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Levels of Metals in Canned Meat Products: Intermetallic Correlations

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The analytical control of heavy metals in food is particularly important, since these pollutants are notably cumulative in nature and, therefore, can be toxic to humans. Their determination in foods of animal origin is, thus, of interest.

In this study analyses of seven heavy metals in semi-preserved ham and shoulder pork, preserved luch pork and pork liver paste were performed to determine the possible influence of the container itself on the levels of metals in such products. Not only were the toxic elements cadmium and lead studied, but also copper, zinc, iron, nickel and manganese which, although not essentially toxic, could, in high concentration, cause public health hazards or a decrease in the organoleptic quality of the canned product, with resultant economic effect. Statistical and metal-to-metal correlation analysis are carried out, and the mean levels of metal found in the different products are compared with the maximum tolerance levels of metals allowed in the European Economic Community countries (Parker 1986).

MATERIALS AND METHODS

The samples analyzed (35 shoulder pork, 14 preserved lunch pork, 15 ham and 16 pork liver paste) in glass, plastic, metallic or china containers coming from countries of the European Economic Community, were purchased in commercial establishments in Santa Cruz de Tenerife (Canary Islands) and were representative of the different products habitually consumed in the Canaries. From each product, 30-35 gr samples were taken, one from the interior of the product and the second from the surface in direct contact with the container. They were then dried under infrared irradiation and then ashed at 450±10°C. The ash was treated with 5mL hot, concentrated hydrochloric acid, filtered and made up to 50mL with deionized water in

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a volumetric flask. Determinations were carried out by flame atomic-absorption spectrophotometry using deuterium arc background correction for Zn, Cd and Pb. Results were treated by applying the Statistical Package for the Social Sciences (Nie *et al.* 1975) compiled and linked in the software of a Digital VAX/VMS 11/780 (V.4.8) computer.

RESULTS AND DISCUSSION

It should first be noted that no significant differences were found between samples taken from the surface and those from the interior of the products.

Table 1 shows the mean, maximum and minimum level values together with the standard deviation for the different meat products analyzed. For every meat product it was observed that the highest concentrations found were those of Zn and Fe, with wide ranges, while Cd was the lowest, with mean values below 100 ppb in every product.

The mean levels of Mn, Ni, Cu and Zn found in pork liver paste were significantly higher than in the rest of the products, but no significant differences were observed for Cd and Pb.

For Cd, Pb and Cu our data fall within the ranges reported by Kirkpatrick and Coffin (1973), Tackacs *et al.* (1975,1976), Parolari and Pezani (1977), Cantoni *et al.*(1979), Ruick and Schmidt (1982) and Ybañez *et al.*(1982). No data were found in the literature for Mn, Fe, Ni and Zn.

Table 2 shows the mean, maximum and minimum values and the standard deviation for the seven metals studied, differentiating not the products but the four types of containers. It can be observed that for Mn, Cu and Ni, products in glass and china containers had higher mean values than those in plastic and metallic containers, while the concentrations of Zn and Cd were similar in the different containers. The samples from plastic and china had lower concentrations of Fe than those from glass and metallic containers. No Pb was detected in any of the samples from china containers.

From the results obtained in this study and comparisons with data for fresh pork meat and liver given by Niinivaara and Antila (1973), Hecht *et al*.(1973), Collet (1975), Holm (1976) Parolari and Pezani (1977), Cantoni *et al.* (1979), Begliomini *et al*.(1979) and Catalá *et al*.(1983), it might be concluded that the concentrations of heavy metals studied in these pork meat and liver products came mostly from the actual products and not from changes brought about by containers.

Table 1. Main statistical data for the four types of meat products analyzed

Meat product	Cu	Ni	Cd	Fe	Mn	Pb	Zn
Shoulder pork							
Mean	1.59	1.69	0.088	10.08	0.38	0.43	18.05
Maximum	7.11	3.62	0.220	24.22	1.84	0.75	27.13
Minimum	0.58	0.49	0.040	1.14	0.13	0.15	4.62
SD*	0.72	0.64	0.025	1.07	0.45	0.13	3.92
Ham							
Mean	1.77	1.39	0.084	8.33	0.39	0.57	14.04
Maximum	8,42	2.33	0.140	11.86	1.77	1.80	25.38
Minimum	0.83	0.80	0.020	1.96	0.08	0.30	1.24
SD	1.65	0.44	0.026	2.42	0.46	0.21	7.09
Lunch pork							
Mean	1.84	1.75	0.070	12.62	0.65	0.49	13.85
Maximum	3.48	3.80	0.140	17.46	2.62	2.06	36.76
Minimum	0.91	0.87	0.030	4.50	0.25	0.27	7.34
SD	0.75	0.74	0.023	2.50	0.46	0.31	6.38
Pork liver paste							
Mean	5.63	5.39	0.073	6.48	1.47	0.30	21.72
Maximum	11.87	10.63	0.190	14.23	2.22	0.38	27.98
Minimum	1.52	1.44	0.030	3.86	0.16	0.22	14.71
SD	2.32	2.39	0.036	2.22	0.45	0.08	4.13

*SD = standard deviation; concentrations in ppm.

Table 2. Main statistical data obtained combining all the samples and differentiating only the four types of containers

Container (N=105*)	Cu	Ni	Cd	Fe	Mn	Pb	Zn
Metallic							
Mean	2.03	1.84	0.084	10.83	0.46	0.51	16.60
Maximum	7.11	6.60	0.220	24.22	1.66	2.06	36.76
Minimum	0.77	0.80	0.030	1.96	0.08	0.27	2.42
SD**	1.42	1.00	0.028	3.31	0.31	0.31	5.80
Glass							
Mean	5.35	5.28	0.080	10.05	1.69	0.29	19.31
Maximum	11.87	10.63	0.190	14.23	2.62	0.36	24.79
Minimum	1.02	1.08	0.040	6.74	0.60	0.22	12.98
SD	4.50	4.45	0.045	2.26	0.64	0.06	4.65
Plastic							
Mean	2.22	2.13	0.080	8.10	0.57	0.45	16.66
Maximum	8.42	5.07	0.160	19.81	1.84	0.75	16.46
Minimum	0.58	0.49	0.020	1.14	0.11	0.15	1.24
SD	1.56	1.28	0.026	2.85	0.54	0.15	5.59
China							
Mean	5.90	5.92	0.072	6.99	1.56	ND***	23.51
Maximum	7.58	7.46	0.110	7.68	2.22	ND	26.17
Minimum	1.52	1.44	0.040	6.15	0.16	ND	15.14
SD	2.50	2.53	0.028	0.70	0.83		4.71

* total number of samples; ** SD = Standard deviation, concentrations in ppm.
*** ND = not detected.

Four E.E.C. countries (Parker 1986), in their legislation on meat products, have set tolerances for only Pb and two for Cd out of the seven metals studied here. Our mean values for Pb in shoulder pork, ham, lunch pork and liver paste are lower than the tolerances established by Ireland (5 ppm) and Italy (1.25 ppm) and are slightly higher than the maximum tolerance levels set by Denmark (0.3 ppm) and Holland (0.4 ppm). The mean values for Cd are lower than tolerances legislated in Denmark (0.1 ppm) and slightly higher than those established by Holland (0.05 ppm).

A between-metal binary statistical analysis was carried out on the overall samples, and for each of the meat product under study. The equations defining the most significant interrrelations found are presented in Table 3, together with their correlation coefficients. The Cu-Ni relationship is noteworthy since it shows the highest correlation coefficient and is, moreover, to be found in the four types of meat products studied.

Table 3. Most noteworthy between-metal correlations

Meat Product	Equation*	Correlation Coefficient
Overall	[Cu] = 0.972[Ni] + 0.137	0.890
Pork shoulder	[Cu] = 0,466[Ni] + 0.708	0.467
Ham	[Cu] = 1.033[Ni] - 0.016	0.968
Lunch Pork	[Cu] = 0.765[Ni] + 0.502	0.758
Liver Paste	[Cu] = 0.936[Ni] + 0.579	0.968
Overall	[Cu] = 2.306[Mn] + 0.943	0.633
Liver Paste	[Cu] = 4.296[Mn] - 0.623	0.823
Overall	[Ni] = 2.221[Mn] + 0.890	0.676
Liver Paste	[Ni] = 4.477[Mn] - 1.122	0.830
Liver Paste	[Mn] = 0.076[Zn] - 0.091	0.690
Ham	[Ni] = 0.124[Fe] + 0.368	0.683

* concentrations in ppm, significance $P \leq 0.0001$.

Figures 1 and 2 show the computer plots for the Cu-Ni correlation in the pork liver paste and overall samples, respectively, The slopes of the corresponding straight lines are arranged according to the sequence ham > liver paste > lunch pork > pork shoulder, indicating the corresponding increase to a greater degree of the concentration of copper as compared to the increase of the nickel concentration.

The Cu-Mn and Ni-Mn correlations were found only in the overall samples and in the liver paste. In both cases the slopes obtained for the liver paste were nearly two times than those for the overall samples, indicating that an increase of Mn in the liver paste

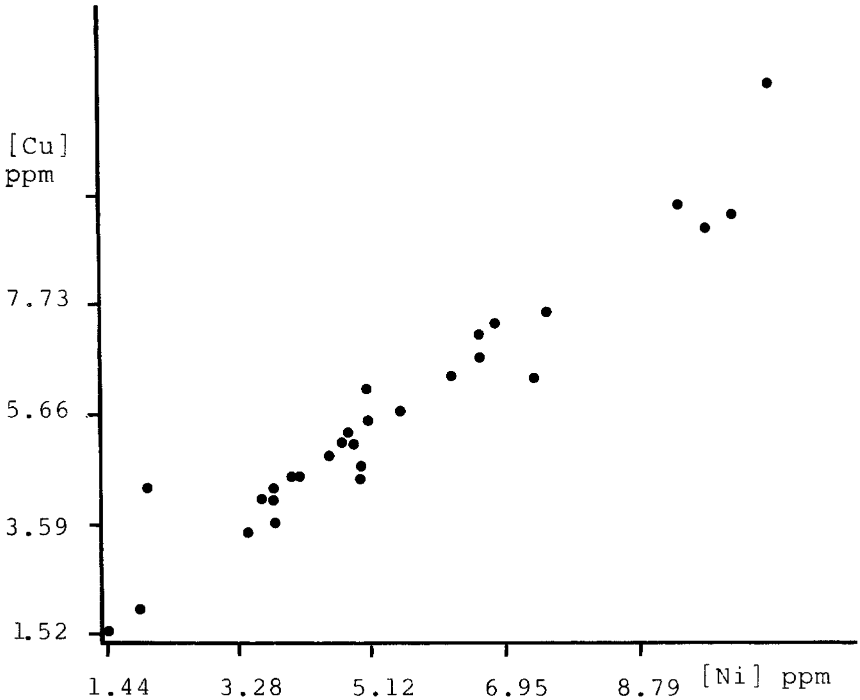

Figure 1. Computer plot of the data [Cu] *versus* [Ni] in pork liver paste

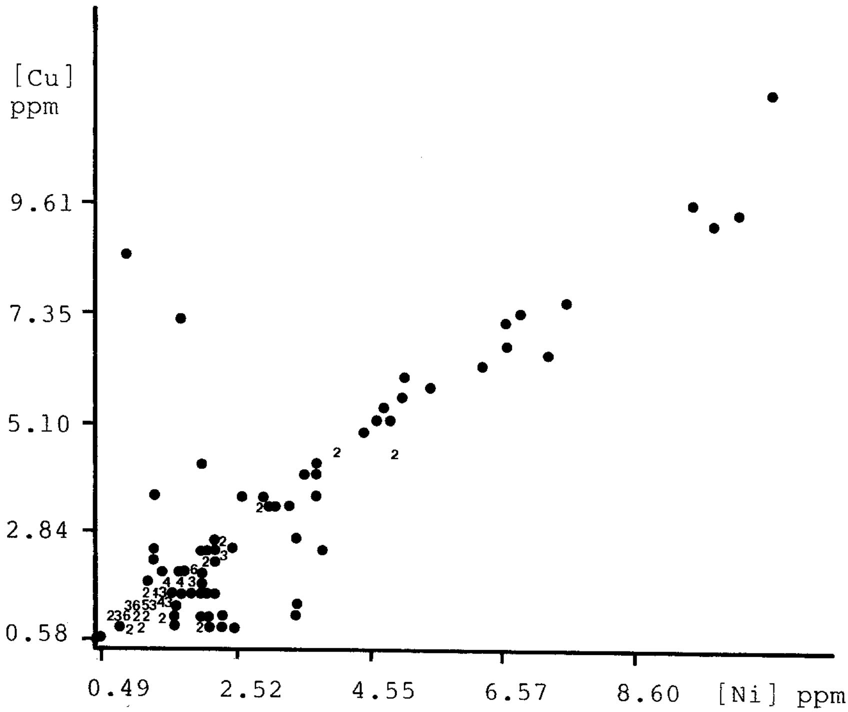

Figure 2. Computer plot of the data [Cu] *versus* [Ni] for all the samples

is accompanied by a greater increase in Cu and Ni concentrations than in the other meat products studied.

It must be emphasized that pork liver paste shows a larger number of intermetallic correlations, possibly due to the fact that liver, being the main detoxifying organ, is, therefore, capable of accumulating greater concentrations of metals than any other organs or tissues.

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