Journal of Food and Bioprocess Engineering (JFBE) 15-23
ORIGINAL ARTICLE

Instrumental texture properties of Spanish *Turrón*, Italian *Torrone* and French *Nougat*

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Received: 27 April 2015 / Accepted: 9 June 2015

Abstract

The characteristic texture of turrón, torrone and nougat was examined. They are typical European confections prepared from almonds, honey, sugars and/or chocolate. Three different instrumental tests: puncture, cutting, and Texture Profile Analysis (TPA), were used in this study and samples prepared from three countries (Spain, Italy, and France), and by six manufacturing companies (two companies per each country). All three tests succeed in finding that Spanish Jijona turrón was softer than chocolate torrone, with nougat presenting intermediate values of hardness. The TPA test proved that nougat was intended to be chewable, which implied high values of cohesiveness, springiness, chewiness, and adhesiveness, while on the contrary turrón and torrone were conceived as been breakable and non-adhesive products. These differences in texture attributes were rather due to differences in the manufacturing conditions (e.g. heating time and/or temperature) than to composition factors (e.g. almond content). Results proved that manufacturing conditions (time, temperature) were more important than percentages of ingredients in determining the texture of turrón, torrone and nougat.

Keywords: almond, confection, honey, Texture Profile Analysis

Introduction

Turrón, *torrone* and *nougat* are typical Spanish, Italian and French confectionery products (Fig 1) made from almonds, sugars and honey and manufactured in traditional ways. Local raw materials are used in the manufacturing of these products; almond and honey are the key ingredients. In this way, Vazquez *et al.* (2006) concluded that the most important quality parameter in commercial transactions of this type of confections is the almond percentage. For example in Spain, *turrón* is commercially classified according to its almond content, which is legislated by the Technical-Sanitary Regulation (R.T.S., 1982). The prices of almonds are quite different and depend mainly on their sensory quality and production being located within the protected geographical regions (Verdu *et al.*, 2007).

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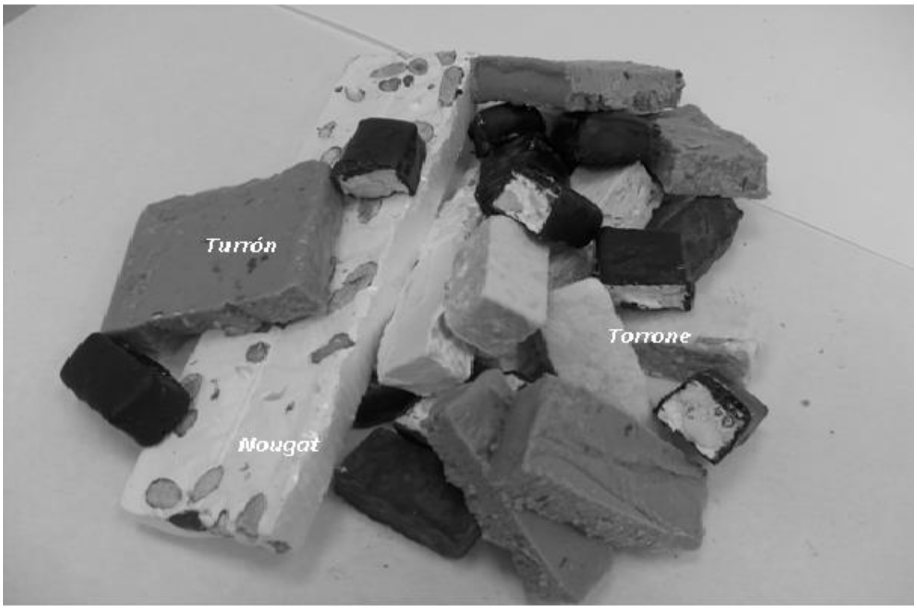

Fig. 1. Aspect of Spanish Jijona *turrón*, Italian *torrone,* and French *nougat*

Also in Taurianova (Reggio Calabria, Southern Italy) the quality of the final products depends mainly on both the quantity and quality of almonds and honey. In general, orange honey and almonds of Sicilia or Puglia (cultivar Pizzuta d'Avola) are used in the manufacturing of *torrone*. Finally, in France mainly lavender honey from the Provence region is used for preparing *nougat*.

To manufacture *turrón*, sucrose, glucose, honey, dextrose and water are placed in a boiler-pan and homogenized with an anchor impeller. The syrup is concentrated to 80 ºBrix. At this point, egg albumin and toasted almonds are added and the whole mass is manually homogenized. The product obtained at this stage is called Alicante *turrón*. After cooling the solid mass is crushed in a stone miller, at this time almond oil is released and the solid particles remain suspended in a continuous fat phase. The suspension is then heated under gentle stirring in a special hemispherical boiler-pan of approximately 0.6 m diameter, called *boixet*, to 50-60 ºC and held at this temperature for about 1 h. It is then heated further to 70-80 ºC and held at this temperature until the consistency seems to be right. The total holding time in the *boixet* is approximately 120 min. The mass coming from the *boixet* is a deformable semi-solid soft mass called Jijona *turrón*. At room temperature, the product becomes harder, giving a breakable non-flowing semi-solid (Vazquez *et al.*, 2007; Chiralt Boix *et al.*, 1999; Lluch *et al.*, 1992; Chiralt *et al.*, 1991). In the manufacturing of Italian *torrone*, honey and sugars (glucose and sucrose) are warmed in a copper container at low temperature and mixed at uniform speed for 2 h in the "*torroniera*", where fresh egg-whites have been added. After this time, the caramel (previously prepared in another copper container), the natural vanilla extract, a handful of pistachios, and the toasted almonds (toasted at 60ºC for 48 h) are added. When all the ingredients are properly mixed, the mass is transfer to a marble table and manually mixed to confer the desired shape using wood frames or appropriate moulds. To obtain the so-called *torrone vaniglia* (vanilla *torrone*) the product is covered on both surfaces with wafer, cut, and packed. On the hand, the mixture could be covered by chocolate and then the product is called *torrone gianduja* (chocolate *torrone*). In general, there are composition and operational differences between these two types of torrone. For instance, the *torrone vaniglia* has longer heating times and higher almond content, which leads to a harder texture.

To be qualified as Montelimar *nougat*, confections must consist, at least, of 30 % of peeled almonds (or 28 % almonds and 2 % pistachio nuts) and 16 % Provence lavender honey. The traditional *nougat* recipe consists in mixing and heating lavender honey with water and sugar, pouring the syrup into whipped egg whites, and finally adding almonds, crushed pistachios and a touch of vanilla. Then, the product is moulded, slightly heated (35ºC) for 12 h, cut, and packed. The main difference between *dur* and *tendre nougats* is the heating temperature, which is higher in the first confection, and leads to a harder texture.

The textural properties of the commercial *turrón*, *torrone* and *nougat* are quite heterogeneous (Lazpita *et al*., 1991) due to several causes:

- The fact that each company uses different temperature and times during the heating steps, according to their experience, will lead to different final textures. The manual control over operational conditions (temperature and time) also leads to heterogeneous products.
- The homogenization level of the final product (highly viscous mass), affected by the industrial equipment and by the operation variables, will affect the microstructural parameters of the product and, therefore, its textural properties.
- Compositional factors also influence the final texture of the products. The oversaturated syrups are mainly constituted by a mixture of glucose, fructose, and sucrose. Small variations in moisture content and sugar composition will affect, for instance the glass transition temperature of pure syrup and also of the amorphous continuous phase of the *Jijona turrón* (Martinez and Chiralt, 1995).

Even though *turrón*, *torrone* and *nougat* have many things in common (main ingredients, consumption concentrated during Christmas, etc.), there are differences in the concepts behind these confections and also differences in the manufacturing conditions (temperatures, times, etc.) which lead to different textures. The aim of this work was to analyze the influence of the country of origin (Spain, Italy or France) and the manufacturing company (2 companies per country) on the final texture of commercial samples of *turrón*, *torrone* and *nougat*.

Materials and methods

Materials

For this particular study, Jijona *turrón*, *torrone gianduja* and *tender/blanc nougat* samples were bought in shops of Spain (Xixona, Alicante), Italy (Taurianova, Reggio Calabria) and France (Montelimar, Provence), respectively. These particular types of confections were used to have products with comparable texture but from different countries. For each country two different manufacturing companies were selected: Spain (“El Lobo” and “1880”), Italy (“Bar Golden” and “Bar D’Agostino”), and France [“Reflets de France” (Tendre) and “du Roy René” (Du Roy René)]. Commercial samples were purchased directly in local stores and products were manufactured in the same season and stored under similar conditions. At least, 10 bars per commercial company were bought.

Texture

Final product texture was assayed on 10-mm cubes, which were made by cutting with a sharp knife, using a Texture Analyzer TA-XT2i (Stable Micro Systems, Surrey, U.K.) with a 25-kg load cell capacity.

Bars of *turrón* were rectangular with the following dimensions: 175 mm × 80 mm × 15 mm, and with a total weight of 300 g. The dimensions of the rectangular tables of *nougat* were: 180 mm × 43 mm × 15 mm, and with a total weight of 200 g. Sizes of *torrone* were around 52 mm x 34 mm x 33 mm and its total weight is about 20 g. The 10 mm of the border of the *turrón* and *nougat* bars were discarded;

this was not done for *torrone* because of the small size of portions.

Three different tests were used with commercial *turrón*, *torrone* and *nougat*: (1) puncture test (PT), (2) cutting test (CT), and c) Texture Profile Analysis (TPA).

PT. This is an empirical hardness indicator, particularly of the food surface, and measurements were recorded using a 2-mm wide cylindrical probe (P/2). This test included both compression and cutting efforts. Penetration rate was 0.3 mm/s for 5 mm after contacting the surface of the confection cube and results were expressed in N (Stable Micro Systems, 1996b).

CT. This is an empirical indicator of the force needed to cut a particular food and measurements were recorded using a knife blade (HDP/BS). This test only included cutting effort. Cutting was performed at 1 mm/s until the confection cube was fully cut; results were expressed in N (Stable Micro Systems, 1996a).

Texture Profile Analysis (TPA). In this case, two compressions were made to give an instrumental texture profile as described by Bourne *et al.* (1978) and Bourne (1978). All instrumental texture analyses were conducted at room temperature 24 ± 2ºC. The samples were compressed to 25 % of their original height with a 10-cm-wide cylindrical probe at a speed of 10 mm/min. Similar test conditions were used by Martinez-Navarrete *et al.* (1996) and Vazquez *et al.* (2006). Texture profile parameters were determined as described by Bourne *et al.* (1978), Bourne (1978) and Rosenthal (1999):

Hardness (N) is defined as the "maximum force required to compress a sample", and it is calculated as the peak force of the first compression of the product;

Adhesiveness (N × s) is defined as the "work to detach a product stuck to the compression plate"; it is assumed to measure the adhesiveness of a sample to the palate and teeth, and it is calculated as the negative area between the first and second compression cycles;

Cohesiveness (%) is a measure of how well the product withstands a second deformation relative to how it behaved under the first deformation (A_2/A_1, A_1 being proportional to the total energy required for the 1st compression and A_2 being proportional to the total energy required for the 2nd compression);

Springiness (%) is a measure of how well a product physically springs back after it has been deformed during the first compression and it is calculated as the ratio between the distance of the second compression peak/distance of the first compression peak;

Chewiness (N) is assumed to be a measure of the work to masticate the sample for swallowing (springiness x hardness x cohesiveness, with springiness and cohesiveness being expressed as fractional numbers between 0 and 1).

Fifteen replicates were carried out for each of the previously mentioned analyses.

Chemical Analyses

The AOAC Official Methods 925.40, 950.48, 963.15, and 977.20 were used for analyzing the moisture, protein, oil, and sugars, respectively, that are present in the *turrón*, *torrone* and *nougat* samples. The equipment used for sugar analyses was a HPLC, Hewlett Packard (Waldbronn, Germany), HP Series 1100, with a refractive index detector (HP Model 1100 Series); the column used was a Supelcogel C-610H column, 30.0 cm × 7.8 mm (id) with a Supelguard C-610H guard column, 5.0 cm × 4.6 mm (id). Authenticated standards of fructose, glucose, sucrose, and maltose were used for the quantification of the sugars.

All chemical analyses were run, at least, in five replicates (Vazquez *et al.*, 2006).

Statistical analyses

All data were subjected to analysis of variance, ANOVA (two factors: country of origin [Spain, Italy and France], and manufacturing company ["El Lobo", "1880", "Reflets de France", "Du

Roy René”, “Bar Golden” and “Bar D’Agostino”]). Tukey's least significant difference multicomparison test was used to determine significant differences among treatments. Significance of differences was represented as $p \leq 0.05$. The statistical analyses were done using Statgraphics Plus 5.0 software (Manugistics, Inc., Rockville, MD, U.S.A.)

Table 1. Main composition (%) variables of Italian *torrone*, French *nougat* and Spanish *turrón* as affected by manufacturing company.

Product	Moisture	Protein	Oil	Sugars	Almond
“1880”	5.02±0.11	15.96±0.39	43.42±0.38	33.23±0.37	69.1±0.4
“El Lobo”	4.28±0.20	14.45±0.23	39.78±0.42	38.25±0.27	64.6±0.3
“Du Roy René”	4.83±0.21	7.35±0.21	21.05±0.30	70.02±5.08	33.2±6.1
“Reflets de France”	5.90±0.23	7.60±0.19	16.88±0.45	65.16±4.64	34.4±1.5
“Bar D’Agostino”	3.69±0.07	9.26±0.10	29.17±1.90	59.11±0.98	40.8±3.1
“Bar Golden”	2.84±0.13	6.94±0.13	29.60±2.13	57.60±1.42	34.5±4.0

Puncture and cutting forces

In general, both the puncture strength and the cutting force were higher in *torrone*, followed by *nougat* and finally by *turrón* (Fig 2). The mean values of these texture attributes were (for *torrone*, *nougat*, and *turrón*, respectively):
puncture strength 8.64±0.42, 3.90±0.70, and 0.74±0.07 N, and cutting force 134±6, 32.2±2.7, and 16.4±1.4 N.

These two texture attributes were positively correlated (R^2=0.8565), indicating that the harder the confection is, the more energy is required to cut it.

A detailed study of the effects of the manufacturing company showed that there were two different groups of companies for each attribute. The first group includes the two Italian companies and one French company, “Reflets de France”, which *nougat* is classified as *tendre*. The second group includes, the two Spanish companies plus the other French company, “du Roy René”, which produces *blanc* nougat. The company manufacturing the hardest (10.2±0.5 N) and most difficult to cut (165±9 N) product was the Italian “Bar Golden”. On the other hand, the Spanish “El Lobo” produces the softest (0.50±0.09 N) and easiest to cut (10.0±1.1 N) confection.

The chocolate layer of the Italian *torrone* could be one of the main reasons why this product showed high values of both puncture and cutting forces. However, other compositional factors did not play a predominant role, because for instance the Spanish products have the highest almond contents (66.9 %) compared to 37.7 % and 33.8 % of *torrone* and *nougat*, respectively, and should theoretically be harder than these other two confections. Manufacturing conditions could also play a significant role, but further studies and information are needed to study these factors in detail.

Table 2. Parameters of the texture profile analysis of Spanish *turrón*, Italian *torrone* and French *nougat* as affected by manufacturing company.

Product	Hardness (N)	Adhesiveness (N s)	Cohesiveness (%)	Springiness (%)	Chewiness (N)
"1880"	55.3±3.6[†]	3.39±0.31	16.4±0.7	50.3±3.3	4.42±0.36
"El Lobo"	36.9±2.4	0.68±0.06	24.6±1.1	55.3±3.7	4.86±0.40
"Du Roy René"	20.3±1.9	7.72±0.75	50.5±4.3	84.4±0.6	7.85±0.49
"Reflets de France"	104±8.0	8.75±0.83	51.3±2.9	82.7±7.2	43.8±5.2
"Bar D'Agostino"	43.7±6.5	1.24±0.17	24.2±2.3	34.6±3.6	3.73±0.73
"Bar Golden"	127±27	3.49±0.57	12.6±1.5	88.0±28.7	11.1±2.8
ANOVA Test					
Variation Source					
Country	**	***	***	**	***
Manufacturing Company	***[‡]	***	***	*	***
Tukey's Multiple Range Test					
Country					
Spain	45.1 c[¥]	2.04 b	20.5 b	52.8 b	4.64 b
France	66.1 b	8.28 a	50.9 a	83.5 a	27.5 a
Italy	85.4 a	2.37 b	18.4 b	61.3 ab	7.42 b
Manufacturing Company					
"1880"	55.3 b	3.39 b	16.4 c	50.3 b	4.42 c
"El Lobo"	36.9 bc	0.69 c	25.6 b	55.4 b	4.86 c
"Du Roy René"	20.3 c	7.72 a	50.5 a	84.4 a	7.85 bc
"Reflets de France"	104 a	8.75 a	51.3 a	82.7 a	43.8 a
"Bar D'Agostino"	43.7 b	1.24 c	24.2 b	34.6 c	3.73 c
"Bar Golden"	127 a	3.49 b	12.6 c	88.0 a	11.1 b

[†] Treatment means of the ANOVA test (values are the mean value of 15 replications); "± values" are standard errors. [‡] N.S. = not significant F ratio ($p < 0.05$); *, **, and ***, significant at $p < 0.05$, 0.01, and 0.001, respectively. [¥] Values followed by the same letter, within the same source of variation, are not significant different ($p < 0.05$), Tukey's multiple-range test

TPA Parameters

In general and considering most of the TPA parameters (adhesiveness, cohesiveness, springiness and chewiness), the French *nougat* showed a different behaviour from those of Spanish *turrón* and Italian *torrone*. The French samples presented the highest values of adhesiveness, cohesiveness, springiness and chewiness, proving that the concept of this product is quite different from those of Jijona *turrón* and *torrone gianduja* (Table 2). The *tender/blanc nougat* is intended to be chewable and for that reason the sugars are cooked to a lower extend (shorter times and/or lower temperatures), resulting in high values of cohesiveness, springiness, chewiness, and as a side effect in high values of adhesiveness. However, *turrón* and *torrone* are intended to be breakable products that do not stick to teeth and/or palate, and easily solve in the saliva. These differences in the concepts behind the products led to the following mean values for French *nougat*: adhesiveness 8 N s, cohesiveness 51 %, springiness 84 %, and chewiness 28 N compared to the following mean values for *turrón* and *torrone*: adhesiveness 2 N s, cohesiveness 19 %, springiness 57 %, and chewiness 6 N.

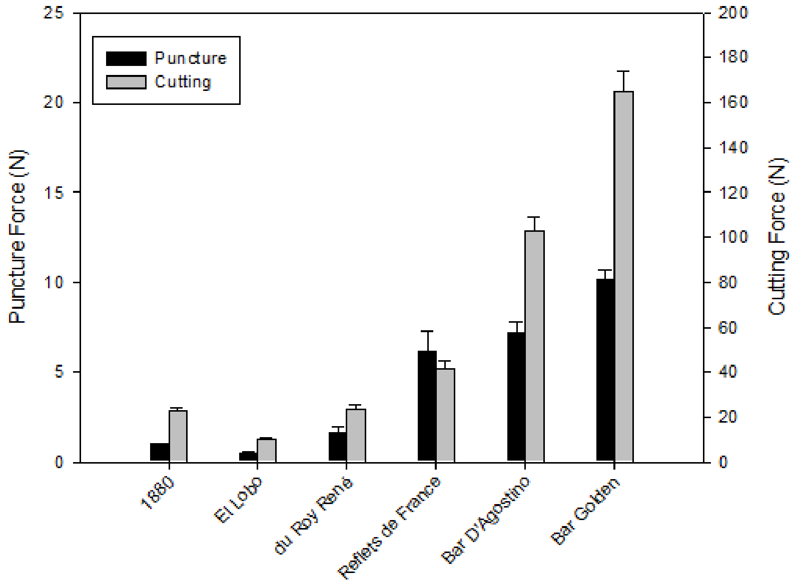

Fig. 2. Puncture and cutting forces (n) of Spanish *turrón*, Italian *torrone* and French *nougat* as affected by manufacturing company

In general, the texture attributes of both Spanish companies were quite similar. Perhaps the most relevant difference could be found in the values of cohesiveness, where "1880" samples presented lower values of this attribute likely because of manufacturing conditions (longer standing times, leading to lower fat content).

The French *nougats* presented similar values of adhesiveness, cohesiveness and springiness but were different in hardness and chewiness, with "Reflets de France" products being harder and needing more energy to be chewed than "Du Roy René" samples.

Among the Italian *torrones*, "Bar Golden" products presented the highest values of hardness, adhesiveness, springiness and chewiness, while "Bar D'Agostino" had the highest value of cohesiveness.

Hardness. Differences in hardness were due to both the manufacturing company and the country of origin (Table 2). In general, *torrone* was harder than *nougat* and *turrón*, which completely agreed with results previously discussed on puncture and cutting forces. Within *torrone* samples, "Bar Golden" presented a hardness of 127±27 N, which was much higher than that of the other Italian product, "Bar D'Agostino", with only 43.7±6.5 N. A similar pattern was found for French *nougat*, with "Reflets de France" samples presenting the highest hardness value, 104±8 N, and "Du Roy René" being in the opposite side with only 20.3±1.9 N. Spanish *turrón*, however, was more homogeneous regarding this parameter, with a mean value of 45.1 N for "1880" and "El Lobo".

Adhesiveness. Adhesiveness is defined as the "work required to pull the food away from a surface", particularly teeth and/or palate (Rosenthal, 1999). This parameter has been previously correlated with the amount of oil close to the surface in *turrón*. However, this is not the case of this experiment because the main unit operation associated with the adhesiveness of these confections is the concentration of sugars, honey and water or caramelisation process. It is quite clear from the data in Table 2 that sugars, honey and water are cooked to a lower degree in *nougat* compared to both *turrón* and *torrone*, and these cooking conditions (shorter cooking time and/or lower temperatures) lead to a more chewable but adhesive product.

Besides, *nougat* had a higher percentage of honey (19 %) than *turrón* (mean of 11 %); no data was available for the honey content in *torrone*. It is well-known that honey is a hygroscopic material and adsorbs water from the surrounding atmosphere, leading to sticky and adhesive products. In this way, for instance Alicante *turrón* and *torrone* are often covered by wafer to avoid the stickiness of the product.

Cohesiveness. The strength of the internal bonds making up the food (Rosenthal, 1999) was statistically the highest in the French products. The cohesiveness was higher in “El Lobo” *turrón* than in “1880”, even though the amount of almond and therefore the amount of oil in “1880” were higher (69.1 % and 43.4 %, respectively) compared to “El Lobo” samples (64.6 % and 39.8 %, respectively). This experimental finding is justify by and extension in the time of the standing stage (period of time between the *boixet* and the packaging stages), in which the excess of oil, non-stabilized fraction, is released from the *turrón* matrix, collected, stored and sold mainly for elaboration of cosmetics (Vazquez *et al.*, 2006). It is well known that Spanish consumers demand products with low oil content; therefore *turrón* manufactures always try to satisfy consumers’ demands and reduce oiliness and consequently cohesiveness of the products with the highest quality (percentage of almond). “Bar D’Agostino” *torrone* presented significant higher values of cohesiveness than “Bar Golden” samples and this difference could be due, at least in part, to the higher almond and therefore protein contents of the first company products (40.8 % and 9.3 %, respectively) compared to those of the second one (34.5 % and 6.9 %, respectively). There were no differences among the values of cohesiveness for the *nougat* samples.

Springiness. Springiness is defined as the extent to which a compressed food returns to its original size when the load is removed (ROSENTHAL, 1999). This TPA parameter was not affected by the manufacturing company in *turrón* and *nougat*. However, the springiness of “Bar Golden” *torrone* was significantly higher than that of “Bar D’Agostino” products.

Chewiness. The chewiness of confections under study was significantly affected by both the country of origin and the manufacturing company. Without any doubt, French *nougat* can be considered as much more chewable than Spanish *turrón* and Italian *torrone*. However, the differences between *turrón* and *torrone* were not significant in this attribute, even though “Bar Golden” products presented higher values of this parameter but mainly due to their higher hardness.

Conclusion

The instrumental texture of *turrón, torrone* and *nougat* was affected by both the country of origin and the manufacturing company. Some general conclusions could be reached regarding the effects of the country of origin, for instance Spanish Jijona *turrón* was softer than chocolate *torrone* and *nougat* (“Reflets de France”); however, the samples of French company “du Roy René” were almost as softer as those of *turrón*. The concepts behind these confections could be clearly defined using the Texture Profile Analysis (TPA). French *nougat* is intended to be a chewable product, with high intensities of adhesiveness, cohesiveness, springiness, and chewiness. On the other hand, *turrón* and *torrone* are pictured as breakable and non-adhesive products, with low values of all TPA attributes except hardness. These differences in texture attributes were mainly due to differences in the manufacturing conditions (especially heating times and/or temperatures).

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