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SURVEY DETECTION OF TRACE HEAVY METALS IN POTATO CHIPS AND ICE CREAM FROM ASSIUT GOVERNORATE, EGYPT

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ABSTRACT

A total of 243 samples of potato chips (135 samples) and ice cream (108 samples) were collected from different regions and brands in Assiut Governorate - Egypt during May to July, 2011. Iron, manganese, copper, aluminum, nickel, lead, cadmium, selenium and arsenic were determined in samples using atomic absorption spectrophotometer. Results revealed no significant differences ($P \leq 0.01$) among regions in most ice cream and potato chips samples. The mean concentration of Lead, cadmium, copper, arsenic (potato chips) and nickel (ice cream) were exceeded than the legal limits established by the Egyptian and Codex standards.

Keywords: Trace heavy metals, Potato chips, Ice cream, Atomic Absorption Spectrometry.

INTRODUCTION

Potato chips and ice cream are common by used in our daily diet. Children also consume potato chips and ice cream in large amounts. Therefore, the trace heavy metals contents in potato chips and ice cream are important. Some metals are essential for humans like iron, copper, zinc and manganese and play an important role in biological systems, but these can produce toxic effects at higher levels (Mendil *et al.,* 2005; Narin *et al*., 2005). Iron, one of the most abundant metals on Earth, is essential to most life forms and to normal human physiology. Iron is an integral part of many proteins and enzymes that maintain good health. In humans, iron is an essential component of proteins involved in oxygen transport (Institute of Medicine: Food and Nutrition Board, 2001). On the other hand, excess amounts of iron can result in toxicity and even death. Manganese has important function for humans like as an enzyme co-factor, as a constituent of metalloenzymes and also has been implicated in carbohydrate metabolism, lipid and sterol metabolism and oxidative phosphorylation (Dundar and Saglam, 2004). The trace mineral selenium (Se) is an essential nutrient and is a key component of a number of functional selenoproteins required for human health (Murphy & Cashman, 2001), but the large amounts can lead to hair loss, brittle nails and other side effects (Ayar *et al.,* 2009). It has been pointed out that concentrations in the range 2–8µg g^{-1} of selenium in foods are harmful (Seiler *et al*., 1994). Trace metals like Pb, Cd, Zn, Cu, Cr and As are toxic (Li

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et al., 2005). Toxic trace metals Al, Pb, Cd and As can contaminate foods from the tools and machines used in the production. The most important sources of lead exposure are industrial emission, soils, car exhaust gases and contaminated food (Viñas *et al*., 2000). Vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on parts of the vegetables exposed to the air from polluted environments (Bahemuka & Mubofu, 1999). The dietary intakes of the elements for overall ages and sexes were 24, 13 and 286 µg/day of lead, cadmium, and nickel, respectively (Dabeka & McKenzie, 1995). According to the Egyptian standards the maximum acceptable limit does not exceed (mg/kg body weight day) for As (0.002), Cu (0.05 - 0.5), Fe (0.8), Cd (0.0067 - 0.0083) and Pb (0.05 children - 0.25 adult). No limitation was imposed for elemental Se (Ayar *et al*., 2009). The present study provides a more detailed determination of the contents of iron, manganese, copper, aluminum, nickel, lead, cadmium, selenium and arsenic in various regions and brands of potato chips and ice cream products in Assiut Governorate market, Egypt.

MATERIALS AND METHODS

Collection of samples

A total of 243 potato chips and ice cream samples were collected from three main regions (Popularly places , center city, and small cities) in Assiut governorate-Egypt .The characteristic, flavors of potato chips (135 samples) and ice cream (108 samples) are presented in Table (1). Samples were collected during three months (from May to July, 2011). From each region, 81 samples (45 potato chips and 36 ice cream samples) with three samples from each brand of potato chips (Tomato, Kebab & cheese flavors of each brand) and ice cream (chocolates, vanilla & vanilla and chocolates). Products were purchased in their original packages. All ice cream samples were stored below −18°C prior to analysis.

Table 1:The working condition for atomic absorption spectrophotometer (model GBC 906 AA)

Element	Wavelength (nm)	Detection limit (µ/L)
Fe	259.940	0.25
Mn	257.610	0.07
Cu	324.754	0.39
As	193.759	1.60
Cd	228.802	0.15
Ni	221.647	0.20
Pb	220.353	0.95
Se	196.090	1.90
Al	309.271	4.10

Table 2. The general characteristics of the potato chips and ice cream brands.

The general characteristics of the 100g potato chips					
Brands	**Flavors**	**Protein**	**Carbohydrate**	**Fat**	**Fiber**
Brand 1	Tomato	6.4	40	36.8	12
Brand 1	Kebab	8.2	51	29.0	5.3
Brand 1	Cheese	8.5	51	29.0	5.2
Brand 2	Tomato	7.0	49	31.0	15
Brand 2	Kebab	7.0	49	31.0	15
Brand 2	Cheese	6.2	59	26.0	3
Brand 3	Tomato	6.4	40	36.8	12
Brand 3	Kebab	6.4	40	36.8	12
Brand 3	Cheese	8.5	51	29	5.2
Brand 4	Tomato	7.0	55	33	15
Brand 4	Kebab	7.0	55	33	15
Brand 4	Cheese	7.0	55	33	15
Brand 5	Tomato	6.4	40	36.8	12
Brand 5	Kebab	6.4	40	36.8	12
Brand 5	Cheese	6.4	40	36.8	12
The general characteristics of the 100 ml ice cream					
companies	**Flavor**	**Protein**	**Carbohydrate**	**Fat**	
Brand 1	Chocolate.	0.78	16.71	5.42	
Brand 1	Vanilla.	1.14	7.14	6.57	
Brand 2	Chocolate	1.07	17.21	6.35	
Brand 2	Vanilla	1.14	16.28	6.42	
Brand 3	Chocolate & Vanilla	1.42	19.00	7.78	
Brand 3	Vanilla	1.42	18.85	7.71	
Brand 4	Chocolate & Vanilla	1.42	19.00	7.78	
Brand 4	Vanilla	1.28	21.57	6.28	
Brand 5	Chocolate & Vanilla	1.00	16.00	13.5	
Brand 6	Chocolate & Vanilla	1.71	25.71	16.5	
Brand 7	Chocolate & Vanilla.	1.25	22.50	19.0	
Brand 8	Chocolate& Vanilla	0.78	16.71	5.42	

Analysis of metals

All samples (potato chips & ice cream) were dried at 100°C. From each sample 1 g was digested with 10 ml of concentrated nitric acid for 1-2 hours, cooled to room temperature and digested with a 10 ml mixture of nitric 0.25% until the solution became colorless. The sample was then diluted to bring it within the concentration range of the standard calibration curves of the metals. The samples and the blanks were treated under the same conditions prior to analysis. Copper (Cu), Iron (Fe), Manganese (Mn), Arsenic (As),Selenium (Se), Aluminum (Al), lead (Pb), nickel (Ni), and cadmium (Cd) were analyzed using atomic absorption analysis. A GBC atomic absorption spectrophotometer model 906 fitted with an eight lamp turret and equipped with a graphite furnace, and an auto sampler was employed for the analysis using an Avanta Sigma Software (Khan *et al*. 1995).

Data analysis

The data was analyzed throughout the one-way analysis of variance (ANOVA) using the SPSS 9.0 program to examine statistical significance of differences of the mean concentrations of Fe, Mn, Cu, As, Cd, Ni, Pb, Se and Al determined in ice cream and potato chips. A probability

level of P ≤ 0.01 was considered statistically significant. Mean± standard deviation, range, minimum and maximum values were also presented.

RESULTS AND DISCUSSION

The mean range (± standard deviation) and range of metals concentrations in the various region and flavors are given in Tables 3 and 4 respectively of potato chips and ice cream analyses. The iron concentrations measured in the present study ranged from 6.63 - 30.28 mg/kg in potato chips and from 3.23 - 32.27 mg/kg in ice cream samples. These results are in agreement with Egyptian standards. The iron levels have been reported in the range of 2.4 - 3.55 µg/g (Narin *et al*., 2005). Significant differences in iron concentration among regions (P≤0.01) were in ice cream samples only.

Table 3. Concentration of trace elements in 135 potato chips samples 45 from each regions and 108 ice cream samples 36 from each regions

		Potato chips		Ice cream	
Element	**Regions**	**Mean ±SD (mg/kg)**	**Range (min.-max)**	**Mean ±SD (mg/kg)**	**Range (min.-max)**
Fe	Popularly places	15.51±6.09	6.66 - 30.28	10.470±8.38	3.23 - 32.27
	Center city	14.25±3.62	10.45 - 22.18	10.230±7.16	3.84 - 28.66
	Small cities	11.17±2.78	6.63 - 16.14	10.560±4.90	3.71 - 18.12
Mn	Popularly places	3.18±0.86	2.18 - 4.23	1.300±1.30	0.39 - 2.53
	Center city	4.10±0.53	2.94 - 5.10	1.710±1.71	0.66 - 4.15
	Small cities	3.35±0.93	1.75 - 5.03	1.940±1.94	1.04 - 3.91
Cu	Popularly places	4.36±0.99	2.73 - 6.71	2.060±2.06	0.55 - 7.36
	Center city	3.56±1.18	1.79 - 5.07	1.480±1.48	0.52 - 2.90
	Small cities	3.46±0.94	2.07 - 5.44	1.620±1.62	0.71 - 2.52
Se	Popularly places	0.08±0.08	0.00 - 0.28	0.068±4.22	0.00 - 0.16
	Center city	0.06±0.08	0.00 - 0.31	0.051±8.89	0.01 - 0.11
	Small cities	0.15±0.16	0.02 - 0.49	0.134±0.11	0.01 - 0.34
Al	Popularly places	5.43±3.25	1.58 - 12.31	13.440±8.44	4.29 - 31.75
	Center city	3.62±3.69	0.19 - 12.24	13.160±7.10	3.61 - 24.30
	Small cities	6.49±5.47	0.02 - 18.52	8.520±3.57	3.04 - 14.17
As	Popularly places	1.76±1.46	0.00 - 0.05	0.0007±2.34	0.001 - 0.080
	Center city	1.96±2.54	0.00 - 0.08	0.0012±4.04	0.000 - 0.014
	Small cities	6.60±1.04	0.00 - 0.03	0.001±2.44	0.005 - 0.007
Cd	Popularly places	0.17±0.16	0.00 - 0.43	0.280±0.24	0.00 - 0.80
	Center city	0.32±0.32	0.00 - 0.097	0.210±0.24	0.00 - 0.82
	Small cities	0.15±0.21	0.00 - 0.75	2.00±4.84	0.00 - 0.15
Ni	Popularly places	0.00±0.00	0.00 - 0.00	0.074±0.25	0.00 - 0.89
	Center city	0.00±0.00	0.00 - 0.00	0.004±1.44	0.00 - 0.05
	Small cities	0.00±0.00	0.00 - 0.00	0.080±0.27	0.00 - 0.95
Pb	Popularly places	0.50±0.21	0.24 - 0.90	0.640±0.46	0.14 - 1.59
	Center city	0.74±0.32	0.31 - 1.47	0.590±0.40	0.15 - 1.67
	Small cities	0.51±0.16	0.23 - 0.85	0.500±0.19	0.29 - 0.84

Significant difference between three regions: *p* ≤0.01

T4

The iron intake is negatively influenced by low nutrient density foods, of high calories but low vitamins and minerals. Sugar sweetened sodas, most desserts and snack foods such as potato chips are examples of low nutrient density foods of high calories but low vitamins and minerals (Narin *et al*., 2005) .The wide variation of iron content in ice cream may be due to the iron content of the raw materials used in the manufacture such as skim milk and soymilk when compared with raw milk (Abdullah *et al.,* 2003).

The level of manganese in foods may vary due to soil deficiencies. High-tech farming and lime added to soil can lower the manganese levels of certain foods. Manganese levels may also be affected by food processing (Tuzen & Soylak, 2007). Manganese concentration measured in the present study ranged from 1.75 - 5.10mg/kg in potato chips and from 0.39 - 4.15 mg/kg in ice cream samples. The manganese levels in the present study recorded mostly agreement with a safe and adequate intake of 2.0-5.0 mg/day for adults in the United States (WHO, 1997). Manganese levels among regions were significantly higher ($p \leq 0.01$) in potato chips samples only. Levels of manganese have been reported 0.884 - 8.40 µg/g in potato chips (Narin *et al*., 2005) and 0.5 – 7.0 µg/g in vegetables (Sanchez-Castillo *et al.,* 1998).

Copper is known to possess vital and toxic effects for many biological systems and may enter the food materials from soil through mineralization by crops, food processing or environmental contamination, as in the application of agricultural inputs, such as copper-based pesticides, which are in common use in farms in some countries (Onianwa *et al*., 2001). Copper concentrations were ranged from 0.52 to 7.36 mg/kg in the potato chips samples and 0.39 to 4.15 mg/kg in the ice cream samples. Significant differences in copper levels among regions were not observed in potato chips and ice cream samples. The most copper levels in potato chips and ice cream were exceeded than the recommended limit of the Egyptian standard (1993).The ranges of copper concentration in potato chips were agreement with those reported in Nigeria (0.07 – 7.30µg/g; Onianwa *et al*., 2001), Tanzania (4.9 – 9.4µg/g; Bahemuka & Mubofu, 1999) and were higher than those reported in Turkey (0.28 to 1.26 µg/g; Narin *et al*., 2005), Mexico (0.3 –1.4 µg/g ;Sanchez-Castillo et al., 1998). The range concentration of copper was 0.46 to 2.48ppm in ice cream samples (El-Tawila, 1998).

The selenium, as one of the important microelement was recently reported to be a considerable antioxidant. Small cites had highest means of selenium content (0.49 mg/kg) of Potato chips samples and (0.34 mg/kg) of ice cream samples. The flavors (cheese) in potato chips and (chocolate &vanilla) in ice cream samples were recorded the highest amount of selenium content. The selenium concentration of potato chips and ice cream samples were below the harmful levels (2–8µg g^{-1}; Seiler *et al*., 1994). There were no significant differences in selenium concentration among studied regions of potato chips and ice cream samples. Committee on Medical Aspects of Food and Nutrition Policy (COMA) set RNIs (Reference Nutrient Intakes) of 0.075 and 0.060 mg selenium/day for males and females respectively, and 0.075 mg selenium/day for lactating women (COMA, 1991). The limit of the US dietary reference intakes is 0.055 mg selenium/day for 14-70 years.

The aluminum content in potato chips and ice cream samples ranged from 0.02 to18.52 mg/kg and 3.04 to 31.75 mg/kg, respectively. The higher concentration of aluminum in ice cream than those in potato chips may be due to the technological production conditions and the aluminum – containing food additives used in ice-cream production such as sugar (Ayar *et al*., 2009). Aluminum powder and aluminum salts (lakes) are also used as coloring matters in decoration of sugar-coated flour confectionery, candy and coatings has also been regarded as the main dietary source (WHO, 2007). The mean concentration of aluminum in some potato chips and ice cream samples were exceeded than the recommended level (3-14mg/day; WHO, 1997). Statistically, there were no significant differences ($P \leq 0.01$) among regions in potato chips and ice cream samples.

Exposure to arsenic is mainly via food intake and drinking water. Long-term exposure to arsenic is related to risking of various forms of cancer (mainly skin cancer) and numerous non cancer diseases, including skin lesions, diabetes, chronic cough and toxic effect on liver, kidney, cardiovascular system and peripheral and central nervous systems (Järup, 2003 & Vahter, 2007). In the present study the highest arsenic content was 6.60 mg/kg of tomato flavors of potato chips samples in small cities and 0.0012 mg/kg of chocolate flavor of ice cream samples in center city. There were no significant differences among regions in the arsenic content of potato chips and ice cream samples. The content of arsenic in ice cream obtained in this study was below the limits of (0.1 - 1.0 mg/kg: Codex & 0.002 mg/kg body weight; Egyptian standards) and ice cream samples in Turkey (0.09 - 0.17 mg/kg; Ayar *et al*., 2009). The arsenic content in potato chips samples were not agreement with the limit of (Egyptian standards, 1993)

Nickel as toxic element can cause a skin disorder known as nickel-eczema and occupational disease. That diseases incidence increased in patients who consume foods rich in nickel, such as oats, nuts, beans and chocolate (Flyvholm *et al*., 1984; Sérgio *et al.,* 2001). In the present study, nickel was not detected in all potato chips samples but was found in some of the ice cream samples. The highest level of nickel was 0.89 mg/kg of chocolate flavor of ice cream samples in small cities these results are an agreement with those of (Flyvholm *et al*., 1984; Sérgio *et al.,* 2001). The limit detected in ice cream samples were exceeded than the toxic limit (600 µg/day; WHO, 1997) and (286 µg/day; Dabeka & McKenzie, 1995). There were no scientific differences in nickel content of ice cream samples among regions.

Cadmium may find its way to the human population through food. Cadmium induced kidney damage; skeletal disorders and other diseases (Järup, 2003). In the present study vanilla flavor ice cream in small cities showed higher cadmium concentration (0.82mg/kg) than those of tomato flavor potato chips in center city (0.75mg/kg). The results in the present study recorded cadmium concentration of potato chips and ice cream samples exceeded than Egyptian standard limitation and exceeded than analyzed samples in Japan (0.1 µg/g of potato chips & $<$0.1 µg/g of ice cream; Kikuchi *et al*., 2002). There were no significant differences among regions of potato

chips and ice cream samples. The cadmium concentrations in potato may be due to the soil in which the potato was grown (Bahemuka & Mubofu, 1999). In ice cream, a recent study suggested that the main inputs of cadmium to animal feed in farmed animals are feeding crops, trace element premixes, fish meal, and minerals such as, limestone and phosphate (Tu *et al*., 2007; Bilandzˇic´ *et al.,* 2011).

The highest mean concentration of lead of potato chips was 1.47 mg/kg and 1.66 mg/kg in ice cream. These levels were exceeded than the allows acceptable levels in Egyptian standard (0.05 mg/kg/week for adults to 0.025 mg/kg/week for children) and Codex (0.20 mg/kg in milk powder, butter, ice cream, whey powder, and drained yogurt samples). The total lead intake from food and beverages has been estimated for adults in various industrialized countries to be 0.25 – 0.30 mg/day (Ayar *et al*., 2009). The statistically analysis show there were no significant differences ($P \leq 0.01$) among different regions. In potato chips, the significant differences may be due to the different potato growing areas and of soil receiving different materials as amendments, also some lands are near from car's way or factories and others may be irrigated by contaminated water (Bahemuka & Mubofu, 1999; Viñas *et al*., 2000). In the ice cream, previous study suggested the source of milk (animals) which may feed on contaminated feeds or water (Bilandzˇic´ *et al*., 2011) and/or to the additives of flavor.

Conclusion

The study shows that the levels of cadmium & copper (potato chips &ice cream samples), Nickel (ice cream samples), Arsenic (potato chips samples), and Aluminum (some potato chips & ice cream samples) not agreement within estimating heavy metals levels in Egyptian standers and codex standers. There were no significant differences in most heavy metals among regions of potato chips and ice cream samples. Nickel was not detected in potato chips samples. The present study recorded that the vanilla flavor of ice cream and tomato flavor of potato chips have highest concentration of lead and cadmium than other flavors. On the other hand, cheese flavor of potato chips and chocolate flavor of ice cream recorded highest iron and copper concentration. The heavy metals concentration of the potato chips may be due to the potatoes water contain (80% approximately; Joint food safety & standards group 1998) and when potato slices are cooked during the manufacture of crisps, the dehydration occurs, which will increase the proportion of dry matter and thus concentrate such elements in the finished product. In ice cream may be due to the raw material, flavorings and additives used in the manufacturing.

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تواجد العناصر الثقيلة فى رقائق البطاطس والايس كريم فى محافظة اسيوط مصر

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من مجموع ٢٤٣ عينة من رقائق البطاطس (135) عينة والآيس كريم (108) عينة تم جمعها من مختلف المناطق والعلامات التجارية من محافظة أسيوط - مصر خلال شهر مايو إلى يوليو ٢٠١١ . تم تحليل العينات باستخدام جهاز إمتصاص الطيف الذري لعنصر الحديد والمنجنيز والنحاس و الألومنيوم والنيكل والرصاص والكادميوم والسيلينيوم والزرنيخ . وكشفت النتائج عن عدم وجود فروق ذات دلالة ($P \geq 0.01$) معنوية بين المناطق في معظم عينات الآيس كريم وايضا فى عينات رقائق البطاطس . تجاوزت تركيزات عنصر الرصاص والكادميوم والنحاس والزرنيخ فى رقائق البطاطس والايس كريم بالاضافة الى ما سبق عنصر النيكل فى الآيس كريم عن الحدود المسموح بها فى المواصفات القياسية المصرية وكذلك المواصفات التى وضعتها Codex .

قام بتحكيم البحث

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Table 4. Concentration of trace elements in 135 potato chips samples 45 from each flavor and 108 ice cream samples 36 from each flavor

	Potato chips			Ice cream		
Element	**Flavors**	**Mean ±SD (mg/kg)**	**Range (min.-max)**	**Flavors**	**Mean ±SD (mg/kg)**	**Range (min.-max)**
	Tomatoes	13.99±5.410	8.860 - 30.280	Vanilla	9.32±7.280	4.33 - 28.66
Fe	Kebab	10.75±2.450	7.660 - 16.470	Chocolate	11.48±8.140	3.22 - 32.27
	Cheese	16.19±4.160	6.630 - 22.180	Vanilla & Chocolate	10.56±4.910	3.71 - 18.12
	Tomatoes	3.82±0.960	2.180 - 5.100	Vanilla	1.52±1.190	0.39 – 4.14
Mn	Kebab	3.54±0.950	2.270 - 4.350	Chocolate	1.49±0.590	0.55 – 2.52
	Cheese	3.45±0.850	1.750 - 4.550	Vanilla & Chocolate	1.94±0.860	1.04 – 3.90
	Tomatoes	3.87±0.920	1.950 - 5.070	Vanilla	1.49±0.970	0.52 – 3.9
Cu	Kebab	3.59±1.030	2.070 - 5.440	Chocolate	2.04±1.830	0.55 - 7.35
	Cheese	3.93±1.340	1.790 - 6.710	Vanilla & Chocolate	1.62±0.620	0.71 - 2.52
	Tomatoes	0.084±0.083	0.000 - 0.284	Vanilla	0.05±0.041	0.013 - 0.117
Se	Kebab	0.057±0.040	0.000 - 0.158	Chocolate	0.06±0.046	0.00 - 0.15
	Cheese	0.161±0.170	0.000 - 0.490	Vanilla & Chocolate	0.13±0.110	0.013 - 0.34
	Tomatoes	3.910±2.030	0.018 - 7.870	Vanilla	15.80±5.190	6.80 - 24.29
Al	Kebab	3.010±1.340	0.600 - 4.360	Chocolate	10.50±9.000	3.61 - 31.74
	Cheese	9.140±5.240	0.180 - 18.500	Vanilla & Chocolate	8.52±3.570	3.03 - 14.17
	Tomatoes	0.140±0.960	0.000 - 0.040	Vanilla	0.001±0.004	0.00 - 0.014
As	Kebab	0.220±0.020	0.000 - 0.700	Chocolate	0.008±0.002	0.00 - 0.008
	Cheese	0.006±0.008	0.000 - 0.020	Vanilla & Chocolate	0.001±0.002	0.00 - 0.007
	Tomatoes	0.370±0.290	0.000 – 0.966	Vanilla	0.267±0.220	0.00 - 0.790
Cd	Kebab	0.040±0.080	0.00 - 0.220	Chocolate	0.199±0.250	0.00 - 0.822
	Cheese	0.220±0.210	0.00 - 0.740	Vanilla & Chocolate	0.020±0.040	0.00 - 0.149
	Tomatoes	0.000±0.000	0.00 - 0.000	Vanilla	0.074±0.250	0.00 - 0.890
Ni	Kebab	0.000±0.000	0.00 - 0.000	Chocolate	0.004±0.010	0.00 - 0.050
	Cheese	0.000±0.000	0.00 - 0.000	Vanilla & Chocolate	0.080±0.270	0.00 - 0.95
	Tomatoes	0.630±0.220	0.30 - 1.000	Vanilla	0.62±0.400	0.14 – 1.58
Pb	Kebab	0.540±0.260	0.23 - 1.340	Chocolate	0.61±0.460	0.14 – 1.66
	Cheese	0.570±0.300	0.22 - 1.470	Vanilla & Chocolate	0.50±0.190	0.29 – 0.83

Significant difference between three regions: $p \leq 0.01$