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Abstract: The physicochemical, sensory and microbiological quality parameters in fresh-cut pineapple products were determined. Containers with fresh-cut pineapple in cylinders or in chunks were considered and the above parameters were studied over a period of ten days of cold storage. Differences were found in chromatic parameters between both formats, with the cylinders being more susceptible to browning. Besides, the cylinders had lower levels of acidity, texture and ascorbic acid. Fresh-cut pineapple in both formats presented slight differences, in general, in the main quality physicochemical characteristics during the ten days of refrigerated storage; with greater changes observed in the ring format. Liquid exudate increased, sucrose content decreased and a greater tendency to browning were observed during the cold storage. Sensory characteristics and microbiological control for both types of format showed a positive evaluation after eight days of storage at 5 °C. Mesophile, psychrophile, mold and yeast loads in both pineapple products were relatively low throughout their useful shelf-life, taking into account that both formats of fresh-cut pineapple products were packed in trays in normal atmosphere without chemical treatment or any additives to extend their commercial life span.

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Dear Editor,

Please find enclosed herewith an electronic copy of our manuscript entitled *"Quality evaluation of minimally fresh-cut processed pineapples"* to consider its publication in *LWT Food Science and Technology.*

Looking forward to hearing from you, I remain

Yours sincerely

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***Highlights (for review)**

Fresh-cut pineapple in cylinders or in chunks were studied for ten days at 5 °C

Physicochemical, sensory and microbiological quality parameters were analyzed

Differences of chromatic and physicochemical parameters were found in both formats

The storage time at 5 ºC affected in a greater extent in cylinder format

Positive evaluation of sensory and microbiological quality was found at least 8 days

Quality evaluation of minimally fresh-cut processed pineapples

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ABSTRACT

The physicochemical, sensory and microbiological quality parameters in fresh-cut pineapple products were determined. Containers with fresh-cut pineapple in cylinders or in chunks were considered and the above parameters were studied over a period of ten days of cold storage. Differences were found in chromatic parameters between both formats, with the cylinders being more susceptible to browning. Besides, the cylinders had lower levels of acidity, texture and ascorbic acid. Fresh-cut pineapple in both formats presented slight differences, in general, in the main quality physicochemical characteristics during the ten days of refrigerated storage; with greater changes observed in the ring format. Liquid exudate increased, sucrose content decreased and a greater tendency to browning were observed during the cold storage. Sensory characteristics and microbiological control for both types of format showed a positive evaluation after eight days of storage at 5 ºC. Mesophile, psychrophile, mold and yeast loads in both pineapple products were relatively low throughout their useful shelf-life, taking into account that both formats of fresh-cut pineapple products were packed in trays in normal atmosphere without chemical treatment or any additives to extend their commercial life span.

Keywords: Fresh pineapple; Minimally processed; Storage; Physicochemical parameters; Sensory and microbiological quality

1. Introduction

Pineapple is a tropical fruit that is consumed both for its pleasant taste and for its important health-promoting properties. Consumer demand is for minimally processed fresh-cut fruits with an optimum degree of maturity, free from defects, and with a high organoleptic and nutritional quality, together with guaranteed hygienic safety (Chonhenchob, Chantarasomboon, & Singh, 2007; Gil, Aguayo, & Kader, 2006). However, quality retention of these food products continues to be challenge; the precise mechanisms and dynamics of deterioration are still not well understood. Minimally processed horticultural products are produced at low temperatures, and the process consists of at least the following stages: washing of the whole product, elimination of inedible parts, chopping, washing and sanitizing. After processing, they are packed in sealed bags or trays with a plastic cover, with or without a modified atmosphere, to be stored and transported in refrigerated conditions. These products are ready to consume and have similar characteristics to fresh products as well as a useful life of between seven to ten days.

Tropical pineapple cultivation is one of the most important sources of income for the primary sector on the island of El Hierro (Canary Islands, Spain). The “Spanish Red” variety was used in the present study, due to its adaptation to the edaphoclimatic conditions of the Canary Islands. Besides, the Canary consumers are well adapted to its high acidity. In the study, physicochemical, sensory and microbiological quality parameters were determined in minimally processed tropical pineapples of the “Red Spanish” variety packed in two types of commercial formats (cylinders and chunks). The study is of particular interest from a commercial point of view, since the two types of cut (cylinders and chunks) were first performed in the industry and not as a pilot laboratory project where hygienic and production conditions are usually more controlled. The results obtained may provide useful and valuable information regarding the storage of these products with the aim of increasing its market value. In addition, the present study can serve as a point of support for subsequent evaluations of different potential pineapple varieties which can be grown in the Canary Islands.

2. Material and methods

2.1. Pineapple sampling and sample preparation

Fifty-two samples of pineapple (*Ananas comosus* (L.) Merr. Cv. "Roja Española" ("Red Spanish") were provided by a farm located on the island of El Hierro (Canary Islands, Spain). Each pineapple was washed with ozonated water, mechanically peeled and subjected to the elimination of the vascular central trunk with industrial machinery (ABL model 6P 15, Italy), resulting in pineapple cylinders with a height 9-10 cm and diameter of 7-8 cm. Half of these cylinders were cut into chunks with a width of ca. 2-3 cm. Subsequently, both the cylinders and chunks were packed separately in trays (ULMA, Smart 500, Spain). The measurements of the amorphous polyethylene terephthalate trays (Groupe Guillin, Spain) were 11.2 cm high, 9.4 cm in internal diameter and 10.6 cm in diameter at the height of the opening. PET film (12 µm) KORO-GPEEL (high barrier to oxygen and water vapor) was used to seal the trays. Each tray weighed between 317 and 486 g, with a mean average value of 391±43 g. A total of 26 trays were packed with pineapple cylinders and another 26 with chunks which were stored at 5 °C until analysis.

2.2. Analytical methods

2.2.1 Physicochemical analyses. These analyses were conducted in two ways:

2.2.1.1 Evolutionary analyses. These analyses were performed inside the trays at the beginning and after 1, 2, 4, 6, 8 and 10 days of storage at 5 ºC. Five trays were chosen at random from each format and were analyzed in duplicate. Analyses of the atmosphere composition (O_2 and CO_2) in the trays were performed with a PBI Dansensor compact model

Checkmate 9900 (Madrid, Spain). Color parameters (L, a*, b*) were measured through the transparent tray using a Minolta Chroma Meter CR-300 (Wheeling, USA). Hue angle (H°), Chroma (C*), browning index (ΔE) and whiteness index (WI) were calculated from previous data using the appropriate formula (Aguayo, Allende, & Artés, 2003).

2.2.1.2 Destructive analyses. Destructive analyses in triplicate were performed using 3 randomly chosen trays of each format opened at the same times as mentioned above.

Pulp color (L, a*, b*, H°, C*) was evaluated directly on the pulp using the methods described above. Texture (N·sec/g) was measured using a Kramer cell, model TA-HD-Plus (Aname, Madrid, Spain). The amount of liquid exuded (g/100 g) in peeling and/or chopping was measured in triplicate.

Samples of each format were minced and homogenized to analyze the remaining physicochemical parameters. Moisture was determined using the AOAC method (AOAC, 2006). Ascorbic acid was determined using the 2,6-dichlorophenol indophenol titration procedure (AOAC, 2006). Total soluble solids (TSS) were determined using a hand refractometer ATAGO ATC-1 (Tokyo, Japan) and pH was measured by a WTW pHmeter (St Woburn, USA). Titratable acidity (TA) was determined by a titration with NaOH, and the results expressed as g of citric acid/100 g (AOAC, 2006). Total phenolic content (TP) was determined by the Folin-Ciocalteu assay after extraction with 50% methanol. The results were expressed as mg gallic acid equivalents (GAE)/g. The antioxidant activity was determined by the DPPH method (2,2-diphenyl-1-picryl hydrazyl) as described Bondet, Brand-Williams, and Berset (1997) and the method based on the radical ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) as described by Re et al. (1999). The antioxidant capacity was calculated using a calibration curve prepared with Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) and the results were expressed as mmol Trolox equivalents (TE)/kg. The determination of sugars was performed by high-performance liquid chromatography (HPLC) according to the method described by Rodríguez-Galdón, Tascón-Rodríguez, Rodríguez-Rodríguez, and Díaz-Romero (2009), with a Waters 2690 HPLC equipped with a differential refractive index detector (Waters model 2414) (Waters Corporation, Millford, Massachusetts, USA). A Water Carbohydrate Analysis column (3.9x300 mm) and 80% acetonitrile as mobile phase were used for the separation.

2.2.2 *Sensory evaluation*. Sensory tests were carried out with a tasting panel of eight people who were regular pineapple consumers. External general appearance, color, taste and smell by acceptance-preference test (using a linear scale in intensity from 0 to 10 from unacceptable to very acceptable) were evaluated. A color test (intense yellow, normal, pale yellow), sweetness (very sweet, normal, tasteless) and smell (pleasant, normal, unpleasant) was also conducted. Finally, the consumers were asked whether or not they would buy the product.

2.2.3 *Microbiological analysis*. In order to evaluate the microbiological quality of the pineapple samples, aerobic mesophile, psychrophile, mold and yeast loads were determined according to Spanish legislation for minimally processed vegetables (Real Decreto 3484/2000). Six grams of pineapple sample were weighed in duplicate and in sterile conditions; after which, 0.1% peptone water (Sigma, Barcelona, Spain) was added. This mixture was homogenized in a Stomacher 80 Biomaster (Seward Limited, United Kingdom) for 2 min. Successive dilutions were made from this suspension. After the specific incubation time (aerobic mesophiles 30 ºC 72 h, psychrophiles 5 ºC 7 day and, molds and yeasts 25 ºC 7 days), the colonies were counted in plates with 30 to 300 isolated colonies.

2.3. Statistics

SPSS version 25.0 (SPSS Inc., Chicago, USA) was used for the statistical analyses. The Kolmogorov–Smirnov test was applied to verify whether the distribution of the variables was normal ($p < 0.05$). When the statistical distribution was not normal, the Kruskal-Wallis non-parametric test was applied. One-Way ANOVA (Duncan's multiple range) was conducted, assuming significant differences when the statistical comparison gave $p < 0.05$. Correlation analysis was performed to study relationships between variables. Factor analysis, using principal components as the method of factor extraction, was used to establish a more simplified view of the relationship among all the parameters analyzed. A Varimax rotation was carried out to facilitate the interpretation of the results. Linear discriminant analysis was applied to classify the pineapple samples in homogeneous groups established by the dependent variable.

3. Results and discussion

3.1. Physicochemical analyses

3.1.1 Evolutionary study

Significant decreases and increases were detected for O_2 and CO_2 concentrations, respectively, throughout the 10 days of study and for both formats (Fig. 1). Other researchers (Manzocco et al., 2016; Marrero & Kader, 2006; Montero-Calderón, Rojas-Graü, Aguiló-Aguayo, Soliva-Fortuny, & Martín-Belloso, 2010; Pan, Zhu, & Li, 2015) reported similar changes. A different behavior of the CO_2 and O_2 concentrations from day 6 of storage at 5 ºC was observed in the two commercial formats (cylinders and chunks). In the case of the chunks, the amount of O_2 disappeared after day 6, whereas it was detected in the cylinders throughout the study. On the other hand, the CO_2 concentration in the chunks increased more after day 6 of storage. Chonhenchob et al. (2007) studied pineapple chunks in different plastic containers observing differences according to the packaging material. The concentrations of the two gases in the samples packaged in PET behaved similarly in the present study, which is logical as the pineapple samples studied here, were packed with this material. When the pineapples were packed with other materials (OPS and OPLA) (Chonhenchob et al., 2007), the concentration of these gases remained fairly constant from the first day of packaging.

Results of evolutionary analysis (data not shown) did not show clear differences in L and Hº between both pineapple formats. In contrast, higher values ($p < 0.05$) of b* and C* were observed in the cylinders with the opposite occurring for a*.

Evolution of the browning index (ΔE) and the whitening index (WI) over storage time behaved differently according to the format (Fig. 2). After day 6, the cylinders had a higher ($p < 0.05$) ΔE index and a lower ($p < 0.05$) WI than the chunks. This finding could be explained by the lower surface per weight unit in the cylinders, so the oxidative activity of the enzymes was concentrated on this lower surface. Likewise, pineapples packaged in cylinders showed significant differences for both indexes over the storage time; this was not observed in the chunks. The ΔE index increased from day 2 in the cylinders, as these samples became darker as the conservation time increased; the ΔE index remained fairly constant for the chunks. A noteworthy decrease of WI with the storage time was found in the pineapple cylinders (Fig. 2), which was reported in a previous investigation (Hernández-Ramos, 2008). However, the WI of pineapple chunks remained constant over the storage time, although there were appreciable oscillations. Therefore, one can deduce that the color of the cylinders changed to a greater extent than it did in the chunks.

3.1.2. Destructive study

Table 1 shows that L values in both formats decreased with the storage time and significant differences were found in the cylinders. From day 2, the pineapples cylinders showed a progressive decrease of L. The a*, b* and C* values observed in both formats did not change ($p < 0.05$) during the 10 days of the study. The b* and C* tended to be higher in the cylinders than in the chunks, while the inverse was observed for a* and H° values. The tonality (Hº) of the cylinders remained constant during the storage time; however, a significant increase was detected in the chunks from day 6.

The L values obtained were lower than those published by others (Bartolomé, Rupérez, & Fuster, 1995; Hernández-Ramos, 2008) who also studied the “Red Spanish” variety; and were similar to those reported by Montero-Calderón et al. (2010) who used “MD2”.

The data here (a*, b* and C*) were within the ranges reported by Hernández-Ramos (2008) in minimally processed pineapples; however, the results of a* and b* were similar to and considerably higher than those described by Montero-Calderón et al. (2010), respectively.

There is no agreement regarding the behavior of color parameters with storage time. Different investigators did not find marked changes while others found them in certain parameters. Gil et al. (2006) did not find significant differences in b* values for the "Tropical Gold" variety over 9 days. Moreover, Montero-Calderón et al. (2010) found a low variability in L, a* and b* among “Gold” cultivar fresh-cut pineapple samples, which explains their heterogeneity. However, the above researchers did not find significant differences according to packaging conditions or storage time. Manzocco et al. (2016) observed that L values for the "Gold" variety decreased over 15 days, while a* and b* values remained fairly constant after day 3. Likewise, Marrero and Kader (2006) detected a decrease in the L, H° and C* values after storage for 15 days at 5°C in the “Smooth Cayenne” variety. In agreement with previous reports, Bierhals, Chiumarelli, and Hubinger (2011) found that the L and H° values decreased significantly over 12 days for the "Perola" variety. Pan et al. (2015) also observed a progressive decrease of L and b* values over 11 days.

Differences in other physicochemical parameters and sugars were observed between both format types (Table 2). The pineapple chunks had a firmer ($p < 0.05$) texture than those packed in cylinders (61.3-70.6 and 51.4-58.7 N·sec/g, respectively). Significant differences in mean texture between the pineapple chunks and cylinders were only observed on day 4 and 10 of cold storage, which is explained by the large detected variation. A slight decrease (without statistical significance) was observed in the pineapple cylinders. Gil et al. (2006) did not find differences in the firmness of the pineapple chunks over 9 days. In contrast, Chonhenchob et al. (2007) and Pan et al. (2015) observed a gradual decrease in texture during the time in storage.

Exudate was already observed from day 1 in both formats and a progressive and significant increase was detected over the storage time. Higher values were found in the chunks, which could be explained by the greater mechanical force exerted on those samples.

Moisture values were fairly constant in the both formats throughout the time in storage, ranging between 84.0 and 88.6%. The pineapple cylinders tended to have higher moisture contents from day 4 of storage.

TSS values ranged from 11 to 15 °Brix, which were slightly higher than those reported by Bartolomé et al. (1995). Other investigators obtained similar contents to (Chonhenchob et al., 2007; Marrero & Kader, 2006; Martínez-Ferrer, Harper, Pérez-Muñoz, & Chaparro, 2002; Montero-Calderón et al., 2010; Pan et al., 2015) or lower contents (Gil et al., 2006; Santos, Vilas Boas, Prado, & Pinheiro, 2005) than the results reported here but in other varieties. A significant decrease of TSS was detected in the pineapple cylinders from day 2 of storage, values which remained relatively constant for the whole storage time in the pineapple chunks, which agrees with Hernández-Ramos (2008) and Santos et al. (2005). Other researchers (Gil et al., 2006; Pan et al., 2015) found that TSS decreased considerably. In contrast, Chonhenchob et al. (2007) reported that the TSS of fresh-cut fruits increased during storage which is explained by the conversion of starch to sugar during the ripening process.

Sucrose content was higher than the fructose and glucose contents in both formats. Glucose correlated with fructose ($r = 0.688$; $p = 0.007$) which suggests a common origin of both sugars from sucrose. Fructose correlated ($r > 0.7$; $p < 0.005$) with all the color parameters, except L, which was highly correlated with sucrose ($r = 0.786$; $p = 0.001$). The contents of the three sugars in the chunks format after day 6 of storage were higher than those in the cylinder format, with significant differences on day 8 and 10 for the three sugars, and on day 6 but only for sucrose. In the cylinder format, a significant decrease of sucrose was observed with the storage time, whereas the fructose slightly increased and glucose did not change. This behavior was not observed in the chunks in the case of sucrose; however, significant differences were found for glucose and fructose. Pan et al. (2015) found that the sugars decreased significantly over time.

TA and pH were moderate and inversely correlated ($r = -0.632$; $p = 0.015$). The values found in the present work for TA and pH (Table 3) were higher and lower, respectively, than the data reported in the literature (Gil et al., 2006; Montero-Calderón et al., 2010; Santos et al., 2005). Considerable differences were found in pH and TA between the two formats. The pineapple cylinders had a higher mean pH value than the chunks. In contrast, the TA content was lower content in the cylinders during the storage time, except at the beginning and on day 10. TA and pH values showed differences in the storage time for both formats, although without any clear trends. Gil et al. (2006) found that the TA did not vary significantly with the storage time, as opposed to the pH, which increased significantly. Santos et al. (2005) did not find a clear trend in the TA with the storage time. However, Chonhenchob et al. (2007) found that the TA decreased during storage; and reported that the TSS/TA ratio increased with storage time for both formats, contrasting with that found here. Montero-Calderón et al. (2010) did not observe significant changes in TSS, TA, pH and the TSS/TA ratio according to atmosphere during the packaging or storage period at 5 ºC. As pineapple is a non-climateric fruit, its properties change little after harvesting. Besides, the storage at 5 ºC slowed down both the deterioration processes and microbiological growth.

The ascorbic acid concentrations varied in both formats, from 12.7 mg/100 g to 20.3 mg/100 g, which are within the reported ranges (Bierhals et al., 2011; George et al., 2015;

Marrero & Kader, 2006). In addition, the pineapple chunks had a higher ascorbic acid concentration than the cylinders during the entire storage time. There were significant differences in both formats according to storage time, but without any clear trends. Montero-Calderón et al. (2010) did not find a variation of vitamin C content throughout the storage time at 5 ºC; other researchers (Gil et al., 2006; Pan et al., 2015) observed a decrease in the ascorbic acid content over time.

TP ranged between 29 and 35 mg GAE/100 g in both formats. No differences were detected in the TP between the formats, however, significant differences were observed according to storage time. Gil et al. (2006) found that phenolic compounds varied widely during storage. Montero-Calderón et al. (2010) found higher values than those found here in the "MD2" variety. They observed that these compounds increased with storage time, reaching a maximum after 5 days. After which, a decrease was observed until day 13 and this remained constant until day 21.

Antioxidant capacity (ABTS and DPPH methods) also varied significantly during the storage time. An increase in DPPH was observed over time, especially for the cylinders; while the ABTS oscillated considerably. Montero-Calderón et al. (2010) did not find noteworthy changes in the antioxidant capacity (DPPH) with the storage time. The values in the present study were similar to those reported by Lu, Sun, Wu, Liu, & Sun (2014) in pineapple pulp belonging to 26 genotypes.

3.2. Sensory analysis

The pineapple cylinders and chunks had an acceptable external general appearance including color, smell, and taste for the first 6 days of storage with a mean average score of more than 6 in the acceptance rating (Fig. 3). Moreover, no unpleasant smells or flavors were detected over the 10 days at 5 ºC. On the contrary, most of the tasters perceived pleasant smells after the first day of packaging, particularly in the pineapple packed in chunks

(87.5%). The number of tasters who mentioned a pleasant smell decreased on day 8, and all the tasters described a normal smell from that day. The sweetness perceived by all the tasters and for both types of format was described as normal, except tasters 1 and 2 who referred to tastelessness in the cylinder format after days 6 and 8 of storage, respectively. These small deficiencies in flavor from day 8 detected by some tasters could be linked with a bulge in the film that sealed the trays. The color perception varied between normal and pale yellow. On day 8, all tasters noted a normal color in the pineapple chunks, while 20% of the tasters noted a pale yellow color in the cylinders.

The acceptance of the tasters (consumers) to purchase the minimally processed pineapple was, in general, good (Table 4). Thus, the pineapple chunks had a 100% acceptance on the 1st, 6th and 8th days of cold storage and 86% on the 4th day; while the degree of acceptance for the cylinder format was somewhat lower (100% only on the 1st day; 71% on the 4th day; 89% on the 6th day; and 60% on the 8th day).

3.3 Microbiological analyses.

The hygienic-sanitary quality of the two formats was generally satisfactory. No significant differences in the psychrophile load was found for all the storage times considered between both types of format. Nor were significant differences found for mesophile and mold and yeast loads between both formats over the whole storage time, except on the 2nd day for mesophiles and the 4th day for molds and yeasts. So, no clear tendencies occurred in the microbial load according to the pineapple format. In contrast, considerable increases with storage time were found in all the types of microorganisms considered. The load of mesophilic microorganisms in the cylinder format increased from values near 3.5 to 6 log(cfu/g), after 10 days of storage at 5 °C (Fig. 4). The initial count of aerobic psychrophilic microorganisms was very low in both formats reaching values near 6 log(cfu/g) on the 10th

day of storage. The increase in the mold and yeast load after 10 days was lower than in the mesophile and psychrophile microorganisms previously cited.

The microbial loads of the types of microorganisms analyzed in the present study were somewhat higher than those available in the literature (George, Razali, Santhirasegaram, & Somasundram, 2015; Hernández-Ramos, 2008). However, it is worth noting the lack of a previous step of sanitization during the manufacturing process of the pineapple products, which could explain these discrepancies.

3.4 Multivariate analysis

Factor analysis was performed considering all the variables for the whole storage time. Six factors were chosen accounting for 90.3% of the total variance. The first factor (34.6% of the variance), is strongly associated with moisture and color variables such as C*, b* and inversely with a*. The second factor (22.0% of total variance) is associated with fructose and, to a lesser extent, with H° and glucose, and the third with L and sucrose. The fourth factor is associated with TSS/acidity and inversely with acidity, and the fifth and sixth factors are related with TP and with ABTS, respectively. From the score plot for all the samples in the first and second factor (Fig. 5), one can see that the pineapple samples were differentiated according to the format. No separation was observed between the pineapple samples as a function of storage time.

Lineal discriminant analysis (LDA) was applied to differentiate the qualitative variables, format (cylinder or chunks) and storage time. After application of the stepwise LDA, a complete (100%, and 100% after cross-validation) of correct classification was obtained when selecting the following three variables: ascorbic acid, texture and ABTS. These results confirmed the previously obtained results using factor analysis

4. Conclusions

Some of the physicochemical parameters were significantly different when "Red Spanish" pineapple was processed in cylinders or chunks. The pineapple cylinders had higher b*, C* and ΔE and lower WI values than the pineapple chunks. Besides, the pineapple cylinders had a higher pH and lower acidity, texture and ascorbic acid than the pineapple chunks. On the other hand, the main physicochemical features of the pineapple (both in cylinder or chunk format) remained stable during the cold storage time, although some modifications occurred progressively. The storage time at 5 ºC affected the pineapple cylinders to a greater extent. A significant decrease of L, WI, TSS and sucrose, and an increase of exudate and DPPH during storage time was observed in the cylinders; while an increase of the exudate, and a decrease in L was only observed in the chunks. A decrease in L usually occurs when a decompartmentalization of the cells due to tissue aging takes place favoring the contact between the enzymes and the substrates responsible for the oxidation.

A positive evaluation with respect to sensory characteristics and microbiological control after 8 days of storage at 5 ºC was found for both format types. No large increase of the microorganism load in both the pineapple products studied was detected throughout their useful life. This fact is noteworthy considering that both pineapple formats were packaged in trays in normal atmosphere, and had neither been subjected to any chemical treatment nor had any additives been added to increase their commercial life span. Factor and discriminant analysis applied on all the physicochemical parameters studied here allowed the differentiation of the pineapples according to both formats.

The preliminary results reported here can contribute, together with future studies, to improve the production and commercialization of minimally processed pineapple products grown and produced in the Canary Islands.

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Table

Table 1

Color parameters of fresh-cut pineapple processed in cylinder or pieces during the storage at 5 ºC.

Day	L	a*	b*	C*	H°
Cylinder format					
0	76.2±2.0 [b]	-5.02±0.72 [a]	20.0±1.4 [a]	20.7±1.5 [a]	104±1.3 [a]
1	72.6±2.2 [ab]	-4.54±0.73 [a]	18.7±2.8 [a]	19.3±2.9 [a]	105±0.4 [a]
2	70.5±6.0 [ab]	-4.16±0.52 [a]	15.5±1.8 [a]	16.0±1.9 [a]	105±0.7 [a]
4	68.9±4.3 [ab]	-3.62±0.86 [a]	15.6±1.2 [a]	16.1±1.4 [a]	103±2.0 [a]
6	68.9±1.7 [ab]	-4.62±0.78 [a]	16.3±2.2 [a]	17.0±2.3 [a]	106±0.8 [a]
8	65.6±8.3 [ab]	-4.87±1.49 [a]	18.8±7.7 [a]	19.4±7.8 [a]	105±1.3 [a]
10	60.1±6.1 [a]	-5.41±1.29 [a]	21.2±4.8 [a]	22.0±4.9 [a]	104±0.2 [a]
Pieces format					
0	72.5±2.3 [a]	-3.80±0.28 [a]	14.5±0.3 [a]	15.0±0.3 [a]	105±1.0 [a]
1	71.3±1.8 [a]	-3.56±0.20 [a]	13.6±0.3 [a]	14.1±0.3 [a]	105±0.7 [a]
2	73.1±2.3 [a]	-3.78±0.08 [a]	12.9±1.5 [a]	13.4±1.4 [a]	107±2.2 [a]
4	70.1±2.2 [a]	-3.60±0.50 [a]	13.8±1.8 [a]	14.2±1.9 [a]	105±0.6 [a]
6	70.3±8.3 [a]	-4.48±0.54 [a]	16.9±3.3 [a]	17.4±3.3 [a]	105±1.2 [a]
8	67.9±1.8 [a]	-3.96±0.66 [a]	14.4±1.2 [a]	14.9±1.4 [a]	105±1.2 [a]
10	67.5±1.3 [a]	-3.67±0.42 [a]	12.3±1.2 [a]	12.8±1.3 [a]	107±0.3 [a]

Different letters in each column denote significant ($p < 0.05$) differences for each presentation during the storage time at 5 ºC.

Table 2

Physicochemical parameters and sugars (fructose, glucose and sucrose) of fresh-cut pineapple processed in cylinder or pieces during the storage at 5 ºC.

Day	Texture (N·sec/g)	Exudate (mL/100 g)	Moisture (%)	TSS (ºBrix)	Fructose (%)	Glucose (%)	Sucrose (%)
Cylinder format							
0	57.5±12 [a]	-	88.6±1.3 [a]	12.1±0.2 [ab]	0.99±0.06 [a]	0.77±0.01 [a]	6.37±0.4 [d]
1	58.7±16 [a]	2.25±0.4 [a]	87.2±2.0 [a]	15.1±0.1 [d]	1.10±0.07 [bc]	0.76±0.04 [a]	5.72±0.4 [c]
2	56.6±8.3 [a]	4.56±0.2 [ab]	84.0±1.3 [a]	15.1±0.2 [d]	1.11±0.06 [c]	0.74±0.02 [a]	5.69±0.5 [c]
4	52.5±5.7 [a]	5.65±0.5 [bc]	86.2±2.7 [a]	12.7±0.6 [bc]	1.01±0.05 [ab]	0.80±0.05 [a]	4.94±0.2 [b]
6	51.7±12 [a]	7.36±1.7 [bc]	87.1±2.3 [a]	13.4±0.4 [c]	1.19±0.03 [c]	0.82±0.04 [a]	5.32±0.2 [bc]
8	52.7±10 [a]	7.65±0.5 [c]	87.0±2.0 [a]	11.5±0.3 [a]	1.11±0.03 [c]	0.80±0.07 [a]	3.86±0.1 [a]
10	51.4±13 [a]	8.39±1.8 [c]	87.4±0.5 [a]	11.3±0.1 [a]	0.97±0.05 [a]	0.86±0.04 [a]	3.85±0.1 [a]
Pieces format							
0	62.1±11	-	85.1±3.4	13.3±0.2 [ab]	1.08±0.06 [a]	0.74±0.03 [a]	5.52±0.4 [bcd]
1	67.3±11	4.55±0.5 [a]	85.8±1.2	13.1±0.1 [a]	1.17±0.08 [ab]	0.74±0.04 [a]	5.39±0.3 [bc]
2	68.5±11	4.91±1.0 [a]	86.9±1.3	14.2±0.2 [d]	1.23±0.05 [b]	0.71±0.03 [a]	5.91±0.3 [d]
4	63.2±2.1	6.59±0.8 [ab]	85.2±2.6	13.7±0.3 [bcd]	1.17±0.07 [ab]	1.00±0.05 [b]	5.19±0.1 [ab]
6	66.9±6.4	8.13±0.7 [bc]	85.9±1.6	13.7±0.5 [abcd]	1.09±0.06 [a]	0.78±0.03 [a]	4.78±0.2 [a]
8	61.3±7.9	9.25±2.4 [cd]	85.4±1.7	13.5±0.5 [abc]	1.34±0.04 [c]	1.15±0.07 [c]	5.79±0.1 [cd]
10	70.6±4.5	10.7±1.2 [d]	85.6±1.1	14.0±0.1 [cd]	1.37±0.07 [c]	1.23±0.05 [c]	5.86±0.3 [cd]

Different letters in each column denote significant ($p < 0.05$) differences for each presentation during the storage time at 5 ºC.

Table 3

pH, titratable acidity, ascorbic acid, total phenolics and antioxidant capacity (ABTS and DPPH) of fresh-cut pineapple processed in cylinder or pieces during the storage at 5 ºC.

Day	pH	TA (mg/100 g)	AA (mg/100 g)	TP (mg GAE/100 g)	DPPH (mg TE/100 g)	ABTS (mg TE/100 g)
Cylinder format						
0	3.31±0.04 [d]	1.18±0.05 [c]	17.6±0.1 [c]	29.8±0.4 [a]	2.63±0.06 [b]	1.82±0.08 [a]
1	3.15±0.05 [a]	1.26±0.02 [d]	12.7±0.3 [a]	33.4±0.6 [c]	2.55±0.09 [b]	1.82±0.09 [a]
2	3.17±0.02 [ab]	1.17±0.03 [bc]	14.5±0.1 [b]	31.6±0.7 [b]	2.29±0.05 [a]	1.84±0.09 [a]
4	3.21±0.03 [bc]	1.02±0.02 [a]	17.9±0.9 [c]	29.8±1.6 [a]	2.62±0.08 [b]	1.86±0.08 [a]
6	3.36±0.02 [e]	0.99±0.02 [a]	19.3±1.0 [c]	29.2±0.2 [a]	2.81±0.09 [c]	1.72±0.03 [a]
8	3.25±0.02 [c]	1.12±0.05 [bc]	18.6±0.9 [c]	30.0±1.1 [a]	3.13±0.07 [d]	1.75±0.05 [a]
10	3.25±0.02 [c]	1.11±0.03 [b]	15.2±0.1 [b]	35.0±0.5 [d]	3.08±0.2 [d]	2.05±0.04 [b]
Pieces format						
0	3.18±0.05 [b]	1.09±0.02 [b]	18.0±0.5 [a]	28.6±1.9 [ab]	2.74±0.03 [bc]	1.96±0.1 [b]
1	3.13±0.06 [ab]	1.34±0.03 [d]	18.6±0.8 [a]	28.1±1.7 [a]	2.17±0.09 [a]	1.71±0.09 [a]
2	3.10±0.01 [a]	1.40±0.05 [e]	19.0±0.8 [a]	30.8±1.5 [bc]	2.59±0.09 [b]	1.92±0.02 [b]
4	3.17±0.01 [ab]	1.24±0.01 [c]	18.1±0.5 [a]	27.2±1.1 [a]	3.02±0.2 [d]	1.99±0.04 [b]
6	3.19±0.01 [b]	1.04±0.04 [ab]	17.5±0.7 [a]	29.3±0.5 [ab]	2.94±0.04 [cd]	1.96±0.03 [b]
8	3.17±0.07 [ab]	1.25±0.02 [c]	20.3±0.2 [b]	31.8±0.9 [cd]	3.03±0.1 [d]	1.87±0.1 [b]
10	3.19±0.01 [b]	1.00±0.01 [a]	20.0±0.9 [b]	33.9±0.6 [d]	3.04±0.1 [d]	1.87±0.2 [b]

Different letters in each column denote significant ($p < 0.05$) differences for each presentation during the storage time at 5 ºC.
TA: titratable acidity; AA: Ascorbic acid; TP: total phenolics; DPPH: 2,2-diphenyl-1-picrylhydrazyl; ABTS: 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid).

Table 4

Consumer acceptance to purchase the fresh-cut pineapple processed in cylinder or pieces during the storage at 5 ºC.

		Day			
Format	Acceptance	1	4	6	8
Cyllinder	Yes	100	71.4	88.9	60
	No	0	28.6	11.1	40
Pieces	Yes	100	85.7	100	100
	No	0	14.3	0	0

Figure

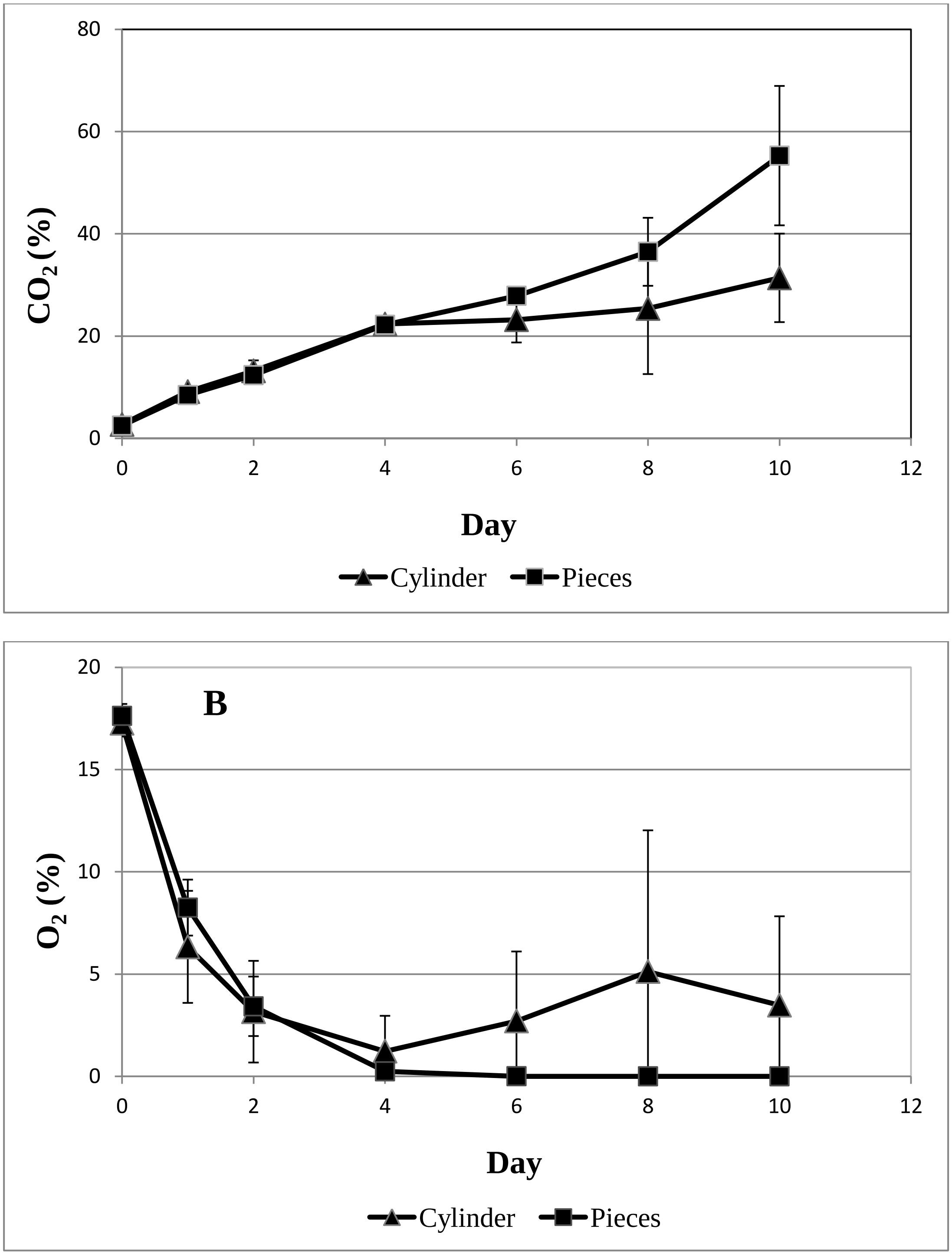

Fig. 1. Evolution of CO_2 (A) and O_2 (B) concentrations inside the pineapple trays during refrigeration storage at 5 ºC considering both presentations.

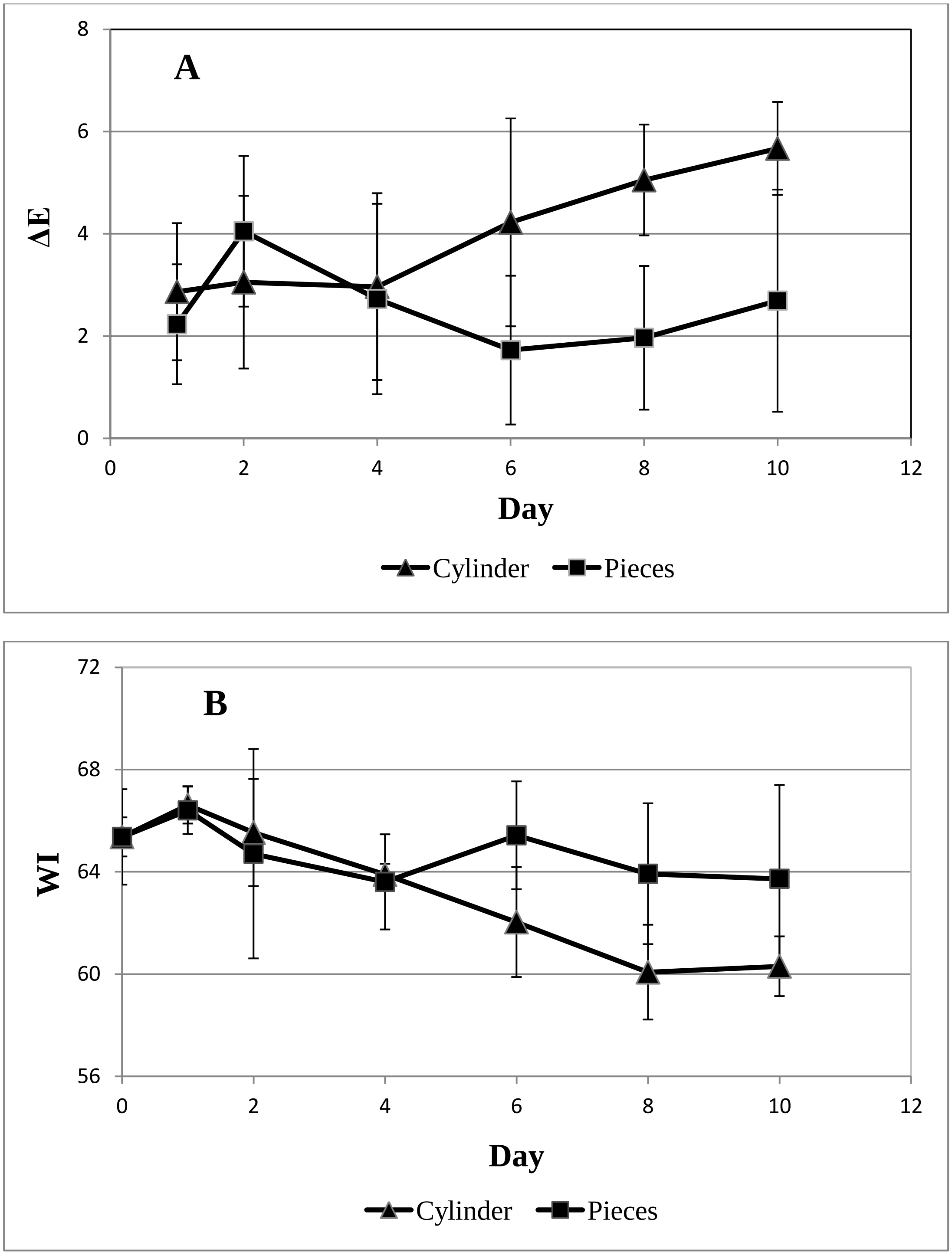

Fig. 2. Evolution of browning index (A) and whiteness index (WI) (B) parameters in minimally processed pineapple trays during refrigeration storage at 5 ºC considering both presentations.

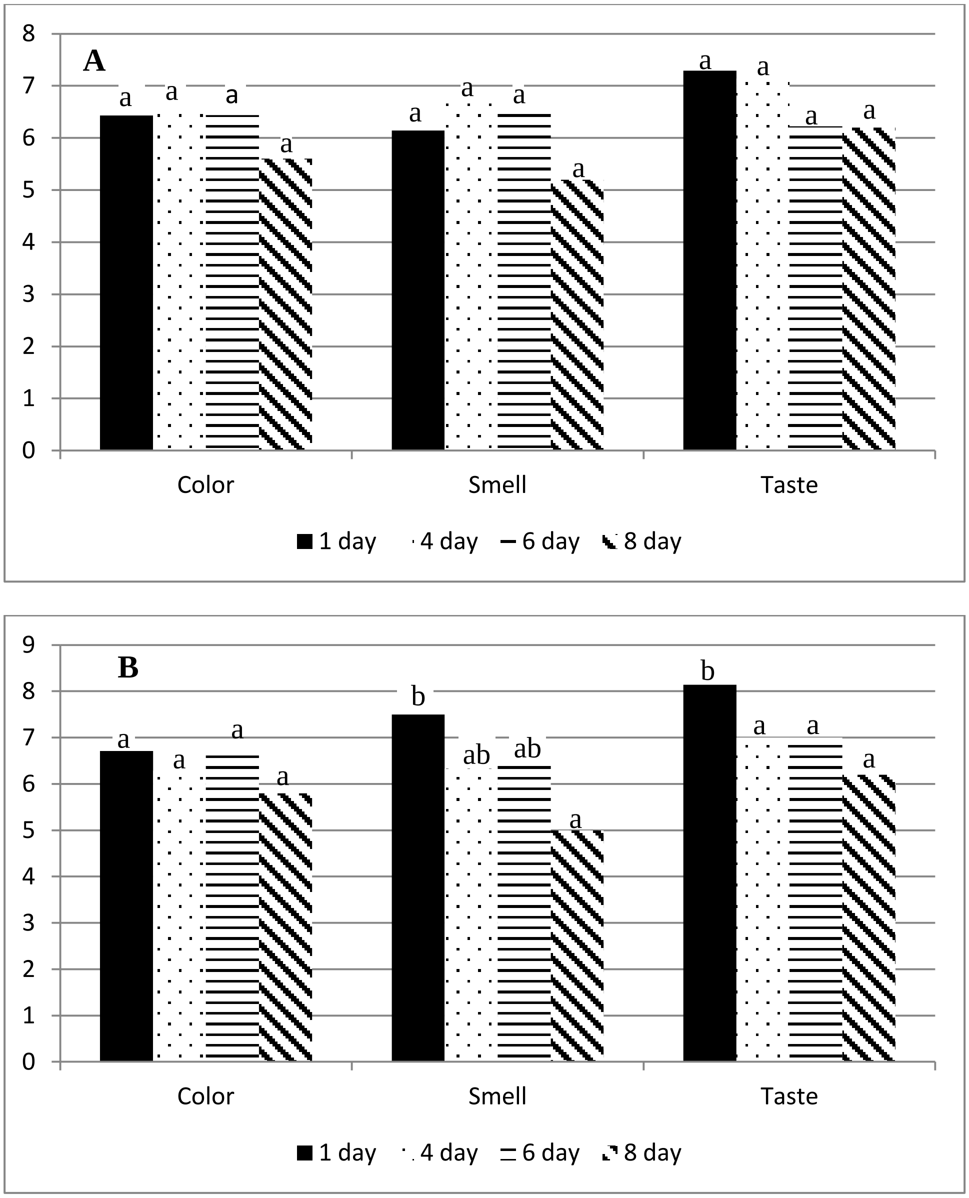

Fig. 3. External general appearance scores during 8 days at 5 ºC of storage considering both presentations (cylinder-A and pieces-B). Mean values within a parameter followed by different letters differ significantly ($p < 0.05$).

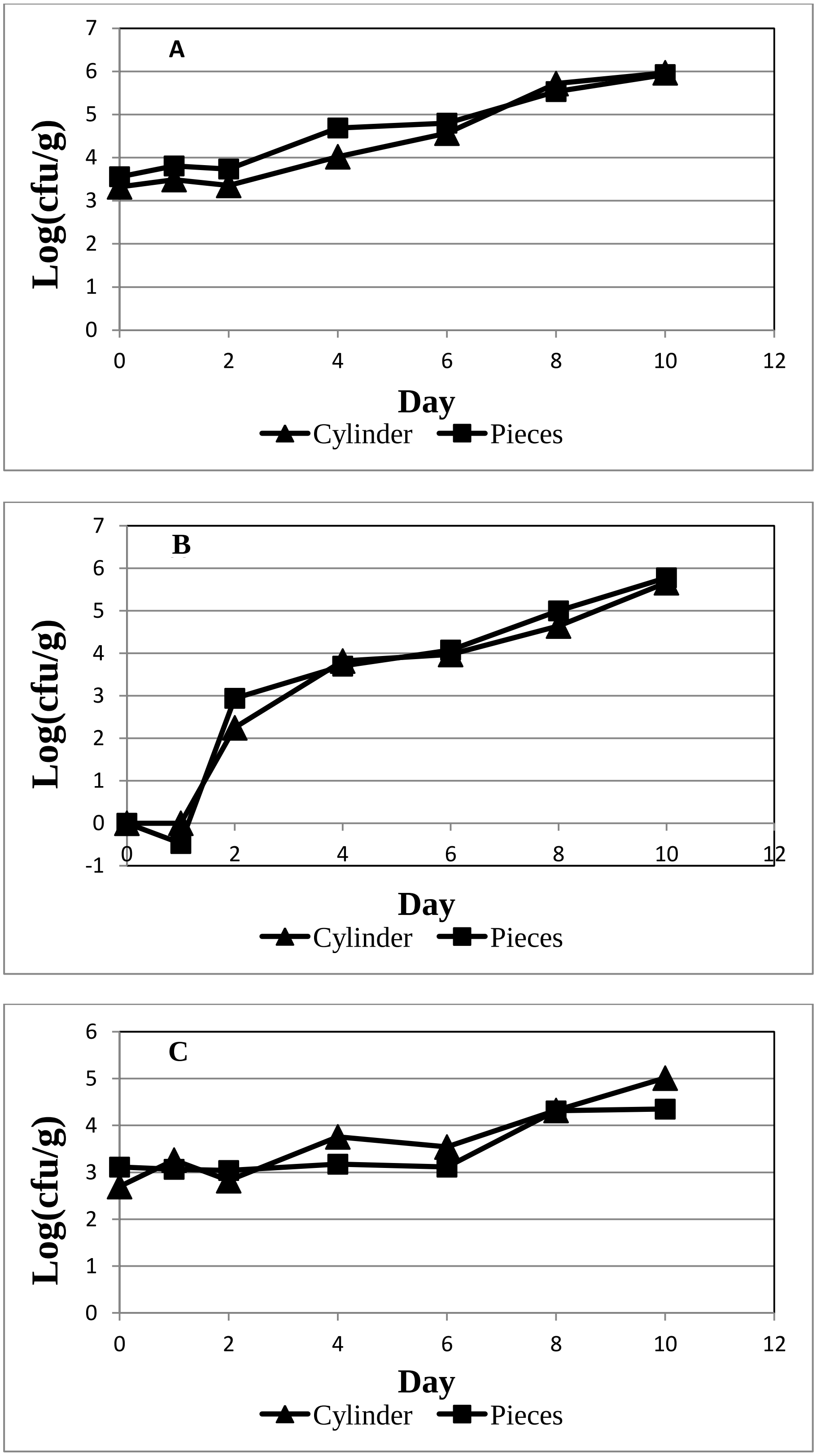

Fig. 4. Evolution of aerobic mesophile (A), psychrophile (B) and mold and yeast (B) in pineapples trays during refrigeration storage at 5 ºC considering both presentations.

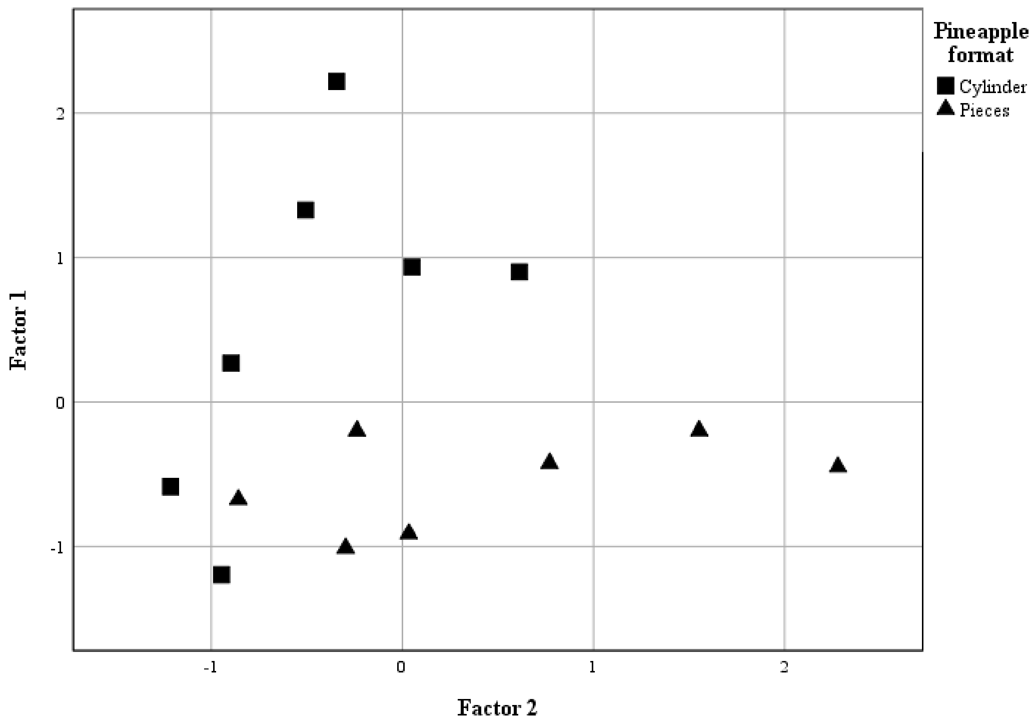

Fig. 5. Scores of the pineapple samples on axes representing the first and second factors differentiating both presentations.

***Conflict of Interest Form**

Conflict of Interest: The authors declare that they have no conflict of interest.