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Copper, iron, manganese and zinc levels in *turrón* from Jijona and Alicante

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The aim of this study was to determine the ash and trace element contents (copper, iron, manganese and zinc) of two traditional types of *turrón* (a typical Spanish Christmas sweet made from almonds, honey, egg white and sugar), popularly known as 'hard' or Alicante *turrón* and 'soft' or Jijona *turrón*. Samples of *turrón* were incinerated, the ashes dissolved in HCl/HNO_3 and the mineral contents determined using atomic absorption spectroscopy. Ash samples of Jijona *turrón* showed greater mineral contents than did Alicante *turrón* (184 and 164 g %, respectively) since the former has a greater almond content. Copper and manganese were present in the smallest quantities. They also showed most variation between the types and categories of the *turrón* investigated, both experimentally and statistically. Mean iron and zinc values were similar in both types of *turrón* and always exceeded 2 mg %. The results obtained suggest that these typical Spanish sweets supply adequate quantities of all the micronutrients investigated. © 1997 Elsevier Science Ltd

INTRODUCTION

Spanish nutritional habits are currently undergoing significant change and consumers are becoming more and more concerned about adopting healthy, well-balanced diets. However, some ideas held by the population concerning certain foods are unclear. There is particular confusion over sweets and desserts which are often consumed at the end of a good meal but are not given much importance as providers of nutrients. Rather, they are consumed for sheer gastronomical pleasure. Concerns about these products generally revolve around their calorific value, rather than their nutritional value. Such is the case of *turrón*, a typical Spanish sweet which is also well known outside Spain. It is traditionally sold and consumed at Christmas.

This work forms part of a series of studies on 'typical Spanish sweets' performed by the authors, and investigates two types of *turrón* popularly known as 'hard' or Alicante *turrón* and 'soft' or Jijona *turrón*. Although many new varieties or 'flavours' have appeared on the market, these traditional types are still dominant. They have been made in Spain for hundreds of years, principally in the two Levant cities, Alicante and Jijona.

This study highlights the excellent nutritional value of both types of *turrón* which provide significant quantities of macronutrients such as fats and carbohydrates and, to a lesser extent, proteins. Copper, iron, manganese and zinc contents were determined since these minerals, though required in small quantities in Man, are necessary in a large number of vital metabolic pathways.

MATERIALS AND METHODS

Samples

Figure 1 summarizes the sampling design used. A total of 66 samples of Alicante and Jijona *turrón* were employed including 42 bars of 'supreme' category and 24 of 'extra' category, corresponding to 7 and 4 commercial brands, respectively. Three different lots of each brand were analyzed. The classification of category is outlined in the *Reglamentación Española Técnico-sanitaria* for the manufacture and sale of *turrón* and marzipan (Real Decreto 1167/1990).

The same commercial brands of Alicante and Jijona *turrón* (but not the same lot numbers) were used for comparison. Of the brands chosen, an analysis was made of those with 'specific denominations' (I, II, III, IV and V), adhered to by some manufacturers, and others not covered by these denominations (VI and VII). All samples were obtained during the *turrón* campaign of 1995, the time of year when the largest stock of these products is available on the Spanish market. Numbering of samples is described in the lower part of Fig. 1.

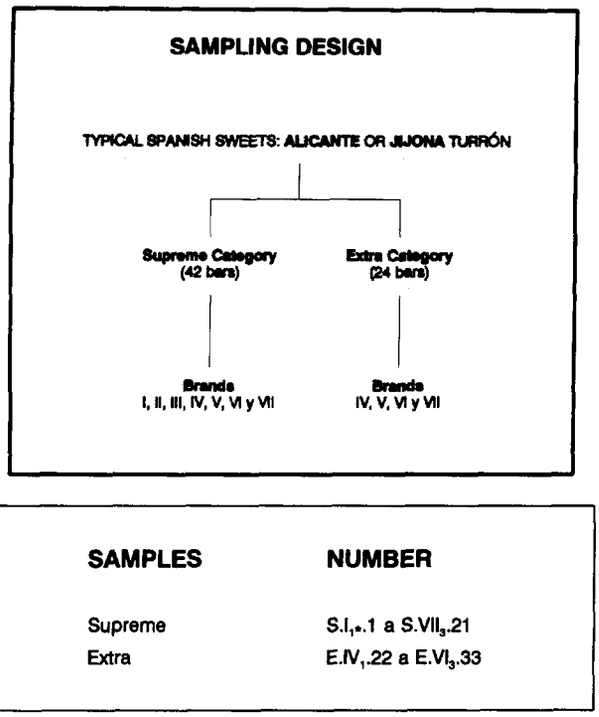

Fig. 1. Sampling design.

Analytical methods

Tablets of *turrón* were grated and 1.5 g collected for the determination of copper, iron, manganese and zinc contents. These samples were incinerated at 450°C. The ashes were dissolved in 50% HCl/HNO_3 and subjected to atomic absorption spectroscopy. The technique employed is clearly described in Fig. 2. An air-acetylene flame and hollow cathode lamp were used for all samples. Calibration curves were prepared using dilutions of stock solutions. Results were expressed as mg $100\,g^{-1}$ product (Torija, 1981).

RESULTS AND DISCUSSION

The results obtained are presented in 5 tables and 2 graphs:

Tables 1 and 2 show the mineral contents of the different lots corresponding to different brands of Alicante and Jijona *turrón*. Table 1 shows results for 'supreme' category *turrón* and Table 2 for 'extra' category.

Tables 3–5 give mean values of the mineral content of different brands of *turrón* plus other statistical data.

Figure 2 shows the mean ash content of types and categories of *turrón*. Figure 3 shows the mean values of all samples (the 66 bars of Alicante and Jijona *turrón* analyzed).

The ash content is largely influenced by the presence of almond in both Alicante and Jijona *turrones* which provides more than 2.5% of this component. Smaller quantities are provided by honey and egg white, two other raw materials used in the manufacture of *turrón* (Saura *et al.*, 1988; Souci *et al.*, 1994).

Figure 2 shows the ash levels obtained for both types of *turrón*. The greater mineral content of the Jijona type should be noted. This *turrón* has mean values of 1.97 and 1.71 g% for 'supreme' and 'extra' categories, respectively. The Alicante type gave slightly lower values of 1.87 and 1.42 g% for the same categories. The manufacture of both types of *turrón* is practically the same. The raw materials, toasted almonds, honey, sugar and egg white are mixed and, once cooled, form Alicante *turrón*. This is then packaged. Jijona *turrón* is prepared in the same manner but once the ingredients are combined they are ground to produce a homogeneous mixture. Finely chopped almonds are added to this mixture, which would provide the greater ash

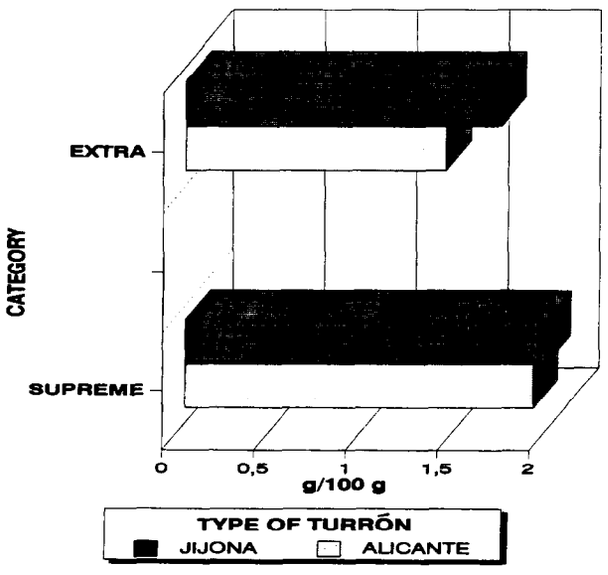

Fig. 2. Mean ash contents of *turrón*. Results expressed as g/100 g product.

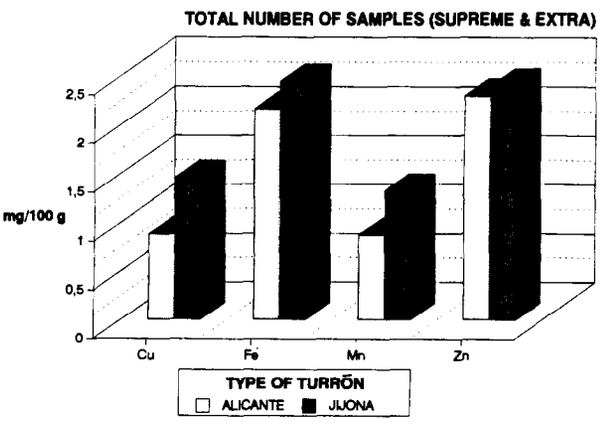

Fig. 3. Mean trace element contents of Alicante and Jijona *turrón*.

Table 1. Trace elements of Alicante and Jijona *turrón* — 'supreme' category. Results expressed in mg 100 g^{-1} product

	Type of *turrón*							
	Alicante				Jijona			
Samples	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn
S.I_1.1.	1.69	2.27	2.25	2.13	1.43	1.77	2.31	1.91
S.I_2.2.	1.84	2.22	2.22	2.66	1.08	2.54	2.49	2.37
S.I_3.3.	1.54	2.54	2.15	3.19	1.04	2.60	2.80	3.23
S.II_1.4.	0.95	1.91	0.71	2.32	1.07	2.25	1.13	2.35
S.II_2.5.	1.11	2.07	1.10	2.12	1.02	2.73	0.87	3.08
S.II_3.6.	1.37	1.79	1.09	2.19	1.00	2.26	1.39	1.71
S.III_1.7.	0.84	2.77	1.00	2.94	0.50	2.83	1.63	2.33
S.III_2.8.	0.87	2.38	1.59	2.48	0.64	2.64	1.07	2.27
S.III_3.9.	0.85	2.75	2.11	2.71	0.67	2.09	0.75	2.41
S.IV_1.10.	0.71	2.06	0.60	2.22	2.37	2.58	0.91	2.12
S.IV_2.11.	0.81	2.21	0.60	2.19	2.49	2.42	0.75	2.12
S.IV_3.12.	0.67	1.95	0.82	1.89	2.64	2.57	0.76	2.34
S.V_1.13.	0.77	1.96	0.69	2.41	2.56	2.67	0.82	2.75
S.V_2.14.	1.32	1.94	0.69	2.63	2.08	2.75	0.95	2.37
S.V_3.15.	1.05	1.98	0.69	2.52	2.89	2.74	0.77	2.56
S.VI_1.16.	0.85	2.59	0.65	1.97	2.34	2.27	0.81	2.48
S.VI_2.17.	0.84	2.48	0.69	2.03	2.84	2.77	0.78	1.84
S.VI_3.18.	0.84	2.70	0.61	2.06	2.95	2.73	0.85	2.79
S.VII_1.19.	0.71	1.79	0.82	1.81	2.36	2.30	0.89	2.49
S.VII_2.20.	0.72	1.91	0.72	1.93	2.43	2.37	0.86	2.31
S.VII_3.21.	0.76	1.90	0.56	1.60	2.46	2.39	0.88	2.32
$\bar{x}$	1.00	2.20	1.06	2.29	1.85	2.49	1.16	2.39
σ	0.34	0.33	0.60	0.39	0.85	0.27	0.62	0.37

content observed. The final stage of the manufacturing process, the so-called *boixet*, involves heating followed by warm mixing and then cooling, to produce this softer type of *turrón*.

Cu, Fe, Mn and Zn levels are shown in Tables 1 and 2. Included in these tables are data for three lots of each brand of each category of *turrón*. The majority of samples of each brand and lot, representing both categories, showed different levels of these four elements.

Copper and manganese were detectable in lesser proportions in both types and categories of *turrón*, especially in the 'extra' category. Less almond is added in its manufacture as specified in the '*Reglamentación Española Técnico-sanitaria para Turrones y Mazapanes*'. This states that Alicante *turrón* should contain a percentage of almonds of 60 and 46% for the 'supreme' and 'extra' categories, respectively. The same categories of Jijona *turrón* contain 64 and 50%, respectively.

This reduction is especially pronounced in Jijona *turrón*, specifically in brands IV, V, VI and VII. Every 'supreme' lot showed values of above 2 mg% for Cu. 'Extra' category lots gave values below 1 mg %. It is

Table 2. Trace elements in samples of Alicante and Jijona *turrón*—'extra' category. Results expressed in mg 100 g^{-1} product

	Type of *turrón*							
	Alicante				Jijona			
Samples	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn
E.IV_1.22.	0.81	2.20	0.54	2.61	0.67	2.15	0.78	1.88
E.IV_2.23.	0.56	2.12	0.43	2.79	0.58	2.18	0.73	2.08
E.IV_3.24.	0.72	2.14	0.53	2.44	0.48	2.47	0.80	2.92
E.V_1.25.	0.72	2.40	0.54	2.36	0.88	2.65	2.51	2.25
E.V_2.26.	0.67	2.68	0.52	2.00	0.75	2.97	2.41	2.20
E.V_3.27.	0.77	2.12	0.57	2.38	0.83	2.27	2.44	1.91
E.VI_1.28.	0.62	1.89	0.57	1.80	0.93	2.24	0.75	3.09
E.VI_2.29.	0.58	2.07	0.53	1.84	0.49	2.24	0.67	3.04
E.VI_3.30.	0.60	2.09	0.55	1.88	0.86	1.69	0.61	1.88
E.VII_1.31.	0.59	1.73	0.45	2.73	0.79	2.07	2.28	2.01
E.VII_2.32.	0.57	1.65	0.46	1.90	0.93	2.50	2.40	3.05
E.VII_3.33.	0.49	1.86	0.48	2.79	0.77	2.69	2.44	2.50
$\bar{x}$	0.64	2.08	0.51	2.29	0.75	2.34	1.57	2.40
σ	0.09	0.28	0.05	0.39	0.16	0.34	0.88	0.49

Table 3. Statistical data obtained from mean trace element contents in Alicante and Jijona *turrón*: Matched T, Wilcoxon and correlations

	Samples	Matched T (p value)	Wilcoxon (p value)	Correlations
Total	Copper	0.0639	0.1549	$r = 0.0631$; $p = 0.846$
	Iron	0.0116	0.0190	$r = 0.0284$; $p = 0.379$
	Manganese	0.0754	0.0324	$r = 0.3603$; $p = 0.253$
	Zinc	0.3740	0.4769	$r = -0.0198$; $p = 0.951$
'Supreme'	Copper	0.0828	0.2188	$r = -0.4613$; $p = 0.259$
	Iron	0.0622	0.1563	$r = 0.1241$; $p = 0.772$
	Manganese	0.3074	0.2969	$r = 0.9249$; $p = 0.001$
	Zinc	0.4285	0.4688	$r = 0.4523$; $p = 0.269$
'Extra'	Copper	0.2991	0.3750	$r = -0.4325$; $p = 0.493$
	Iron	0.1558	0.1250	$r = 0.4007$; $p = 0.528$
	Manganese	0.1226	0.1250	$r = -0.1426$; $p = 0.592$
	Zinc	0.6989	1.0000	$r = -0.5048$; $p = 0.418$

Table 4. Mean trace element contents and analysis of variance of different brands of *turrón* — 'supreme' category (mg 100 g^{-1} product)

	Type of *turrón*							
	Alicante				Jijona			
Brands	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn
I	1.69	2.34	2.21	2.66	1.18	2.30	2.53	2.50
II	1.14	1.92	0.97	2.21	1.03	2.41	1.13	2.38
III	0.85	2.63	1.57	2.71	0.60	2.52	1.15	2.34
IV	0.73	2.07	0.67	2.10	2.50	2.52	0.81	2.19
V	1.05	1.96	0.69	2.52	2.51	2.72	0.85	2.56
VI	0.84	2.59	0.65	2.02	2.71	2.59	0.81	2.37
VII	0.73	1.87	0.70	1.78	2.42	2.35	0.88	2.37

Analysis of variance

	Tail Probability			
	Cu	Fe	Mn	Zn
Type	0.0000	0.0002	0.1680	0.3408
Brand	0.0000	0.0033	0.0000	0.0692

Table 5. Mean trace element content and analysis of variance of diferent brands of *turrón* — 'extra' category (mg 100 g^{-1} product)

	Type of *turrón*							
	Alicante				Jijona			
Brands	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn
IV	0.67	2.15	0.50	2.61	0.58	2.27	0.77	2.29
V	0.72	2.40	0.54	2.25	0.82	2.63	2.45	2.12
VI	0.60	2.02	0.55	1.84	0.76	2.06	0.68	2.67
VII	0.55	1.75	0.46	2.47	0.83	2.42	2.37	2.52

Analysis of variance

	Tail Probability			
	Cu	Fe	Mn	Zn
Type	0.0341	0.0158	0.0000	0.5384
Brand	0.2512	0.0138	0.0000	0.5189

interesting to note that the mean Cu values of the 'supreme' category of both *turrón* types are very different, as are their deviations from the mean ($x = 1.00 \pm 0.34$ and $x = 1.85 \pm 0.85$). In contrast, mean Cu contents are similar in the 'extra' categories of *turrón* of both types and there is also a decrease in deviation (Table 2).

Manganese levels differed between types of *turrón*. There was no similarity between types in 'extra' category *turrón*. However, 'extra' Alicante *turrón* showed 50% less Mn than did 'supreme' category ($\bar{x} = 0.51 \pm 0.05$ for 'supreme' and $x = 1.06 \pm 0.60$ for 'extra'). The Jijona type showed the opposite with the mean value of 'supreme' at 1.16 mg% ± 0.62 and that of 'extra' at 1.57 mg% ± 0.88. This was due to a considerable increase in Mn levels in brands V and VII.

Iron and zinc levels were similar and considerable in both types of *turrón* and were the elements found in greatest concentrations. Zinc levels were slightly higher than iron levels when the total numbers of samples were considered (66 bars), and when the 'supreme' (42 bars) and the 'extra' (24 bars) categories were considered separately. This can be observed in Tables 1 and 2 and also in Fig. 2.

Mean contents of Zn were practically the same in the Alicante and Jijona *turrón*, exceeding 2.25 mg% in both types. The spread of results for both types and 'supreme' and 'extra' categories were similar.

Zinc is important in the diet. Recent studies suggest that deficiencies occur since this element is not abundant in our food; its bioavailability is also low. The quantities of Zn found in these types of *turrón* suggest that they are important in the Spanish diet.

Iron is an important nutrient which increases hemoglobin levels. It is difficult to absorb since the process occurs in two stages. Absorption may be increased by sugars, vitamins C and E, citric and malic acids. Tables 1 and 2 reflect the iron contents of both types of *turrón* and show that these sweets are good providers of this element.

Mean values of iron, unlike zinc, are similar in both *turrón* types and categories and show similar deviations from the mean in the different samples analyzed.

'Supreme' category was expected to have a slightly greater Fe content than 'extra' category, as seen for the other elements studied. Though the almond content (the main provider of Fe) of the 'extra' category is lower than that of the 'supreme' category, this seems to be compensated for by an increase in the proportion of honey.

Prior to discussion of statistical results, it should be noted that no great variations were found between brands pertaining to the 'specific denominations' (I, II, III, IV and V) and those which do not form part of this nomenclature (VI and VII). This was to be expected since the study considers levels of micronutrients which occur in lower proportions than macronutrients. Differences in macronutrient content between *turrones* of specific denominations in both 'supreme' and 'extra' categories were the object of a previous paper.

Statistical analysis was performed, first taking into account mean values of the total number of samples and second the two categories of *turrón* separately. The BMDP3D statistics program was used to perform Matched T and Wilcoxon tests, the results of which are shown in Table 3. A significant difference ($p = < 0.05$) in Fe and Mn levels between Alicante and Jijona *turrón* was observed when the samples were considered as a whole. This also occurs when mean values are considered (Matched T) and also if values are ranked (Wilcoxon). In the case of Mn, this degree of significance increases slightly when the Matched T test is applied, which again suggests a difference in mean content of this element between the two varieties of *turrón*, which supports the experimental evidence. This is not true for Fe where similar experimental results were obtained, although a disparity between the mean values of Fe in both types of *turrón* was clearly demonstrated by both statistical tests. Finally it should be pointed out that different experimental values for Cu were confirmed by the Matched T test ($p = 0.06$) but not by the Wilcoxon test ($p = 0.15$).

With respect to 'supreme' and 'extra' categories, degrees of significance for mineral elements were always much higher than $p = 0.05$. This suggests a greater similarity of the mean contents of these elements in the two types of *turrón*. However, this was not the case for Fe in the 'supreme' category. The matched T test gave a p value of 0.0622, which, if considered significant due to its similarity to $p = 0.05$, suggests a different mean content. However, this was not confirmed by the experimental results.

Tables 4 and 5 show a double analysis of variance according to the type of *turrón*, and brands of both types. For 'supreme' and 'extra' categories, Cu and Mn levels were seen to be different (99.9% confidence limits), according to the type or brand of *turrón*, as suggested experimentally. Fe and Zn levels may be described as different since the former (in both categories) shows levels which are significantly lower than $p = 0.05$, demonstrating differences between type and brand. Given that its level of significance is much greater than $p = 0.05$, for zinc there is great similarity of results (except within the brands of 'supreme' quality where $p = 0.0692$). This is in accordance with experimental findings.

Finally, the only correlation found for manganese was $r = 0.9249$ and $p = 0.001$ in the 'supreme' category. The other elements showed no correlations worth mentioning either for the total sample or when 'supreme' and 'extra' categories were considered separately.

CONCLUSIONS

1. Jijona *turrón* has a higher ash level than Alicante *turrón* due to a higher almond content.

2. The results otained for the four elements determined show heterogeneity within the three lots of each brand of both types of *turrón*.
3. Of the four elements studied, copper and manganese levels were lowest and also the most different at both experimental and statistical level, ($p = < 0.05$ for copper in the 'extra' category with respect to the type of *turrón*). This was also confirmed in the 'supreme' quality with respect to type and brand (with 99.99% confidence). It can also be claimed with the same level of confidence that mean Mn contents were different for the brands of each *turrón* type and for 'supreme' and 'extra' categories. This difference was maintained between Alicante and Jijona *turrones* for the 'extra' category but not for the 'supreme'.
4. Mean iron and zinc contents were similar in both types of *turrón* and were always over 2 mg%. This was not confirmed statistically in the case of iron where differences were apparent in both types and brands of *turrón*, confirmed by low levels of significance. This similarity of results was shown in the case of zinc, except in the 'supreme' category of the different brands.
5. No significant differences were found between the levels of these elements in brands with 'specific denomination' and those not forming part of this nomenclature.
6. Alicante and Jijona *turrón* appear to supply adequate quantities of the micronutrients studied, principally iron and zinc, both being important in a balanced diet. However, this may be especially important in the case of zinc since a general deficit of this element exists in the modern Spanish diet. It might therefore be advisable to consume *turrón* throughout the year, rather than just at Christmas time.

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