Benlloch Tinoco, M.; Igual Ramo, M.; Salvador Alcaraz, A.; Rodrigo Aliaga, MD.; Martínez Navarrete, N. (2014). Quality and acceptability of microwave and conventionally pasteurized kiwifruit puree. Food and Bioprocess Technology. 7(11):3282-3292. doi:10.1007/s11947-014-1315-9.

QUALITY AND ACCEPTABILITY OF MICROWAVE AND CONVENTIONALLY PASTEURISED KIWIFRUIT PUREE

María Benlloch-Tinoco[1], Marta Igual[1], Ana Salvador[2], Dolores Rodrigo[2], Nuria Martínez-Navarrete[1*]

[1]*Universitat Politècnica de València, Food Technology Department, Food Investigation and Innovation Group, Camino de Vera s/n, 46022 Valencia, Spain*

[2]*Instituto de Agroquímica y Tecnología de Alimentos (IATA-CSIC), Avda. Agustín Escardino 7, 46980 Paterna, Valencia, Spain*

[*]*Corresponding author. Tel.: +34 96 387 70 07x73655; fax: +34 96 387 73 69. E-mail address: nmartin@tal.upv.es (N. Martínez-Navarrete).*

Abstract:

The development and optimization of food preservation processes seems to be necessary in order to address consumer expectations related to secure, fresh-like foods. To this end, the sensory, nutritional and functional properties must be maximally retained. In order to contribute to the acquisition of knowledge about the adequacy of microwave processing as a means of preserving fruit-based products, the present study compares the impact of microwave heating with conventional thermal processing. The consumer acceptance of fresh and pasteurised kiwifruit puree was studied as was the content of water, soluble solids and bioactive compounds, the pH, consistency, viscosity, colour coordinates and antioxidant capacity as well as the effect of the thermal treatment on enzyme and microbial inactivation. As bioactive compounds, both the content of vitamins C, A, and E, and the total flavonoid, phenol and tannin content have been considered. As the obtained results show, not only was microwaved puree preferred by consumers but it also exhibited a superior maintenance of the nutritive and functional properties of the fruit, smaller colour changes and a content of inactivated enzymes and microorganisms equal to or greater than the conventionally heated sample.

Keywords: Consumer perception, bioactive compounds, enzymes, microorganisms, microwave heating, conventional heating.

1. INTRODUCTION

One of the most relevant trends in food manufacturing has stemmed from the recent increased demand for convenient, easy-to-preserve and health-promoting foods (Elez-Martínez et al. 2006). The development and optimization of novel food preservation processes seems to be a successful means of addressing consumer expectations, leading to the industrial sector showing a greater interest in exploiting new technologies (Señorans et al. 2003).

Bearing in mind the important role which the organoleptic characteristics of food play in the quality perception of a product, sensory assessment must be considered as an essential tool to help guide any modification of the food processing step, taking great care of what consumer expectations are and what information positively affects their decision to purchase (Di Monaco et al. 2005). However, to date, there still seems to be a need for sensory analyses that focus on the impact emerging technologies have on the consumer acceptance of processed products (Da Costa et al. 2000).

Microwave heating (MW) presents commercially proven applications with which to preserve fruit and vegetable products (Salazar-González et al. 2012). This technology could potentially replace conventional heat processes for some specific purposes, overcoming the slow heating rates found in conventional canning operations of thick materials (Awua et al. 2007) and offering the possibility of obtaining safe, stable and superior quality products (Salazar-González et al. 2012). However, as the currently published information on the consumer acceptance of microwaved products is both scarce and inconsistent, it has to be said that there is still a gap in knowledge concerning the fundamental understanding of the effects of MW when applied to food. In this regard, in-depth sensory research work is considered that could relevantly contribute to increase the knowledge of how MW affects food quality and, perhaps, to expand its use on an industrial level. Some of the few studies dealing with the sensory assessment of microwave processing applied to different food products have been conducted by Igual et al. (2013), Benlloch-Tinoco et al. (2012), Huang et al. (2007), Gerard and Roberts (2004), Guan et al. (2002), Valero et al. (2002) and Fathima et al. (2001), using different approaches to achieve their purpose. Triangle differentiation tests were employed by Gerard and Roberts (2004) and Igual et al. (2013) to compare the sensory properties of some fresh and microwaved apple juice or microwaved, conventionally heated and fresh grapefruit juice, respectively. Benlloch-Tinoco et al. (2012) and Huang et al. (2007) carried out a descriptive analysis of the sensory properties of a kiwifruit puree subjected to several microwave treatments and a microwaved green tea compared with a conventionally heat processed one. Guan et al. 2002, Valero et al. 2002 and Fathima et al. 2001 evaluated the impact of microwave processing on the consumer acceptance of shelf-stable macaroni and cheese, milk and selected greens. However, no available data have been found on the acceptance of kiwifruit-based products.

In order to contribute to the acquisition of knowledge about microwave processing as a means of preserving fruit-based products, the aim of the present study was to evaluate the impact of microwave and conventional thermal processing on both the consumer acceptance and on some chemical, physical and biochemical properties of a ready-to-eat kiwifruit puree. The properties analysed were the water, soluble solid and bioactive compound content, the pH, consistency, viscosity, colour coordinates and the antioxidant capacity of fresh and pasteurised purees, as well as the effect of the heating treatments on enzyme activity and microbial inactivation.

2. MATERIAL AND METHODS

2.1. Sample preparation

Kiwifruit (*Actinida deliciosa* var. Hayward) was purchased from a local supermarket. Fruit pieces, selected on the basis of a similar appearance and a soluble solid content of about 13-14 ºBrix, were peeled, washed with distilled water, cut into slices and triturated with a Thermomix (TM 21, Vorwerk, Spain), using the fourth power level for one minute.

2.2. Treatments

Processing conditions were chosen based on preliminary experiments to simulate pasteurization treatments in terms of the enzyme and microbial inactivation achieved (Benlloch-Tinoco et al. 2013; Zheng and Lu, 2011). After the assay of several power-time combinations for microwave heating and temperature-time combinations for conventional heating, those reaching 90% of POD inactivation and 5 $\log_{10}$ cycles of *L. monocytogenes* inactivation, described below, were selected to carry out the present work (Benlloch-Tinoco et al. 2012).

2.2.1. Microwave treatment

A microwave oven (model: 3038GC, NORM, China), provided with a glass turntable plate, was used to treat the kiwifruit puree. A sample of 500 g was tempered to an initial temperature of 25 °C and then heated in the microwave oven in a standard size glass beaker (9 cm inner diameter and 12 cm length) (BKL3-1K0-006O, Labbox, Spain) at 1000W for 340s. The temperature of the sample in the coldest spot, previously identified (data not shown), was continuously recorded by means of a fibre-optic probe (CR/JP/11/11671, Enelec, Spain) which was connected to a temperature datalogger (FOTEMP1-OEM, Enelec, Spain). The microwave treated samples (MW) were immediately cooled in ice-water until the puree reached 35 ºC.

2.2.2. *Conventional thermal treatment*

A vertical pilot plant scale stainless steel batch retort (Calderería Palou S.L., Barcelona, Spain) was used to carry out the conventional thermal process (C). A sample of 450 g was heated in a standard size tin can (7 cm inner diameter and 11.5 cm height) at 84ºC for 300 s. Prior to the treatment, the samples were preheated at 45 ºC to shorten and standardise the come-up time. Under these conditions, a come-up time of 18 min was needed to reach the treatment temperature. The product temperature was registered in the coldest spot of the sample using a thermocouple (type T) connected to a datalogger (Fluke 2176A, Fluke Corporation Inc, USA). Conventional thermally-treated samples (C) were immediately cooled in ice-water until the puree reached 35 ºC.

2.3. Sensory assessment

Testing was carried out in a sensory laboratory equipped with individual booths (ISO 8589 1988). Data acquisition was performed by using Compusense five release 5.0 software (Compusense Inc., Guelph, Ontario, Canada). A total of 82 consumers, 54 female and 27 male aged from 18 to 65 years old, took part in the study. All of them were asked if they were regular kiwifruit consumers. The consumers evaluated 3 samples (MW, C and the untreated one) which were tempered at 25 °C before the assessment and served in plastic disposable standard size containers identified with random three-digit codes, following a balanced complete block experimental design. Consumer acceptance testing was carried out using a 9-point hedonic scale (9 = like very much; 1 = dislike very much). The consumers scored their liking for the appearance, colour, odour, taste, sweetness, acidity, texture and overall acceptance of each sample. Additionally, the adequacy of three of the attributes (sweetness, acidity and texture) was measured using bipolar "just-about right" (JAR) scales (from 1=much too little to 5=much too much, with 3=just about right).

2.4. Analytical determinations

The treated samples and a non-treated sample used as control were analysed as described below. Each analysis was carried out in triplicate.

2.4.1. Physicochemical properties, enzyme activity and antioxidant activity

Water content, soluble solids, pH, consistency, viscosity, colour coordinates, peroxidase (POD), polyphenoloxidase (PPO) and pectinmethylesterase (PME) activity and antioxidant activity (AOA) were measured as described by Benlloch-Tinoco et al. (2012) and Benlloch-Tinoco et al. (2013).

2.4.2. Bioactive compounds

The content of vitamins C (Vit. C), A (Vit. A), and E (Vit. E) and total phenols (TP) were measured as previously described Igual et al. (2010) and García-Martínez et al. (2012).

Total tannins (TT) were evaluated spectrophotometrically, using the Folin-Denis method, which involves the reduction of the reagent by tannin compounds, as explained by Taira (1995) but with some modifications. The extraction consisted of homogenizing 5 g of the sample (T25 Janke and Kunkel turrax) with 45 mL of 0.56N HCl and boiled (100ºC) for 30 min. Then the homogenate was cooled, neutralised with 2N NaOH and centrifuged (10,000 rpm, 5 min, 4 ºC). The supernatant was brought to 100 mL with distilled water. An aliquot (1 mL) of this sample was mixed with 6 mL of distilled water, 0.5 mL of 1N phenol reagent (Sigma-Aldrich, Germany). The samples were well shaken and incubated for 3 min in darkness, 1 mL of 7.5% sodium carbonate aqueous solution and 1.5 mL of distilled water were added. Samples were allowed to stand for 1 h at room temperature before absorbance was measured at 725 nm in a UV-visible spectrophotometer (Thermo Electron Corporation, USA). The TT content was expressed as mg of gallic acid equivalents (GAE) per 100 g of kiwifruit, using a standard curve range of 0.05-0.34 mg of gallic acid (Sigma-Aldrich, Germany)/mL.

Total flavonoids (TF) were measured spectrophotometrically, following the method described by Djeridane et al. (2006) based on the formation of a flavonoid-aluminium complex. For total flavonoid quantification, 1 mL of the same extract used to measure TP content was mixed with 1 mL of 20g/L $AlCl_3$ methanolic solution. After incubation at room temperature for 30 min in darkness, the absorbance of the reaction mixture was measured at 430 nm using the aforementioned spectrophotometer. The TF content was expressed as mg of rutin equivalents (RE) per 100g of sample, using a standard curve range of 0-0.05 mg of rutin (Sigma-Aldrich, Germany)/mL.

2.4.3. *Microbiological analysis*

L. monocytogenes inactivation was evaluated as described by Benlloch-Tinoco et al. (2014). The total mesophilic bacteria (TMB) and yeast and mold (Y&M) counts were examined by diluting the uninoculated samples in 0.1% (w/v) sterile peptone water (Scharlab Chemie S. A., Barcelona, Spain) and enumerating the viable cells in Plate Count Agar (PCA, Scharlab Chemie S. A., Barcelona, Spain) and Potato Dextrose Agar (PDA, Scharlab Chemie S. A., Barcelona, Spain) acidified with tartaric acid (10%) (TA, Sigma-Aldrich, Germany), adding 1mL of TA per 10mL of PDA, respectively. The selected dilutions were incubated at 30ºC for 48 h for TMB and at 25ºC for 5 days for Y&M.

2.5. Statistical analyses

An analysis of variance (ANOVA) with one factor, at a confidence level of 95% ($p<0.05$), was applied using the Statgraphics Centurion XV software program (StatPoint Technologies, Inc., Warrenton, VA, USA) to evaluate the differences among samples. The JAR results were analysed by penalty analysis to identify potential directions for product improvement on the basis of consumer acceptance by highlighting the most penalizing attributes in terms of liking. A cluster analysis was carried out to classify consumers according to their preference patterns. Agglomerative Hierarchical Clustering (AHC) was performed using Euclidian distance with Ward's method as the aggregation criterion. XLSTAT 2009.4.03 statistical software (Microsoft, Mountain View, CA) was used to analyze sensory data and to study the correlation between physicochemical parameters and sensory attributes by using a Pearson correlation matrix.

3. RESULTS AND DISCUSSION

3.1. Consumer acceptance

3.1.1. Liking tests

A sensory analysis was performed to elucidate how the technology employed to preserve a ready-to-eat kiwifruit puree affected the consumer acceptance of the product. The treated (MW, C) and the untreated kiwifruit puree samples were tasted to this end. Consumers scored the overall acceptance, appearance, colour, odour, taste, sweetness, acidity and texture liking of the three samples. The consumers' scores are shown in Table 1. As expected, the fresh sample showed the highest scores for all the attributes evaluated. Most consumers' liking scores significantly ($p<0.05$) decreased after both treatments (MW and C). The microwaved puree presented intermediate scores, between the fresh and the conventionally heated sample. However, it should be noted that no significant differences between the sweetness, acidity and consistency of the fresh sample and MW sample were found. In turn, with the aim of gaining a better understanding of consumer responses, the liking results were also analyzed by clusters. Consumers were distributed into two clusters based on their different perception of the samples (Figure 1). The number of consumers in each cluster varied from one attribute to another. In this respect, cluster 1 and cluster 2 were formed by 59 and 22 consumers for “overall acceptance”, 51 and 25 consumers for “appearance”, 22 and 57 consumers for “colour”, 47 and 28 consumers for “odour”, 64 and 16 consumers for “taste”, 16 and 59 consumers for “sweetness”, 23 and 56 consumers for “acidity” and 27 and 43 consumers for “consistency”, respectively. The mean value of the different sensory attributes scored by each consumer cluster was studied by means of a one-way ANOVA. From Figure 1, it can be seen that none of the samples studied by cluster 2 gave any significant differences ($p<0.05$) between the overall acceptance and taste liking. This cluster was formed by a small number of consumers ($n=22$ for overall acceptance and $n=16$ for taste) and, in addition, between 55-75% of them did not frequently eat kiwifruit. However, cluster 1 basically liked MW better than the C sample. When odour was evaluated, small differences between samples were found by cluster 2, 50% of which was formed by consumers that did not frequently consume kiwifruit, but again cluster 1 preferred MW to C puree. For acidity and sweetness, cluster 1 seemed to like the treated samples (MW, C) more than the fresh one, while cluster 2 had a preference for the fresh sample and liked the sweetness of the MW sample significantly more ($p<0.05$) than the C . Although, the heating process seemed to have a noticeable impact on the perception of the samples’ sweetness and acidity, most consumers (cluster 2, n=56 for acidity and n=59 for sweetness) appreciated significant differences ($p<0.05$) between the treated samples in favour of MW. Additionally, 50-57% of those consumers who gave a similar score to MW and C did not frequently eat kiwifruit. As regards appearance and colour, the majority of the consumers (cluster 1, n=51 for appearance and cluster 2, n=57 for colour) preferred the appearance and colour of the fresh sample without detecting any significant differences ($p>0.05$) between the treated ones. The rest of the subjects exhibited a significant ($p<0.05$) preference for the fresh and MW samples. On the other hand, cluster 1 found small differences in the consistency of the samples, while most of the subjects (cluster 2, n=43) liked the fresh puree better, followed by the MW one and finally the C one. To sum up, when both treated samples were compared, cluster 1 significantly ($p<0.05$) preferred the MW puree in terms of its taste, colour, odour and overall acceptance, while cluster 2 significantly ($p<0.05$) preferred the MW puree over the C puree in appearance, consistency and sweetness, although no significant differences ($p>0.05$) between samples were found for the other attributes scored (Figure 1).

These results are a clear indicator of the fact that consumers much prefer and more readily accept the kiwifruit puree subjected to MW treatment than the conventionally heated one. Given the different nature of the heating processes that take place under conventional and microwave treatments, it has been recognised that MW allows reduced processing times and so a better maintenance of the nutritive, functional and sensory properties of food. This premise has been corroborated by different studies into the sensory properties of different food products when subjected to microwave process evaluation. Several authors reported that microwave processing allowed fruit and vegetable-based products, macaroni and cheese or milk to be obtained with acceptable, or indeed enhanced, sensory properties. When the comparison between microwaved and conventionally heated samples was established, it was mostly non-perceivable differences that were found and, in some cases, MW implied a better preservation of the evaluated sensory properties (Fathima et al. 2001; Gerard and Roberts 2004; Guan et al. 2002; Huang et al. 2007; Igual et al. 2013; Valero et al. 2002).

3.1.2. Attribute adequacy and its relationship with liking-penalty analysis

In order to improve the understanding of the attributes that most affected the liking ratings of the evaluated kiwifruit samples, a penalty analysis was carried out (Laguna et al. 2013). The significance of penalties (drops in overall liking) was based on the proportion of consumers stating that an attribute was "not enough" (−) or "too much" (+). So, an attribute was considered significant for liking when the respondent percentage of consumers was higher than 20% (Xiong and Meullenet, 2006) and the penalty score (drop in overall liking) was higher than 1. Significant penalties by percentage of consumers are presented in Figure 2. Bearing these criteria in mind, the fewer the attributes located in the upper right-hand corner of the penalty plot, the better the acceptance of the kiwifruit sample. According to the obtained results, the majority of the sensory attributes evaluated in this study were found to be adequate by consumers, with only "sweetness" and "acidity" penalizing and deviating from the ideal "right point" ones. In general terms, consumers perceived all the kiwifruit samples as "too acidic" and "not sweet enough". Accordingly, it might be assumed that heat processing (MW, C) did not promote this deviation from the ideal "sweetness" and "acidity" "right point" values, since this fact seemed to be mainly related to the low pH and °Brix values that are characteristic of the fresh fruit selected for the research work (see section 3.3).

3.2. Effect of treatments on inactivation of enzymes and microorganisms

The safety and stability of all the kiwifruit puree samples were investigated. In this respect, how effective both the microwave and conventional thermal treatments are at inactivating enzymes and microorganisms was checked. Table 2 shows POD, PPO and PME activity, TMB and Y&M counts and the $\log_{10}$ cycles reduced of *L. monocytogenes* for the treated and untreated kiwifruit puree. In general terms, the obtained values for enzyme activity (POD, PPO and PME) and the initial population of TMB and Y&M in the fresh kiwifruit puree were close to those reported by other authors working on this fruit and other similar fruit-based products (Benlloch-Tinoco et al. 2013; Picouet et al. 2009).

As expected, MW and C treatments provoked the level of enzyme inactivation and microbial decontamination required of them in order to be considered as adequate pasteurization processes. Both treatments inactivated 90% of POD, the enzyme selected as an indicator of treatment efficiency, (Benlloch-Tinoco et al. 2013; Zheng and Lu 2011) and reduced more than 5 $\log_{10}$ cycles of the most important pathogenic microorganism (*L. monocytogenes*), taking into consideration the characteristics of the product (FDA, 2004; NACMCF¸ 2006). Neither the POD inactivation nor the *L. monocytogenes* inactivation were found to be different ($p>0.05$), regardless of whether the samples were treated conventionally or by microwave (Table 2). In the same way, MW and C processing similarly ($p>0.05$) reduced the content of TMB (2.8 $\log_{10}$ cycles) and Y&M (2.4 $\log_{10}$ cycles) in the puree. However, MW was shown to be significantly more effective at inactivating PPO and PME enzymes than the C treatment ($p<0.05$). Other authors have reported that microwaves are more effective than conventional heating at inactivating enzymes in fruit or vegetable products, which seems to be related to the interaction of microwave energy with the polar and/or charged moieties of these compounds. In this regard, Tajchakavit and Ramaswamy (1997), Matsui et al. (2008) and Zheng and Lu (2011) found that MW was faster at inactivating PME in orange juice, PPO and POD in coconut water and POD in carrot, respectively, than other conventional heating methods.

3.3 Effect of treatments on the physicochemical properties, bioactive compounds and antioxidant activity

The physicochemical properties, the content of the major bioactive compounds and the antioxidant activity of the kiwifruit puree, before and after processing, are summarised in Table 3. The fresh sample used in this work presented the characteristic values of all the analysed properties shown in the bibliography for kiwifruit (Fiorentino et al. 2009; Park et al. 2011; Zolfaghari et al. 2010). As previously reported by other authors, kiwifruit has a high content of vitamin C and E along with a marked antioxidant activity. Actually, its content of vitamin C is even higher than that found in grapefruit and orange (Igual et al. 2010), citric fruits which are widely recognized as a good source of this bioactive compound. Given the substantial content of such vitamins (C, E), kiwifruit is assumed to provide an antioxidant protective effect under both hydrophobic and hydrophilic conditions (Tanaka et al. 1997). All these excellent nutritional and functional characteristics were highlighted by Fiorentino et al. (2009), who defined this fruit as a unique and precious cocktail of protective phytochemicals.

The parameters shown in Table 3 were used to evaluate the impact of MW and C treatments on the quality of the product. From Table 3, it can be observed that TT content and pH were the sole parameters to remain significantly ($p>0.05$) unchanged after processing. The a* and b* colour coordinates were affected in a similar way by both MW and C heating. While the a* values significantly increased as a consequence of processing, the b* values significantly ($p<0.05$) decreased, these differences being higher when the C treatment was applied. Accordingly, processed samples slightly changed to redder, less yellow tones. However, the L* coordinate was exclusively affected by the MW treatment that gave place to a significantly ($p<0.05$) more luminous kiwifruit puree (Table 3). This increase in luminosity has been previously described and could be mostly attributed to the degradative loss of pigments instead of to the typical browning reactions in heating processes (Benlloch-Tinoco et al. 2012). The total colour difference parameter was calculated with respect to the non-treated sample. Both treatments lead to colour differences which are noticeable to the human eye ($\Delta E^*>3$, Bodart et al. 2008), with the ΔE^* value being significantly ($p<0.05$) higher in the C sample. On the other hand, as expected, both MW and C treatments significantly ($p<0.05$) increased the consistency and viscosity of the puree, changes that can be explained by the increase in the soluble pectin content in the aqueous phase of the product (pectin solubilisation) due to the high temperatures reached (Contreras et al. 2007). As regards the effect of the treatments on the bioactive compounds and the AOA of the samples, significant ($p<0.05$) losses were found in all the analysed compounds, except TT, vitamin A being the most labile (loss of 100%) (Table 3). The impact of the heating processes on the bioactive compound content of several fruit-based products has been reviewed by Rawson et al. (2011), who highlighted thermal pasteurization as a treatment severe enough to reduce the levels of most bioactive compounds present in fruit, with vitamins found to be among the most heat-sensitive food components (Awuah et al. 2007). Although simple thermal decomposition would appear to be the most likely cause for these losses, their degradation may be a complex phenomenon which is also dependent on oxygen, light, pH, water solubility and the presence of chemical, metal or other compounds that could catalyse deteriorative reactions (Awuah et al. 2007). On the other hand, the changes observed in the rest of the bioactive compounds and AOA were significantly ($p<0.05$) higher when kiwifruit puree was conventionally heated. In this respect, a loss of 0.5% and 26.7% of vitamin C, 9.4% and 83.3% of vitamin E, 21.8% and 29.5% of TP, 36.2% and 50.9% of TF and 65.7% and 77.6% of AOA under MW and C treatments were found, respectively. The results obtained point out that microwave processing allowed the nutritional and functional properties of the kiwifruit puree to be better maintained than the conventional thermal treatment. Similar results have been extensively reported in the bibliography. Igual et al. (2010) found a superior retention of ascorbic acid in grapefruit juice pasteurized by microwaves when compared to a conventional pasteurization treatment. Barrett and Lloyd (2012) reviewed the effect of microwave processing on the bioactive compounds of products of vegetable origin and reported that microwaves, more than conventional heating, lead to a relatively high retention of the vitamin C in most fruits and vegetables. In the same way, microwaves allowed the phenolic compounds of unpeeled potatoes, tomatoes and spinach to be better retained than boiling water.

3.4. Correlation between Instrumental and Sensory Data

A Pearson correlation matrix was constructed using the instrumental and sensory data (data not shown). Significant ($p<0.05$) and meaningful correlations were found between instrumental parameters and sensory descriptors. In this regard, sensory “appearance” (R^2=-0.999) and “colour” (R^2=-0.999) were negatively correlated with the instrumental a* parameter. Taking into consideration that negative a* values are associated with green tones, as expected, the lower the a* values corresponding to the sample, the better the consumers liking of the product’s appearance and colour. Additionally, sensory “taste” was positively correlated with sensory “sweetness”

(R^2=0.999), “acidity” (R^2=0.999) and “consistency” (R^2=0.999). In the same way, “overall acceptance” was positively correlated with sensory “taste” (R^2=0.999), “acidity” (R^2=0.999) and “consistency” (R^2=0.999). Accordingly, the sweeter, the more acid and the thicker, the better the taste liking and the greater the overall acceptance of the kiwifruit puree.

4. CONCLUSIONS

The results obtained in this study clearly pointed out that microwaved kiwi puree was preferred by the consumers from a sensory point of view. Besides, microwave processing not only better preserved the nutritive and functional properties of the fruit and produced smaller colour changes, but also inactivated enzymes and microorganisms to the same, or greater, extent than conventional heating.

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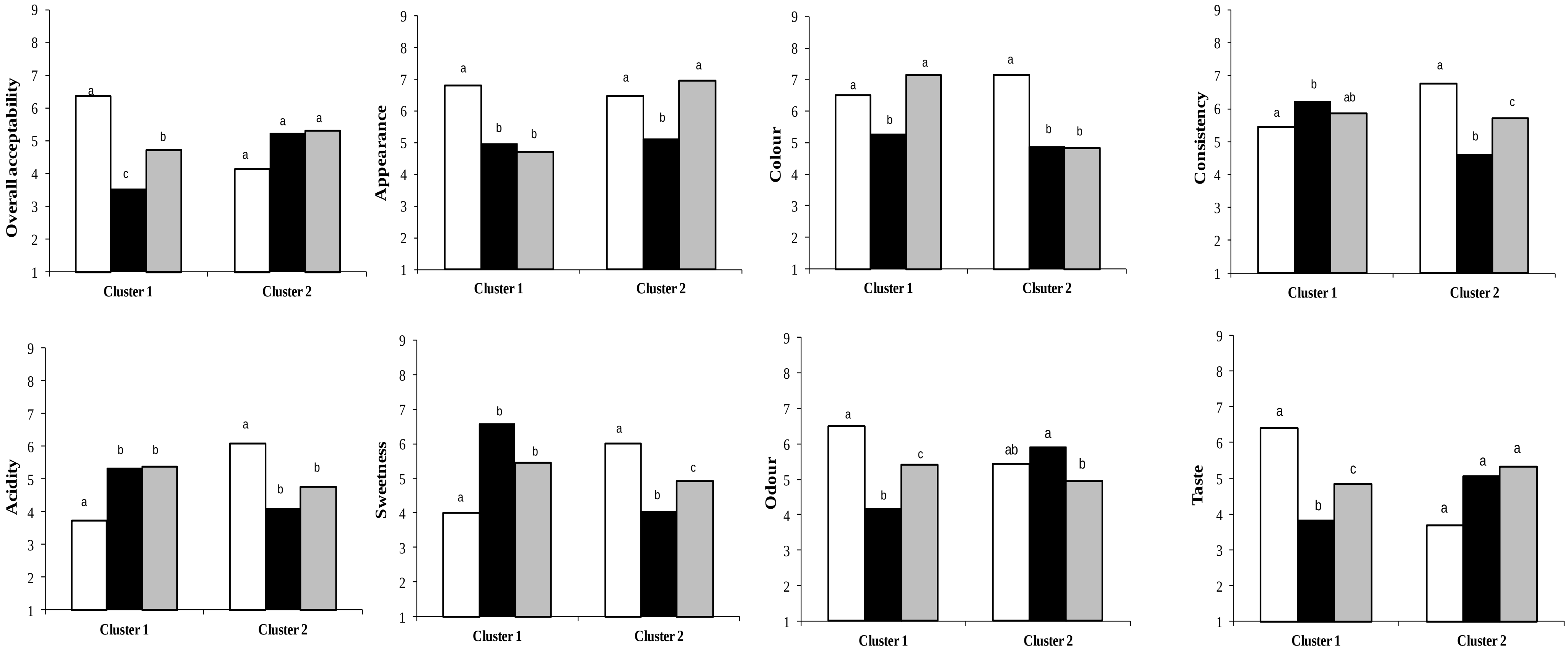

Figure 1. Mean values of the different sensory attributes scored by each consumer cluster corresponding to the fresh (□), conventionally heated (■) and microwaved (■) kiwifruit puree. Identical letters for each cluster indicate no significant difference among the samples according to the Tukey's test ($p<0.05$).

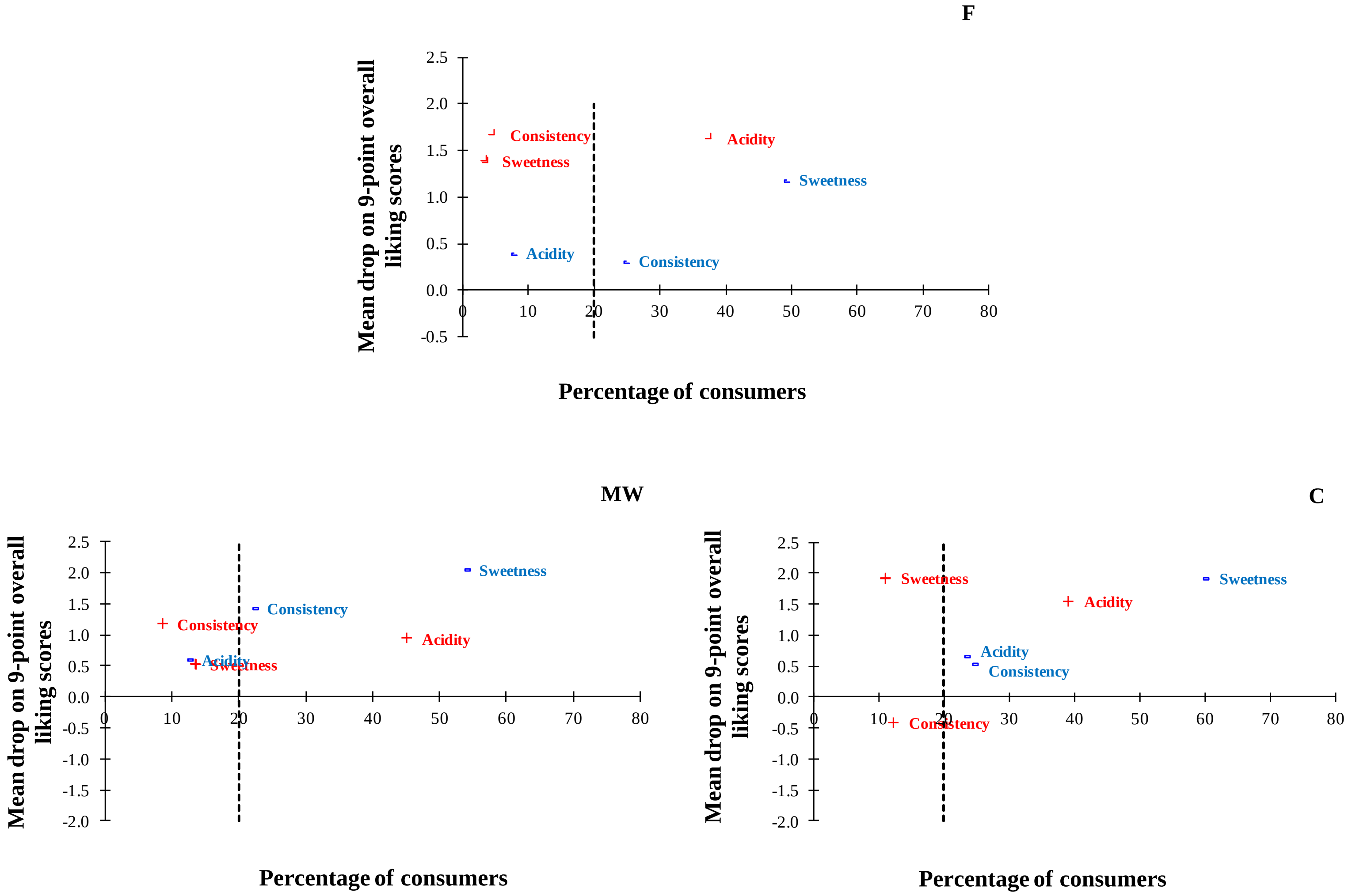

Figure 2. Representation of significant penalties (drops in liking) by proportion of panellists for the fresh (F), microwaved (MW) and conventionally heated (C) kiwifruit puree.

Table 1. Mean values of the different sensory attributes scored by consumers (n=82) corresponding to the fresh (F), microwaved (MW) and conventionally heated (C) kiwifruit puree.

	F	MW	C
Overall acceptance	5.76^{a}	4.90^{b}	4.01^{c}
Appearance	6.67^{a}	5.51^{b}	5.11^{b}
Colour	6.96^{a}	5.52^{b}	5.06^{b}
Odour	6.00^{a}	5.22^{b}	4.84^{b}
Taste	5.87^{a}	4.96^{b}	4.13^{c}
Sweetness	5.51^{a}	5.00^{ab}	4.60^{b}
Acidity	5.39^{a}	4.95^{ab}	4.49^{b}
Consistency	6.17^{a}	5.74^{ab}	5.31^{b}

In rows, different letters denote significant differences ($p<0.05$) according to the Tukey's test.

Table 2. Average values (and standard deviation) of peroxidase (POD), polyphenoloxidase (PPO) and pectinmethylesterase (PME) activity, total mesophilic bacteria (TMB) and yeast and mold (Y&M) counts and $\log_{10}$ cycles reduced of *L. monocytogenes* of fresh (F), microwaved (MW) and conventionally heated (C) kiwifruit puree.

	F	**MW**	**C**
POD ($Abs \cdot min^{-1} \cdot g^{-1}$)	10.2 (0.2)^{b}	1.05 (0.02)^{a}	1.11 (0.05)^{a}
PPO ($Abs \cdot min^{-1} \cdot g^{-1}$)	6.77 (0.07)^{c}	1.31 (0.04)^{a}	2.3 (0.2)^{b}
PME ($U \cdot g^{-1}$)	0.43 (0.04)^{c}	0.045 (0.011)^{a}	0.10 (0.06)^{b}
TMB (log CFU/mL)	3.08 (0.12)^{b}	0.27 (0.10)^{a}	0.24 (0.13)^{a}
Y&M (log CFU/mL)	2.88 (0.10)^{b}	0.44 (0.07)^{a}	0.46 (0.06)^{a}
L. monocytogenes ($\log(N/N_0)$)	-	-7.0 (0.2)^{a}	-6.96 (0.11)^{a}

In rows, different letters denote significant differences ($p<0.05$) according to the Tukey's test.

Table 3. Mean values (standard deviation) of content of water (x_w), soluble solid (ºBrix), vitamin C (Vit. C), vitamin A (Vit. A), vitamin E (Vit. E), total phenols (TP), total flavonoids (TF) and total tannins (TT), antioxidant activity (AOA), pH, consistency, viscosity, colour coordinates (L*, a* and b*) and colour diference (ΔE) of fresh (F), microwaved (MW) and conventionally heated (C) kiwifruit puree.

	F	**MW**	**C**
x_w (g/100g)	85.17 (0.13)^b	84.4 (0.2)^a	84.9 (0.2)^b
ºBrix (g/100g LP)	13.67 (0.06)^a	14.33 (0.06)^c	13.9 (0.2)^b
Vit. C (mg/100g)	75.9 (1.3)^b	75.5 (1.1)^b	55.63 (0.07)^a
Vit. A (mg/100g)	0.057 (0.007)^b	ND^a	ND^a
Vit. E (mg/100g)	2.45 (0.06)^c	2.22 (0.07)^b	0.41 (0.05)^a
TP (mg GAE/100g)	22 (2)^c	17.2 (0.5)^b	15.5 (0.2)^a
TF (mg RE/100g)	1.16 (0.05)^c	0.74 (0.06)^b	0.57(0.02)^a
TT (mg GAE/100g)	14.40 (0.10)^a	10.6 (0.8)^a	9.9 (0.3)^a
AOA (mM Trolox/g)	5.81 (0.05)^c	1.99 (0.06)^b	1.3 (0.3)^a
pH	3.33 (0.02)^a	3.33 (0.02)^a	3.34 (0.02)^a
Flow distance (mm/g)	5.1 (0.2)^b	3.3 (0.2)^a	3.0 (0.8)^a
Viscosity (Pa·s)	1.57 (0.06)^a	2.3 (0.2)^c	1.87 (0.02)^b
L*	40.17 (0.02)^b	41.71 (0.02)^c	39.423 (0.006)^b
a*	-1.557 (0.006)^a	1.027 (0.006)^b	1.707 (0.006)^c
b*	30.700 (0.010)^c	26.74 (0.02)^b	26.60 (0.03)^a
ΔE	-	4.98 (0.09)^a	5.29 (0.02)^b

LP: liquid phase; ND: not detected

In rows, different letters denote significant differences ($p<0.05$) according to the Tukey's test.