Optical, mechanical and sensorial properties of based-isomaltulose gummy confections

A. Periche, A. Heredia, I. Escriche, A. Andrés, M.L. Castelló*

Universitat Politècnica de València. Institute of Food Engineering for Development.

P.O.Box: 46022 Valencia, Spain.

Corresponding author mcasgo@upvnet.upv.es Tel:+34963879967.Fax: +34963877956

Abstract

The replacement of traditional sugars by isomaltulose could be a revolution in the confectionery sector, since isomaltulose is a functional, digestible, non-cariogenic and low glycemic disaccharide. This study assesses the addition of isomaltulose (ranging between 30-70% in combination with fructose) with different percentages of gelatine (6-10%) in gummy confection by analyzing its effect on composition, water activity (a_w), pH, mechanical and optical properties, and sensory perception. Results show that the combination of 30% isomaltulose and 70% fructose in the total amount of sugars would be suitable for developing functional gummy confections. Besides its stability (a_w (0.79±0.02) and ºBrix (73.5±1.3)) and great similarity to commercial gummies in terms of optical and mechanical properties, it received high global acceptability and intention of buying scores. Additionally, the correlation between instrumental and sensorial parameters leads to the conclusion that the instrumental texture could be suitable for evaluating consumer's global acceptability for this innovative product.

Keywords: gummy confections, isomaltulose, fructose, non-cariogenic, glycemic index and insulinemic index.

1.Introduction

Confectionery products are not exactly foods, but they are widely consumed by children and adults. According to the Spanish association of confectionary products, more than 50% of adults regularly consume candies and chewing gums (Martínez, 2012). Confectionery is a lucrative and continuously growing market in Europe. Between 2005 and 2009 the whole category of confectionery products increased by 19% and it is expected it to grow by 16% through 2014 (Moloughney, 2011). The growth in the consumption of confectionery products is related to the pleasurable effects and wellness they are capable of providing us when consumed in moderate quantities. In fact, O´Neil, Fulgoni and Nicklas (2011) reported a lower body fat index and precursors for type 2 diabetes development in subjects who consumed a moderate amount of confectionaries compared to those who do not eat these products. Nevertheless, excessive consumption has been associated with a high incidence of some health diseases such as obesity, tooth decay and hyperglycemia. Despite the positive effects of their consumption in moderation, the overconsumption of confectionery products by children continues to concern parents.

Among confectionery products, gummy confection is second in sales (Moloughney, 2011). Therefore, there is continual consumer demand for more exciting textures, flavors and appearances in gummy confection. In addition, consumer demand is turning away from traditional products to low-sugar or healthier products. Traditional gummy confection consists of high amounts of sucrose and glucose syrup combined with a gelling agent, commonly known as gelatine, along with acids, flavorings and colourings (Marfil *et al.,* 2012). The replacement of sucrose and glucose syrup with healthier natural sugars could lead to the production of added value gummy confections. In this context, isomaltulose has been pointed out as a suitable sucrose replacer in most food and beverages (Lina *et al.,* 2002). Isomaltulose is a reducing sugar occurring naturally, in little quantity, in honey, sugar cane juice and some molasses (Bárez *et al*., 2000). Commercial isomaltulose, also known as Palatinose®, is obtained from sucrose by enzymatic rearrangement of the glycosidic linkage from a (1,2)-fructoside to a (1,6)-fructoside followed by crystallization (Schiweck *et al.,* 1990). Isomaltulose is characterized as having a profile of color, texture and taste which is similar to sucrose (regular sugar) although there are some differences. It has only half the sweetening power of sucrose and its solubility is only 30% at 25ºC (Kaga and Mizutani, 1985; Schiweck *et al*., 1990). In terms of health, the linkage (1,6)-fructoside is hardly hydrolyzed by enzymes produced by oral bacteria, therefore isomaltulose preserves dental health due to prevention of tooth decay (Matsuyama *et al.,* 1997). It is also considered suitable for the formulation of foods for athletes and diabetics because of its low-glycemic and low-insulinemic indexes (Kawai *et al.,* 1989; Lina *et al*., 2002), since it provides the same amount of energy as common sugar, but for a significantly longer period. Unlike artificial sweeteners such as sodium cyclamate, saccharin, aspartame, polyols (sorbitol), isomaltulose has not laxative effect. In fact, only bifidobacteria, no enterobacteria, are able to ferment isomaltulose, which limits the growth of microorganisms of putrefaction to cause diarrhea (Weidenhagen and Lorenz, 1957).

As mentioned before, the main technological handicap for the successful replacement of sucrose and glucose syrup with isomaltulose in gummy confections could be its lower solubility and sweetening power than common sugar. Therefore, the mixture of isomaltulose with other natural healthier sugar, such as fructose (common sugar in the formulation of sweet foods) could be an alternative, which solves these problems. Fructose is one of the sugars found in plants, fruits and especially in honey. Industrially, the hydrolysis of sugar cane leads to an equal amount of glucose and fructose. The most important properties of this sugar are its sweetening power, which is nearly twice that of sucrose, and its high hygroscopicity (ideal for syrups) and insulin-independent metabolism, which has led it to become the quintessential substitute for sucrose. Although recent studies have refuted this property since they show that fructose is ultimately metabolized as glucose, and is therefore not recommended for diabetics (Elliot *et al.,* 2002), fructose is safe for healthy individuals as long as it is consumed in moderate quantities (Mann *et al*., 2004).

Any substitution of one ingredient by another, or by a combination of ingredients, can affect the physical and chemical properties of the food matrix, and therefore sensory acceptability. In this context, the aim of this study was to evaluate the possible replacement of sucrose and glucose syrup with isomaltulose and fructose, by analyzing their effect on physicochemical, textural and optical properties in different gummy confection formulations. Additionally, a sensory acceptance study was carried out and a correlation between instrumental measures and sensory attributes was made for the formulation, which most resembled (from the point of view of instrumental parameters) commercial gummy confections.

2. Materials and methods

2.1. Materials

Isomaltulose (Beneo-Palatinit; Germany), sucrose (Azucarera Ebro S.L.; Spain), fructose (Gabot Biochemical Industries; Israel), glucose syrup 43 DE (Emilio Peña, S.A., Spain), corn starch (Roquette, France), gelatine A 220 Bloom (Junca Gelatines S.L.; Spain), strawberry flavouring (Flavorix Aromáticos S.A.; Spain), natural red liquid colour (Roha Europe S.L.; Spain) and sunflower oil (Koipesol, Spain) were used as ingredients in the formulation of gummy confections.

2.2. Experimental Procedure

The gummy confections prepared consisted of 6-10 % of gelatine, 40% of water and 50-54% of sugars as recommended for gummy confections (Edwards, 2002). Also, 0.2 ppm of red coloring and 0.5 ppm of strawberry flavoring were added in all cases. Six different mixtures of sugars were studied. The control sample (code: S) was prepared with 40% of sucrose and 60% of glucose syrup (40:60 (w/w)) of the total sugar content. Other samples were obtained combining different sugars (isomaltulose, glucose syrup or fructose). In order to simplify the description of each sample, the percentage of the total amount of sugars replaced is shown between brackets along with the code used: isomaltulose: glucose syrup (40:60, w/w), (code: I), fructose:glucose syrup (40:60, w/w) (code: F); isomaltulose:fructose (30:70, w/w) (code: I30) and isomaltulose:fructose (50:50, w/w) (code: I50). In this study, the gelatine percentage (6, 8 or 10%) was always shown next to these codes. In addition to the control sample, a total of 14 different formulations were studied.

A thermal blender (Thermomix, TM31, Vorwerk, Germany) was used to blend the sugars and water until they reached boiling temperature at 300 rpm for 10 minutes. This mixture was shaken until reaching 60ºC following which pH and ºBrix were measured. The gelatine was then dissolved in water in a gelling agent: water ratio of 1:2 (w/w) to obtain a homogeneous mix and subsequently added to the syrup with the flavoring and coloring agents. All the ingredients were blended for 5 minutes at 60ºC and 300 rpm. The final mixture was poured into silicone moulds with a thin layer of sunflower oil. The silicone moulds have cylindrical shape with a diameter of 28 mm and a height of 20 mm. Then, the moulds were placed in a chamber at 20 °C for 24 hours. The samples were removed from their mould and analyses of texture, color, water activity and moisture performed.

2.3. Analytical determinations

2.3.1 Physicochemical Analyses

Soluble solid content (ºBrix) (measured with a refractometer at 20ºC, ATAGO 3 T), and pH (by a pH-meter, SevenEasy, Mettler Toledo) were evaluated in the initial syrup. Moisture content (obtained gravimetrically by drying to a constant weight in a vacuum oven at 60ºC (AOAC, 20.103, 2000) and water activity (by dew point hygrometer, Aqualab, 4TE) were measured on the final products. All analyses were carried out in triplicate.

2.3.2 Colour

Instrumental measurements of color were conducted at room temperature in a Minolta spectrophotometer (model CM-3600d) by placing the gummy confections on the diaphragm aperture (8 mm). CIEL*a*b* coordinates were obtained using illuminant D65 and standard observer (10° visual field) as references. The parameters registered were: L* (brightness), a* (red component), b* (yellow component), chrome ($C^*=[(a^*)^2+(b^*)^2]^{1/2}$) and hue ($h^*=arctg(b^*/a^*)$). The samples were previously measured with both black and white calibration tiles in order to study the possible translucency of the samples, since different spectrum was obtained with the black and white tiles. The results were analysed using the Kubelka Munk theory (Kubelka and Munk, 1931).

2.3.3 Texture

The samples which have the same shape and dimensions as the silicone moulds were subjected to an instrumental texture profile analysis (TPA) test using a TA.XT plus Texture Analyzer (Stable Micro Systems, U.K.) equipped with a load cell of 50 kg and a 45 mm diameter cylindrical probe. The test conditions involved two consecutive cycles of 50% compression with 15 s between cycles. The test speed was 1 mm/s. From the resulting force-time curve the following parameters were quantified, and are defined by Bourne (1978) as: hardness (N) (maximum peak force during the first compression cycle), springiness (the ratio between the time of the beginning of the second cycle and the time of the end of the first cycle), cohesiveness (the ratio of the positive force area during the second compression and the first compression), gumminess (N) (hardness x cohesiveness).

2.4. Sensory Evaluation

An acceptance test using a 9-point hedonic scale (ISO 4121:2003) was used to evaluate the following attributes: appearance, color, strawberry flavor, sweetness, texture, hardness, gumminess, springiness, cohesiveness and global preference (ISO 5492:2008). Moreover, intention of buying was considered. The panel consisted of 17 trained panelists who are regular consumers of this kind of sweet. For every formulation tested, the panelists evaluated three units independently. Testing sessions were conducted in a sensory evaluation laboratory built according to the international standards for test rooms.

2.5. Statistical Analyses

Statgraphics Centurion was used to perform the multifactor Analyses of Variance (ANOVA) in order to discern whether the effect of the process variables (kind of sugar and percentage of gelatine) on the final product was significant. The interactions between factors were also considered. Furthermore, Principal Component Analysis (PCA) and Partial Least Square regression (PLS2) were applied to describe the relationships between the sensory and the instrumental texture measurements. These analyses were performed using the Unscrambler version.10X (CAMO Process AS, Oslo, Norway).

3. Results and discussion

3.1. Compositional characteristics, pH and water activity

Table 1 shows the resulting ºBrix and pH of syrup for each formulation in addition to moisture content (%), water activity and the theoretical sweetening power of the gummy confections depending on the degree to which conventional sugars were replaced and the percentage of sugar used.

The content of soluble solids in the syrup was higher in the case of samples confected with isomaltulose and fructose in granulated form than when glucose syrup was used, given the amount of water in this syrup. These results are coherent with those established in other studies on gummy confections (Edwards, 2002). Furthermore, pH was higher in samples confected with glucose syrup than in the other cases. Specifically, one point less of pH was registered in samples confected with isomaltulose-fructose in comparison to the other samples, meaning that there could be an increase in their shelf life.

All formulations showed lower than the recommended moisture content values (24%) for this type of product (Edwards, 2002), except in the case of the samples confected with glucose syrup and fructose (samples F), which exceeded this limit. Additionally, the statistical analysis showed that the interaction between the sugar and the percentage of gelatine used had a significant effect, the control samples (S) and samples with glucose syrup and fructose (F) were responsible for these significant differences.

Water activity indicates the fraction of the total humidity of a product which is free and consequently subject to the growth of microorganisms and to different chemical reactions which might affect stability of these products. In this regard, samples made up of 30 % of isomaltulose and 70 % of fructose (with respect to the total amount of sugars) and with the lowest content of gelatine (I306) had the least water activity, which might imply higher stability than in the other cases. In contrast, the formulation with fructose and glucose syrup and with 8% of gelatine (F8) had the most water activity and hence was the most likely to be spoilt. On the other hand, samples formulated with isomaltulose-fructose in granulated form (I30 and I50) had less water activity than samples formulated with isomaltulose and glucose syrup (I), showing the increased ability of this combination of sugars to retain water.

According to the above results, mixtures of isomaltulose-fructose with the lowest level of gelatine (6%) would be recommendable for gummy confections in terms of composition (moisture content and soluble solids), pH and water activity.

Finally, as for the inherent sweetness of the sugars studied, the higher the proportion of isomaltulose, the lower the sweetness of the samples.

3.2. Instrumental mechanical and optical properties

Texture is the result of the interaction and arrangement of various constituents and structural elements at both macroscopic and microscopic levels (Ibañez *et al.,* 1998). Table 2 shows the mean values, and standard deviation, of the mechanical parameters from TPA (springiness, hardness (N), gumminess (N) and cohesiveness) of the gummy confections formulated with the different combination of sugars and percentage of gelatine studied. The statistical effect (F-ratio and level of significance from ANOVA multifactor) of the percentage of gelatine and combination of sugars on the mechanical parameters studied is also shown in Table 2. Regarding texture, the replacement of sucrose and glucose syrup by isomaltulose and/or fructose (F, I, I30 and I50) led to gummy confections with lower hardness and gumminess than the control samples (S) with the same percentage of gelatine. The effect of the percentage of gelatine was the variable in the formulation with the most influence (higher values of F-ratio) on both hardness and gumminess, although the combination of sugars also had a significant effect on these mechanical parameters. The difference in terms of hardness and gumminess between the samples formulated with isomaltulose and/or fructose and the control samples was noteworthy for the samples I30 or I50 and 10% of gelatine, but not at lower percentages of gelatine.

Cohesiveness results from the interaction of structural forces acting at a molecular level. The results of this study indicated that the new formulations exhibited higher cohesiveness than the control sample (S). Therefore, the incorporation of isomaltulose in the formulation of gummy confections enhanced the structural stability of the samples. A statistical significant effect of both individual parameters (percentage of gelatine and combination of sugars) was also found for cohesiveness. Nevertheless, the combination of sugars used in the formulation had more of an influence than the percentage of gelatine on this parameter unlike in the case of hardness and gumminess. Moreover, the formulation (combination of sugars and percentage of gelatine) had more of an influence on hardness and gumminess (higher F-ratios and level of significance) than on the cohesiveness and springiness of the samples (Table 2).

Lastly, the samples exhibited high springiness (values above 0.95) which was similar to control samples (S). Consequently, the presence of isomaltulose in the gum structure had a positive effect on the elastic properties of the samples.

Figure 1 shows the color planes L*-a* and b*-a* of control samples and confected gummies with isomaltulose and/or fructose.

The results obtained indicated that values of luminosity were very similar in all formulations. However, it is noteworthy that it was not possible to replace the overall percentage of sugars with more than 50% of isomaltulose due to the crystallisation of the sugars and the appearance of a whitish instead of a translucent color according to some previous trials (data not shown). In fact, samples formulated with isomaltulose and glucose syrup with 8 and 10% of gelatine (I8 and I10) and samples with 50% of isomaltulose and 50% of fructose in the weight of sugars (I50) in this study, showed values of luminosity which were slightly higher than in the other cases. This behaviour might be related to the lower solubility of isomaltulose at room temperature, which could lead to crystallization (Schiweck *et al.,* 1990; Kaga and Mizutani, 1985).

Statistical analysis (ANOVA multifactor) showed that the effect of the interaction between the blend of sugars and the percentage of gelatine and their interactions on luminosity and coordinates a* and b* (data not shown) was significant.

It is also noteworthy that the samples I50 showed greater values of both a* and b* coordinates, with a tendency towards an orange colour, although not perceivable visually. On the whole, the increase in the percentage of gelatine used led to an increase in both coordinates, except for the control samples and the sample confected with a mixture of 70% fructose and 30 % isomaltulose in the weight of sugars (I30). In coherence with these results, the values of chrome (data not shown) were greater in samples I50, followed by samples confected with 60% of glucose syrup and 40% of isomaltulose in the weight of sugars with 10% of gelatine (I10). In this regard, isomaltulose might improve the purity of the gummies' color. Nevertheless, the samples I30 were the most similar to control samples, so this increase in purity associated with high concentrations of isomaltulose might considerably modify the color of samples. In terms of hue (data not shown), samples were placed very close in quadrants I and IV of the chromatic diagram. This suggests that the samples were very similar.

According to the results for colour, the recommended formulation would be 30% of isomaltulose and 70% of fructose in the weight of sugars (I30) since it showed an appearance similar to control samples (S), regardless of the percentage of gelatine used.

3.3. Sensory Evaluation

An acceptance test (using a 9-point hedonic scale) was carried out for the formulation which most resembled (from the point of view of the instrumental parameters) the sample that was prepared with a composition of sugars equivalent to the commercial gummies coded as S8 (40% sucrose and 60% of glucose syrup with 8% of gelatine). This control sample was also considered in the acceptance test.

To this end, a principal component analysis (PCA), of the instrumental parameters (hardness, gumminess, cohesiveness and elasticity) of 12 formulations was performed. The formulations I506, I508, I5010 were not considered due to the fact that they crystallized in the rest stage.

Figure 2 shows the PCA biplot (score “formulations” and loading “instrumental variables”) obtained. The first two components accounted for 82 % of the total variance (PC1, 52 % and PC2, 30 %). The proximity between formulations implies similar texture profiles, while the proximity between variables shows the degree of correlation between these formulations.

Taking the above consideration, the samples I10 (40% of isomaltulose and 60% of glucose syrup in the total sugar content with 10% of gelatine) and S10 (40% of sucrose and 60% of glucose syrup in the total sugar content and 10% of gelatine) placed in the figure at the right end of the right axis of the figure are more rubbery and hard than the samples situated on the opposite site (left axis). The cohesiveness and springiness had less influence on the PC1 because they were situated near the center of this axis.

As observed in Figure 2, the I3010 formulation (30% of isomaltulose and 70% of fructose in the total sugar content with 10% gelatine) was the nearest to the control sample S8 (40% of sucrose and 60% of glucose syrup in the total sugar content and 8% of gelatine), so it was chosen for the sensory analysis.

As mentioned in materials and methods, 17 trained panelists evaluated the acceptance of the samples on the basis of the attributes: appearance, color, strawberry flavor, sweetness, texture, hardness, gumminess, springiness, cohesiveness, global preference and intention of buying. With this aim every attribute was scored in each sample by using a 9-point hedonic scale.

An ANOVA analysis was carried out for every one of these attributes considering "formulation" as a factor. Table 3 shows the average score, the standard deviation and the F-ratio obtained for each attribute evaluated in both the selected (I3010) and the control formulation (S8).

Color was the only attribute where significant differences (P-value=0.025) were shown between the selected formulation and the control sample. Sample I3010 was scored better in terms of visual appearance, color, and sweetness, than the control sample. On the contrary, the texture attributes (elasticity, hardness, gumminess, cohesiveness) obtained slightly higher scores in the sample S8. The same score was obtained by both samples for aroma, which proves that the type of sugars and the percentage of gelatine had no influence on the aroma evaluation. Finally, sample I3010 had the best average score for global preference (6.4) and intention of buying (6.9), although no significant differences were observed with respect to the other formulation (averages scores of 6.1 and 6.5, respectively).

3.4. Correlation between sensory and instrumental variables

Texture is the characteristic that decisively influences the consumer when eating gummy confection. For this reason identifying the consumer's preference with regard to this attribute is essential for the industry, both from the point of view of quality control and the design of new products. The use of textural instrumental equipment which gives information equivalent to that provided by a sensory panel could be a great aid.

However, first it is essential to assess whether the sensory information about this type of product correlates with the instrumental variables. With this aim in mind, Figure 3 shows the results from PLS2 regression analysis, which describes the relationship between the instrumental variables (X-matrix) and the acceptability score for the sensory attributes (Y-matrix). The sensory parameters placed in the outer ellipse are correlated with the instrumental variables, with the exception of sensorial cohesiveness, which being placed in the inner ellipse is not correlated (r^2=50%). Sensorial gumminess and hardness were negatively correlated with respect to instrumental gumminess and hardness, and positively correlated with instrumental springiness and cohesiveness. That is to say, the lower the instrumental values for gumminess and hardness and the higher the values for springiness and cohesiveness, the higher the sensorial acceptance scores and the global preference. In other words, the panelists preferred samples with low hardness and gumminess and high springiness and cohesiveness.

In summary, the correlation between instrumental and sensorial parameters leads to the conclusion that instrumental texture measurement could be suitable for evaluating consumer opinion about gummy confections without the need to use a trained panel.

4. Conclusions

The replacement of traditional sugars by isomaltulose and fructose in gummy confections is possible. More specifically, the combination of 30% of isomaltulose and 70% of fructose in the total amount of sugars would be recommendable to develop healthier gummy confections in terms of low cariogenicity and glycemic index. These gummies showed instrumental color and texture characteristics which were similar to commercial gummies. Additionally, a trained panel rated it with good global preference and intention of buying scores. Finally, a high correlation between instrumental and sensorial parameters was found. Therefore, it could be concluded that instrumental texture parameters are adequate tools for estimating the global preference of consumers for this kind of gummy confections.

5. Acknowlegments

The authors thank the Universitat Politècnica de València for funding the project PAID 2011-ref: 2012 and the PhD scholarship.

6. Conflict of Interest Statement

The authors disclose that they do not have any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence, or be perceived to influence, their work.

7. References

AOAC (2000). Official Methods of Analysis of AOAC International (17th edition). Gaithersburg, MD, USA.

Barez, J., Villanova, R., Garcia, S., Pala, T., Paramas, A., & Sanchez, J. (2000). Geographical discrimination of honeys through the employment of sugar patterns and common chemical quality parameters. *European Food Research and Technology*, 210, 437–444.

Bourne, M.C. (1978). Texture profile analysis. *Food technology*, 32, 62-66.

Bray, G.A., Nielsen, S.J., & Popkin, B.M. (2004). Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *American Society for Clinical Nutrition*, 79 (4), 537-543.

Edwards, W.P. (2002). La ciencia de las golosinas. Editorial Acribia, S.A., Zaragoza.

Elliot. S.S., Keim, N.L., Stern, J.S., Teff, K., & Havel, P.J. (2002). Fructose, weight gain, and the insulin resistance syndrome. *The American Journal of Clinical Nutrition*, 76(5), 911-922.

González, P., Camacho, F., & Robles, A. (1989). Hidrolizados enzimáticos de interés en la industria agroalimentaria. I. Hidrolizados de cereales. *Alimentación, equipos y tecnología*, 8(3), 201-207.

Ibañez, F.C., Loygorri, S., Ordoñez, A., & Torre, I.P. (1998). Evaluación instrumental y sensorial de la textura en quesos de oveja con Denominación de Origen. *Alimentaria*, 292, 49 -53.

ISO 5492 (2008). Sensory analysis. Vocabulary. International Organization for Standardization.

ISO 4121 (2003). Sensory analysis. Guidelines for the use of quantitative response scales. International Organization for Standardization.

Kaga, T., & Mizutani, T. (1985). Verwendung von Palatinose fur Nahrungsmittel. *Seito Gijutsu Kenkyukaishi*, 34, 45-57.

Kawai, K., Yoshikawa, H., Murayam, Y., Okuda, Y., & Yamashita, K. (1989). Usefulness of palatinose as a caloric sweetener for diabetic patients. *Hormone and Metabolic Research*, 21, 338–340.

Kubelka, P., & Munk, F. (1931). Ein Beitrag zur Optik der Farbanstriche. Zeitschrift für technische Physik (Leipzing),12, 593-620.

Lina, B., Jonker, D., & Kozianowski, G. (2002). Isomaltulose (Palatinose®): a review of biological and toxicologycal studies. *Food and Chemical Toxicology*, 40, 1375-1381.

Mann, J.I., De Leeuw, I., Hermansen, K., Karamanos, B., Karlström, B., Katsilambros, N., Riccardi, G., Rivellese, A.A., Rizkalla, S., Slama, G., Toeller, M., Uusitupa, M., & Vessby, B. (2004). Evidence based nutritional approaches to treatment and prevention of Diabetes mellitus. Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes (EASD). *Nutrition Metabolism and Cardiovascular Diseases*, 14: 373-394.

Marfil, P., Anhê, A., & Telis, V. (2012). Texture and Microstructure of Gelatine/Corn Starch Based Gummy Confections. *Food Biophysics*, 7, 236-243.

Martínez, O. (2012). Report Spanish Confectionary Association. Produlce. Madrid, Spain.

Matsuyama, J., Sato, T., & Hoshino, E. (1997). Acid production from palatinose, palatinit, erythritol and maltitol by bacteria isolated from dental plaque on human deciduous teeth. *Japanese Association for Oral Biology*, 39, 91-99.

Moloughney, S. (2011). Is there a place for healthiness in the indulgent world of candy, chocolate and gum? URL: http://www.nutraceuticalsworld.com/issues/2011-03/view_features/functional-confectionery-finding-the-sweet-spot/

O'Neil, C., Fulgoni, V., & Nicklas, T. (2011). Association of candy consumption with body weight measures, other health risk factors for cardiovascular disease, and diet quality in US children and adolescents: NHANES 1999_2004. *Food and Nutrition Research*, 55 5794.

Schiweck, H., Munir, M., Rapp, K., Schenider, B., & Bogel, M. (1990). New developments in the use of sucrose as an industrial bulk chemical. *Zuckerindustrie,* 115, 555–565.

Weidenhagen, R., & Lorenz, S. (1957). Palatinose (6-alpha-glucopyr- 716 anosido-fructofuranose), ein neues bakterielles *Umwandlungsprodukt der Saccharose. Zeitschrift fur die Zuckerindustrie*, 7, 533–534; *und Angewandte Chemie*, 69, 641.

Table captions

Table 1. Mean and standard deviation of ºBrix and pH initial syrup and moisture content (%), water activity and sweetness of the gummy confections.

	Initial syrup		Product: gummy confection		
Formulation	ºBrix	pH	Moisture content (%)	a_w	Sweetness (SP)*
S6			16.167 (0.303)^a	0.822(0.003)^c	38
S8	69.7 (1.3)^a	6.1 (0.4)^a	17.90 (0.14)^b	0.837(0.015)^c	36
S10			21.047 (1.005)^c	0.844(0.007)^c	35
F6			24.5 (0.6)^e	0.843(0.014)^c	49
F8	70 (2)^a	5.7 (0.6)^b	31.5 (0.3)^f	0.908(0.006)^a	47
F10			31.6 (0.4)^f	0.868(0.018)^b	45
I6			21.9 (1.3)^c	0.859(0.004)^b	23
I8	70.9 (0.5)^a	5.81 (0.07)^b	23.8 (0.7)^e	0.867(0.003)^b	22
I10			24.3 (1.7)^e	0.851(0.012)^b	21
I306			23.2 (0.3)^d	0.721(0.007)^e	62
I308	73.5 (1.3)^b	5.10 (0.04)^c	22.9 (1.4)^{de}	0.788(0.005)^d	59
I3010			22.9 (0.2)^d	0.792(0.013)^d	57
I506			21.99 (0.16)^{cd}	0.796(0.005)^d	49
I508	72.4 (2.3)^b	5.12 (0.07)^c	22.5 (0.5)^d	0.812(0.003)^d	47
I5010			22.8 (0.7)^d	0.831(0.012)^c	45

*Theoretical Sweetness Power of the gummy confections: $SP=\Sigma m_i \cdot SP_i/\Sigma m_i$ (m_i: grams of each compound; SP_i: Sweetness Power of each component (individual sugar)) (González et al., 1989).

Table 2. Mean and standard deviation of hardness (N), gumminess (N), springiness and cohesiveness. F-ratio and level of significance from ANOVA multifactor of the factors: percentage of gelatine and combination of sugars.

Formulation	Hardness (N)	Gumminess (N)	Springiness	Cohesiveness
S6	27.1(1.6)^{h}	24.4(1.6)^{g}	0.95(0.02)^{b}	0.90(0.03)^{d}
S8	44.3(0.5)^{d}	40.4(0.4)^{cd}	0.965(0.002)^{b}	0.912(0.002)^{d}
S10	62.1(0.5)^{a}	56.2(0.3)^{a}	0.969(0.002)^{ab}	0.905(0.002)^{d}
F6	21.3(0.3)^{i}	20.14(0.12)^{h}	0.972(0.006)^{ab}	0.94(0.02)^{abc}
F8	39(2)^{ef}	38(2)^{d}	0.97(0.02)^{ab}	0.961(0.003)^{ab}
F10	41.1(1.2)^{e}	39.2(0.5)^{d}	0.984(0.004)^{a}	0.953(0.015)^{abc}
I6	21.2(0.7)^{i}	19.3(0.5)^{h}	0.95(0.02)^{b}	0.91(0.02)^{d}
I8	44.2(0.6)^{d}	41.7(0.6)^{c}	0.983(0.005)^{a}	0.943(0.002)^{abc}
I10	59.4(1.6)^{b}	56.3(1.2)^{a}	0.962(0.012)^{b}	0.948(0.006)^{abc}
I306	22.3(0.8)^{i}	20.7(0.9)^{h}	0.960(0.013)^{b}	0.931(0.016)^{bcd}
I308	34.1(0.2)^{g}	32.2(0.3)^{f}	0.977(0.007)^{ab}	0.947(0.004)^{abc}
I3010	37.1(0.5)^{f}	35.2(0.7)^{e}	0.98(0.01)^{ab}	0.951(0.006)^{abc}
I506	22.8(0.2)^{i}	21.40(0.08)^{h}	0.980(0.006)^{ab}	0.935(0.008)^{b}
I508	37.6(0.8)^{f}	35.3(0.7)^{e}	0.975(0.006)^{ab}	0.939(0.003)^{bc}
I5010	48.2(1.9)^{c}	45.4(1.5)^{b}	0.977(0.005)^{ab}	0.943(0.007)^{abc}
ANOVA (F-Ratio)				
Sugars combination	232.21**	217.16**	2.45	14.77**
% Gelatine	2352.63**	2825.34**	3.6*	5.77**
Interaction	72.01**	82.60**	1.74	0.88

** Statistical significance≥99% (p-value≤ 0.01)
* Statistical significance≥95% (p-value≤ 0.05)

Table 3. Mean of score, standard deviation and the F-ratio of each attribute evaluated by means of sensorial analysis using a 9-point hedonic scale.* Statistical significance≥95% (p-value≤ 0.05).

Attribute	S8	I3010	F-ratio
Appearance	7.2 (1.5)	7.88 (1.12)	2.41
Colour	6.9 (1.7)	8.0 (0.8)	5.55*
Aroma	6.5 (1.8)	6.5 (1.9)	0.00
Sweetness	6.47 (1.007)	6.23 (1.09)	0.43
Texture	7 (1)	6.6 (1.5)	1.47
Springiness	6.2 (1.8)	5.7 (1.5)	0.52
Hardness	5.9 (1.8)	5.3 (1.5)	1.05
Gumminess	6.3 (1.6)	5.7 (1.5)	1.51
Cohesiveness	6.3 (1.7)	6.6 (1.5)	0.29
Global preference	6.1 (1.6)	6.35 (1.06)	0.26
Intention of buying	6.6 (1.5)	6.9 (1.4)	0.48

Figure captions

Figure 1. Colour planes L*-a* and b*-a* of control samples and confected gummies with isomaltulose and/or fructose.

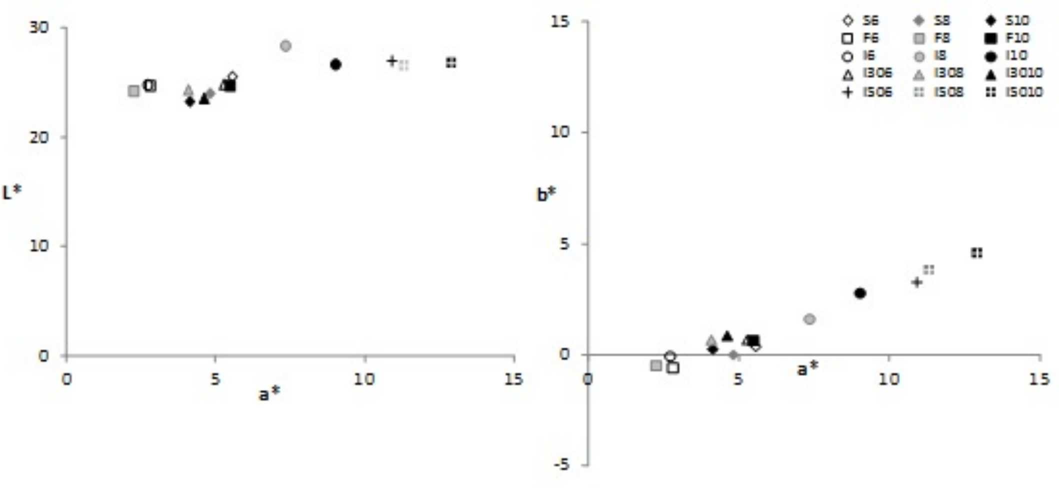


Figure 2. Bi-plot of Principal Components Analysis for the samples (white rhombus ◊) and the texture parameters (black rhombus ♦).

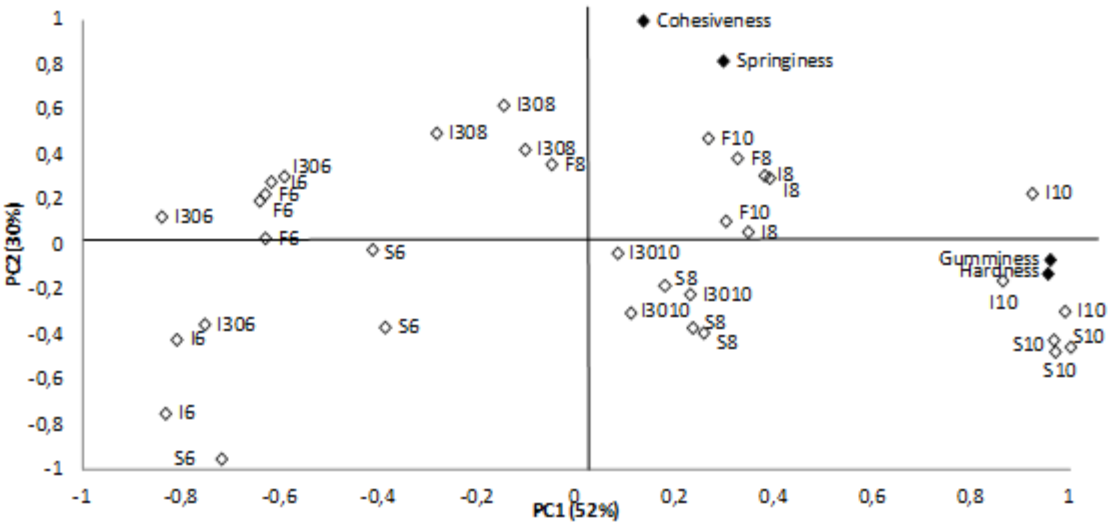
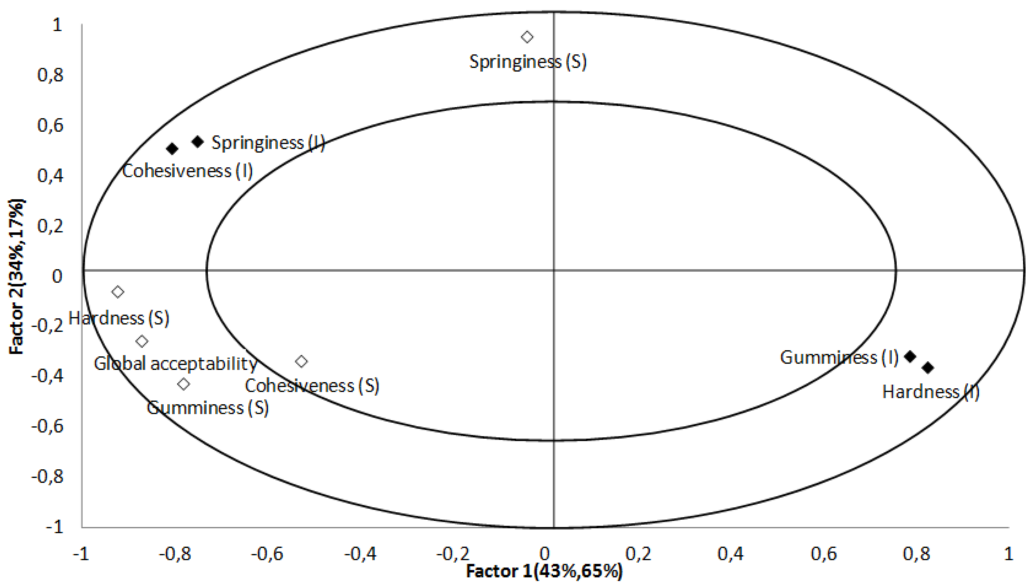


Figure 3. Correlation loadings (X and Y) between instrumental and sensory texture variables. Black rhombus (♦) instrumental and white rhombus (◊) sensory texture variables.


Springiness (S)
Springiness (I)
Cohesiveness (I)
Hardness (S)
Global acceptability
Cohesiveness (S)
Gumminess (S)
Gumminess (I)
Hardness (I)
Factor 2(34%,17%)
Factor 1(43%,65%)
1
0,8
0,6
0,4
0,2
0
-0,2
-0,4
-0,6
-0,8
-1
-1
-0,8
-0,6
-0,4
-0,2
0
0,2
0,4
0,6
0,8
1