pickling process mentioned above will definately have effects on the nutritional compositions of pickled vegtables. However, it is important to conduct more research in this area.

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