International Journal of Applied Research

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2015; 1(13): 90-94
www.allresearchjournal.com
Received: 20-10-2015
Accepted: 22-11-2015

Gordon A
Accra polytechnic, SLT department, Accra, Ghana.

Yahaya B
Accra polytechnic, SLT department, Accra, Ghana.

Ayittey K
Accra polytechnic, SLT department, Accra, Ghana.

Adjei-Mensah R
Ghana Standard Authority, Accra, Ghana.

Correspondence
Gordon A
Accra polytechnic, SLT department, Accra, Ghana.

Migration of iron and tin from tin plated coated cans into tomato paste

Gordon A, Yahaya B, Ayittey K, Adjei-Mensah R

Abstract
Canned products like tomato paste on the Ghanaian market are sometimes sold on open market. This practice leads to accelerated deterioration of the product and leaching of metallic constituent of the can into the product. Levels of tin and iron were analyzed in eight different brands of canned tomato paste namely A5, A3, A6, A1, A7, A8, A4 and A2 stored under different experimental conditions. Samples were subjected to in room (28 ˚C, relative humidity of 70-78), fridge (≤4 ˚C) and under simulated tropical condition of ambient temperature at 32 ˚C and relative humidity at 85%. The initial concentrations of tin in the different brands range from 0.0519 mg/kg to 2.7029 mg/kg. The Tin content for the initial analysis were found to be less than the maximum acceptable limit of 250 mg/kg. The tin content in all samples after test in varying conditions remain within the acceptable limits though an increase of up to 4.3688 mg/kg was observed in A3 products. The iron content in the different brands range from 25.1300 mg/kg - 86.7373 mg/kg. All the canned tomato paste contains the mineral iron higher above the acceptable limit of 15 mg/Kg. A1 recorded the highest iron concentration of 97.9756 mg/Kg and the least in Gina's with concentration 26.3123 mg/Kg in samples stored in fridge at week 6. A3 tomato paste recorded the highest concentration of 143.8379 mg/Kg and the least in Gina's tomato paste with content 39.9452 mg/Kg at 6th week of storage at room temperature. A1 recorded the highest concentration of 204.8071 mg/Kg and the least in A4 with concentration 47.3405 mg/Kg in samples stored under Simulated Tropical Temperature and Humidity for 6 weeks. The rate of leaching of metallic constituents from the metallic container into the paste of tomato increased with an increasing temperature. 18.1380 $mgKg^{-1}week^{-1}$ was the highest rate of iron migration recorded with the least <0.0001 $mgKg^{-1}week^{-1}$ for Tin. The exposure of canned tomato paste on the open market could render the product unwholesome for consumption by shortening its shelf life as observed for products subjected to Simulated Tropical Temperature and Humidity. The tin and iron content in each product remained virtually stable during storage under refrigeration conditions but varied under room and Simulated Tropical conditions with significant difference in the tin and iron content at 95% confidence interval.

Keywords: Tin, Iron, Tin tomato paste

1. Introduction

Tomatoes are acidic and contain an excellent amount of vitamin A and C, making them especially easy to preserve in home by canning or as tomato sauce or paste. Canning is a method of preserving food in which the food contents are processed and sealed in an airtight container. Canning provides a typical shelf life ranging from one to five years. Under specific circumstances like freeze-dried canning, the product can last as long as 30 years in an edible state.

Canned tomato paste is prepared from the matured tomato packed with or without a suitable liquid packing medium other than added water, and seasoning ingredient appropriate to the product. Most cans used for preservation are made of iron coated with tin (Blunden and Wallace, 2003) [9].

Canned products like tomato paste on the Ghanaian market are sometimes sold on open market in alternating heat and cold under high humidity tropical conditions. Most of the products develop visible rust on the outside long before the expiry date.

Acidic foods are more aggressive to the tin coating in metal cans and canned acidic foods have higher tin contents. Tomato-based products tend to have high levels of tin as nitrate in the food accelerates corrosion of the tin (Food Safety Authority of Ireland, 2009) [8].

Cans are well lacquered to prolong the shelve-life of the product they carry (Catal´a *et al.,* 1998) [5]. However, unlacquered cans, partially lacquered and broken lacquered cans contaminate the product when stored under unstable undesirable conditions "alternating between hot, cold, moist, and dry atmospheric conditions". Uncontrolled expansion and contractions of the cans leads to breakage of the protective layer leading to leaching of undesirable metals into the canned food product. The reactions can modify the flavor characteristic of the product conferring to it metallic flavor (Bernardo and Santos, 2005) [4]. This phenomenon leads to decrease in shelf-life of canned tomato paste been sold on the open market. It is known that adequate iron in a diet is very important for decreasing the incidence of anemia, however overload is deadly, above 18 ppm (Demirezen and Uruc, 2006) [6]. The maximum CODEX permissible limit for tin and iron in canned tomato paste are 250mgkg^{-1} and 15mgkg^{-1} respectively (codex, 1994) [2].

2. Materials and Methods

2.1 Materials and Reagents

Plastic spoon, Glass rod, Tin cutter, Sample containers with covers, Spatulas, 100 mL volumetric flask, Wash bottle, 100 and 1000 mL Measuring cylinders and 0.45 µm Membrane filter, pipette.

10% nitric acid solution, Deionized water, 30% Hydrogen peroxide, concentrated nitric acid, Acetylene gas, 1000 ppm standard solution for (tin and iron).

Analytical balance, Milestone microwave digester, Cathode lamps (tin and iron), Atomic absorption spectrometer.

2.3 Test Samples

The 8 brands of tin tomato used were coded A1, A2, A3, A4, A5, A6, A7 and A8.

2.4 Methods

Thirty eight sample of each brand of tomato paste was used for the test. At each stage of the elemental composition test, three sample per each brand were opened and subjected to the analysis. The tin and Iron content in each sample were determined before subjecting the samples with similar batched to the test conditions. The remaining samples were subjected to three different storage conditions for a period of six weeks. Analysis for tin and iron were done at two weeks interval for the three different storage conditions. The three different storage conditions were, in room (28 ˚C, relative humidity of 70-78%), fridge (≤4 ˚C) and under simulated tropical condition of ambient temperature at 32 ˚C and relative humidity at 85% (Climatetemp.info, 2011) [1].

Sample preparation

The eight different brands of the tomato pastes, coded "A1, A2, A3, A4, A5, A6, A7 and A8" were used for the test. Each product was cut opened, emptied into sample containers homogenized and cupped. For each test, approximately 0.5g was weighed into Teflon vessels and 4 mL of nitric acid and 2 mL of hydrogen peroxide was added. The samples were micro-wave digested for 40 minutes and finally, diluted to 20 mL. Each diluted sample was analyzed for tin and iron using the atomic absorption spectrometer. The analytical preparation procedure was repeated for each sample stored under different conditions before analysis. The samples stored under different conditions were analyzed on the 2 weeks of storage, 4 weeks of storage and finally 6 week of storage.

Standard preparation

To quantify the test elements at each point of analysis, Standard calibration curves were constructed using 10 point concentration standards. The linearity of iron was determined using a concentration range of 2 mg/Kg to 230 mg/kg. That of tin was within the range of 0.05 mg/Kg – 5.0 mg/Kg.

3. Results and Discussion

The concentrations of tin in the different brands range from 0.0519 mg/kg to 2.7029 mg/kg. The highest concentration was observed in A3 tomato paste. The Tin content for the initial analysis were found to be less than the maximum acceptable limit of 250 mg/kg. The iron concentrations in the different brands range from 25.1300 mg/kg - 86.7373 mg/kg with the highest concentration observed in A8 and the least in A2 tomato paste. All the canned tomato paste contains the mineral iron higher above the acceptable limit of 15mg/Kg. The high values of iron concentrations may be from the metallic can or inherent contamination from the paste (Onabanjo and Oguntona, 2003) [3].

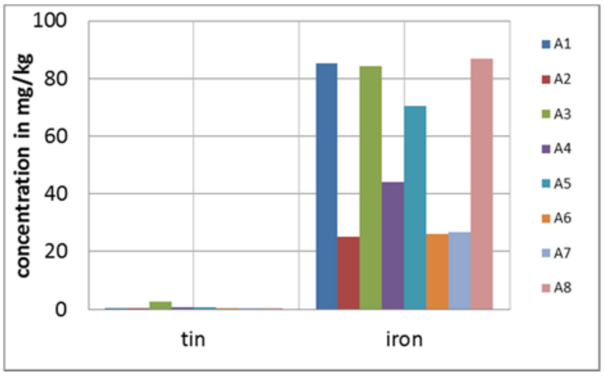

Fig 1: Tin and Iron content in different brands of tomato paste (Initial Concentration).

Under Refrigeration conditions.

The concentrations of tin in the brands of tomato paste stored under test condition ranged from 0.0519 mg/Kg - 2.7137 mg/Kg from week 0 - week 6 of storage for all products. The highest concentration was observed in A3 and the least in A2 tomato paste. All products tested during this period had their tin content below the maximum CODEX permissible limit "250 mg/Kg" for canned tomato paste.

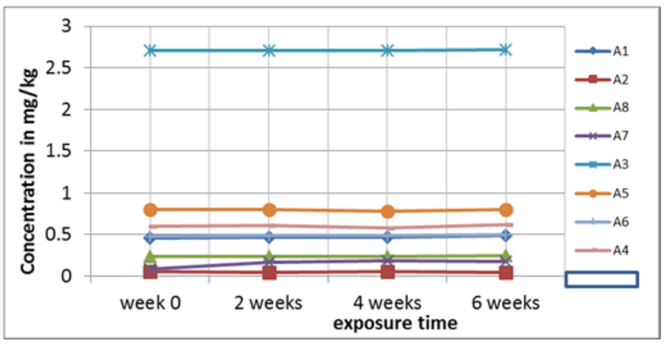

Fig 2: Tin Concentration profile in samples stored in Fridge

The concentrations of iron in the brands of tomato paste stored ranged from 25.1340 mg/Kg - 97.9756 mg/Kg from week 0 – week 6 of storage for all products. A8 recorded the highest level and A2 recorded the least after six weeks of test. All products failed the iron limit test as they are all above the permissible limit of 15 mg/Kg. ANOVA performed at 95% confidence interval shows that shows that there were no statistical reliable difference between Iron content present from the start of analysis to the 6th week for all samples apart from A8.

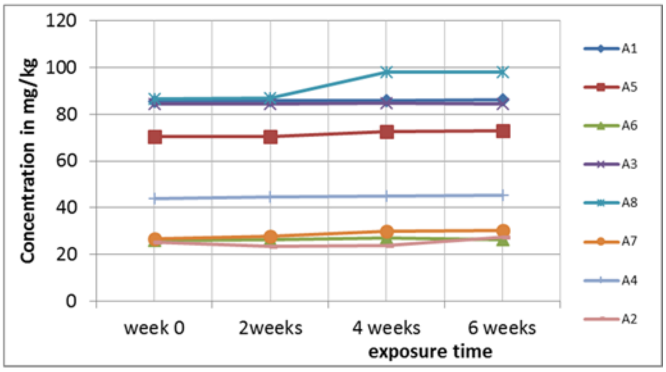

Fig 3: Iron Concentration profile in samples stored in Fridge

Under Room conditions

The concentrations of Tin in the different brands were observed increasing with exposure time from 2nd week to the 6th week except A7 tomato paste whose concentration increased from week 0 to the 6th week. The concentrations ranged for all samples were observed to be 0.0518 mg/Kg- 3.428 mg/Kg. Tin in all the samples were below the CODEX maximum acceptance limit of 250 mg/kg after the 6 week test. ANOVA performed at 95% confidence interval reveals that there was statistical reliable difference between tin content present from the start of analysis to the 6th week for all samples. A3 tomato paste has the highest tin content after the test and A6 the least.

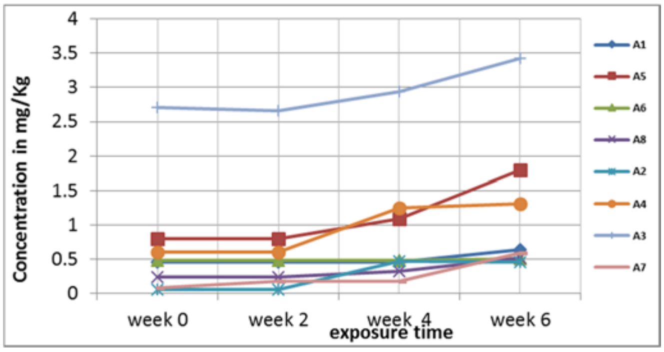

Fig 4: Tin Concentration profile in samples stored under ambient condition

The iron concentrations in the samples increased with exposure time. The trend was seen in all the brands of tomato paste used for the study, except A5 tomato paste which showed slight increase in the concentrations from 70.5600 mg/Kg at week 0 to 78.2999mg/Kg at week 6.

At week 6, A3 had the highest concentration with 143.8379 mg/Kg and A6 least concentration of 36.9452mg/Kg. All test samples failed the ANOVA performed for the six week period of the test at 95% confidence interval. The iron content were above the CODEX acceptance limit even from the start of test.

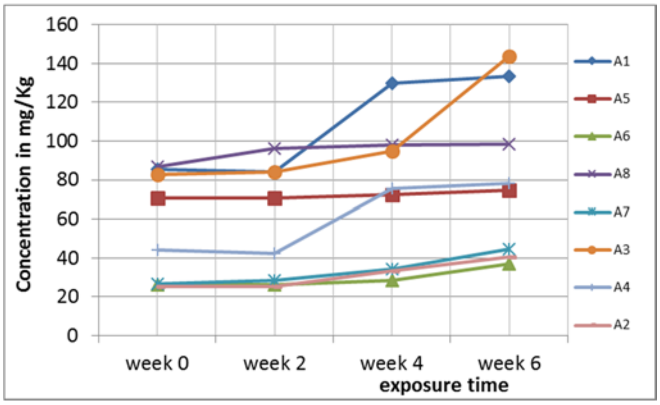

Fig 5: Iron Concentration profile in samples stored under ambient condition

Under Simulated Tropical Temperature and Humidity

The concentration of tin in the eight different brands of tomato paste increased during the test process. The highest concentrations was observed in A3 tomato paste which ranged from 2.7029 mg/Kg to 4.3688 mg/Kg as compare to A7 which ranged from 0.0853 mg/Kg – 0.7943 mg/Kg from week 0 to week 6. All samples tested for Tin after 6th week under simulated conditions were below the maximum permissible limit for tin 250 mg/Kg. There was appreciable increase in the tin content for all samples. There were statistical reliable difference at 95% confidence interval for variation of results at different test points for all samples.

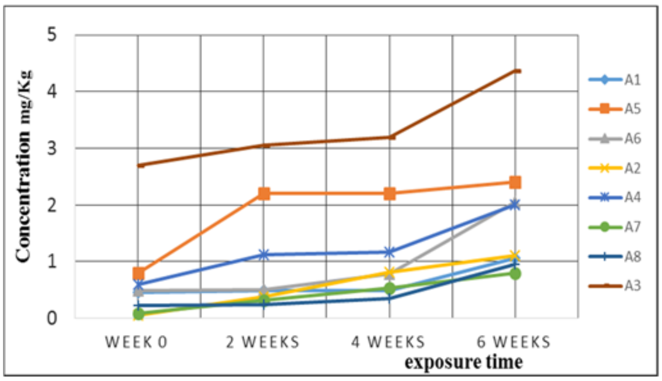

Fig 6: Tin Concentration profile in samples stored under accelerated degradation conditions

The Iron content of the product increased during the test. The highest concentration was observed in A1 with 204.8071 $mgkg^{-1}$ at week 6 as compared to the samples on hold where A3 had the highest concentration of 143.8379 $mgkg^{-1}$. The least concentration was in A7 with concentration 47.3405 $mgkg^{-1}$. The concentrations of iron in all the samples were above the CODEX maximum limit of 15 $mgkg^{-1}$. The high concentration of iron was due to migration of iron from the metallic can from the 2nd week to the 6th week. All the cans used for the canning of the various brands were lacquered and the lacquers remained physically intact after the six weeks exposure to simulation chamber condition.

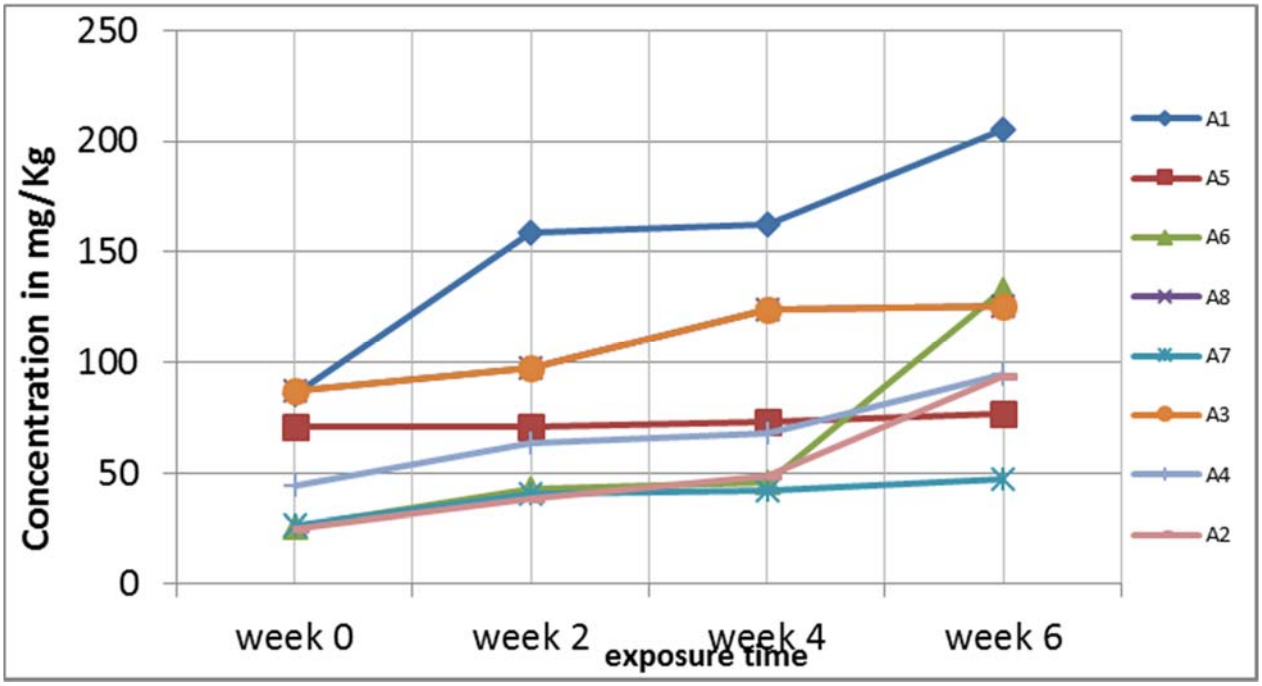

Fig 7: Iron Concentration profile in samples stored under accelerated degradation conditions

Rate of migration of Iron and Tin

The rate of migration was determined for the elements under test. The rate of iron migration under simulated tropical conditions was observed to be the highest followed by sample stored under ambient room temperature and under refrigerated conditions. A1 recorded 18.1380 $mgKg^{-1}week^{-1}$ as the highest migration rate of iron and the least 0.0429 $mgKg^{-1}week^{-1}$ in A2 under refrigeration conditions. The rate of tin leaching was the least in all product

An iron container covered with a layer of tin can is prevented from rusting as long as the tin layer remains intact. However, once the surface has been scratched, rusting occurs rapidly. Based on the standard reduction potentials "Sn(*s*) *E*° = -0.14 V, Fe(*s*) *E*°= -0.44 V", iron acts as the anode and tin as the cathode in the corrosion process leading to accelerated degradation rate.

Table 1: Rate of migration of tin and iron from tin plated canned into tomato paste

		Rate of Migration in $mgKg^{-1}week^{-1}$							
Test condition	**Element**	**A1**	**A5**	**A6**	**A2**	**A4**	**A7**	**A8**	**A3**
Acce	Tin	0.0902	0.2408	0.2492	0.1810	0.2125	0.1167	0.1134	0.2565
	Iron	18.1380	1.0523	16.1880	10.7730	7.8056	3.1648	7.1518	7.1518
fridge	Tin	0.0035	0.0007	0.0024	<0.0001	0.0005	0.0137	0.0001	0.0017
	Iron	0.1301	0.4543	0.0701	0.0429	2.2459	0.6211	0.2316	0.3680
Room	Tin	0.0260	0.1626	0.0025	0.0818	0.1371	0.0755	0.0466	0.1232
	Iron	9.5124	0.6826	1.7570	2.7549	6.8130	3.0049	1.8764	9.6908

All the cans were lacquered and they physically remain intact in all cans after the six weeks exposure. It was only iron contents that were high in the samples. Migration of the metallic constituent from the containers into products may occur due to discontinuity of the inner lining and the acidic nature of the tomato paste.

The study conducted showed that the samples stored under the simulated tropical temperature of 32 °C at 85% relative humidity in an accelerated degradation chamber conditions, recorded highest migration of tin and iron into the canned product.

4. Conclusion

All the cans were lacquered and they physically remain intact in all cans after the six weeks exposure. It was only the iron contents that were high in the samples. Migration of the metallic constituent from the containers into products may occur due to discontinuity of the inner lining and a brake in the tin protective coat leading to accelerated degradation and the leaching of its content into the product. The Tin content increase the least with iron content the most under all test conditions.

Samples stored under tropical simulate condition had the highest migration rate with 18.138 mg/kg/week for iron and 0.2565 mg/kg/week for tin.

The least concentration was observed for Tin under refrigeration condition with ≤ 0.0001 mg/kg/week. Tomato paste available in Tin plated cans sold in the open market under tropical environmental condition leads to accelerated degradation of the can and subsequently unwholesome product for consumption.

5. Reference

1. Climatetemp. info, Ghana Climate Guide to the Average Weather & Temperatures with Graphs Elucidating Sun-shine and Rainfall Data & Information about Wind Speeds & Humidity, 2011. http://www.climatetemp.info/ghana.
2. Codex Alimentarius Joint FAO. WHO 1994; P16:5A.

3. Onabanjo OO, Oguntona CRB. Iron, zinc, copper and phytate content of standardized Nigerian dishes, Journal of Food Composition and Analysis. 2003, 16(6):669-676.
   http://dx.doi.org/10.1016/S0889-1575 (03)00063-2
4. Bernardo PEM, Santos JLC, Costa NG. Influence of the lacquer and end lining compound on the shelf life of the steel beverage can, Progress in Organic Coatings, 2005; 54(1):34-42.
   http://dx.doi.org/10.1016/j.porgcoat.2005.04.002
5. Catal´a R, Caba˜nes JM, Bastidas JM. An impedance study on the corrosion properties of lacquered tinplate cans in contact with tuna and mussels in pickled sauce, Corros Sci. 1998; 40(9):1455-1467.
   http://dx.doi.org/10.1016/S0010-938X (98)00050-X
6. Demirezen D, K Uruc. Comparative study of trace elements in certain fish, meat and meat products. Meat Sci. 2006; 74:255-260.
7. Browning E. Toxicity of industrial metals, 2nd edition. London, Butterworth, 1969.
8. Food Safty. Authority of Ireland, Toxicology Factsheet Series, Mercury, Lead, Cadmium, Tin and Arsenic in Food. 2009; 1:6.
9. Blunden S, Wallace T. Tin in canned food: a review and understanding of occurrence and effect, Food and Chemical Toxicology. 2003; 41:1651-1662.