XIII EQA

PORTO 14-16 SETEMBRO

LIVRO DE ATAS

Livro de Atas do XIII Encontro de Química dos Alimentos

Disponibilidade, valorização e inovação: uma abordagem multidimensional dos alimentos

14 a 16 de setembro de 2016

Porto, Portugal

Universidade do Porto
LAQV/REQUIMTE
Sociedade Portuguesa de Química

Ficha Técnica

Título: Livro de Atas do XIII Encontro de Química dos Alimentos

Autor: Comissão Organizadora

Tipo de suporte: Eletrónico

Detalhe do suporte: PDF

Edição: 1.ª Edição

ISBN: 978-989-8124-15-9

Ano 2016

Esta publicação reúne as comunicações apresentadas no XIII Encontro de Química dos Alimentos sob a forma de ata científica.

A aceitação das comunicações foi feita com base nos resumos apresentados: o texto integral que aqui se reúne é da inteira responsabilidade dos autores.

Influence of packing material on the quality parameters and bioactivity of smoothies

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Keywords: smoothie; physico-chemical profile; functional properties; shelf-life.

ABSTRACT

Smoothies are blended beverages that might include fruit pulp, fruit juice, vegetables, yoghurt or milk. These products are good examples of the food industry reply to the growing awareness of consumers regarding healthier foods with simple ingredients and clean labels. As relatively new products, different profiling studies are needed to ensure their claimed properties. Furthermore, different packing materials are used, which might be related with the smoothies' quality throughout their shelf-life. Accordingly, different physicochemical parameters and bioactivity indicators were assessed in commercial smoothies packed in three different materials: clear polyethylene terephthalate (PET), opaque high density polyethylene (HDPE) and TetraPrisma® aseptic (TetraPak®), along different shelf-life periods. Linear discriminant analysis was used to allow a suitable comprehension of the obtained results [1]. To overcome potentially biased outcomes induced by the compositional dissimilarity among smoothies, the statistical analysis were conducted on the differences measured throughout shelf-life, instead of the absolute values. In general, HDPE packed smoothies showed a higher capacity to retain their flavonoid contents along the shelf-life, besides maintaining more effectively the lightness parameter. Furthermore, chroma and total titratable acidity tended to be preserved in PET and TetraPak® packing. On the other hand, the antioxidant activity (DPPH radicals scavenging activity and reducing power) and the contents in total phenols and tannins could not be effectively maintained in any case. Despite the found differences, the results seem to indicate that none of the available packing materials represents a totally effective solution.

1. INTRODUCTION

Smoothies are blended beverages containing fruit, fruit juice, yoghurt, milk, or honey.

Fruit smoothies are recent available options in the food market, which could be a convenient choice to complement a healthy diet, due to their health-promoting properties [2]. In fact, smoothies might inclusively be considered as examples of the so called superfoods, which are defined as natural foods regarded as especially beneficial because of its nutrient profile or its health-protecting qualities [3].
Thermal processing is the most common method to extend shelf storage of juice drinks [2], but some smoothies are often minimally processed, contributing to the preservation of "fresh-like" flavors, taste, appearance and nutritional properties [4], thereby avoiding some of the pitfalls of traditional thermal preservation, such as reactions leading to undesirable organoleptic texture properties and loss of nutritionally beneficial components [5]. Considering preventive nutrition principles, it is of utmost importance to know their composition in bioactive components. Therefore, different quality parameters (pH, titratable acidity, total soluble solids and chromatic indicators) and bioactive compounds (total phenolics, flavonoids and tannins) were evaluated in 16 types of smoothies. The antioxidant activity was also measured through the ferric reducing antioxidant power (FRAP) and 2,2-diphenyl-1-picrylhydrazyl (DPPH·) scavenging ability. To evaluate eventual changes along the products' shelf storage, the laboratory analyses were performed in samples submitted to different storage periods, from purchasing date until a maximum period of 21 days; differences found within each period were characterized by applying a general linear model (GLM). Furthermore, the interactions among smoothie formulation and packing material (clear polyethylene terephthalate, opaque high density polyethylene and TetraPak®) with all the reported parameters were studied using linear discriminant analyses (LDA).

2. MATERIALS AND METHODS

2.1. Sampling

Smoothies were selected in local supermarkets and herbalist shops, according to: i) "smoothie" denomination in the label; ii) "smoothie" denomination in the profile shelf; iii) attributes of the product associated to the smoothie definition. In addition, information in labels was in agreement with the latest guidelines of the Food and Drug Administration, which indicate that beverages that purport to contain juice (fruit or vegetable juice) must declare the correspondent percentage. For each smoothie, three samples of the same lot were acquired and stored in similar conditions as in the market (4 ºC and controlled light exposure using a glassy transparent refrigerator). In order to have products with similar production timing, all selected samples had the same (or highly similar) expiration date. All smoothies were clarified and filtered before performing the analytical assays.

2.2. Chemical and physical analysis

pH was measured directly in each sample with a pH meter Basic 20+ (Crison, Barcelona, Spain). TTA was expressed in g malic acid/100 mL of product. TSS was determined using a digital refractometer HI 96801 (Hanna Instruments, Cluj-Napoca, Romania) with automatic temperature compensation and the results were expressed in ºBrix. Chromatic parameters were measured using a colorimeter Chroma meter CR-400 (Konica Minolta, Tokyo, Japan) using the CIELab system [1].

Total phenolics, total flavonoids and tannins contente were spectrophotometrically determined [1]. Total phenolics, total flavonoids and total tannins respectively expressed as milligrams of gallic acid equivalents (GAE), epicatechin equivalents (EE) and tannic acid equivalents (TAE) per 100 mL of smoothie.

2.3. Antioxidant activity

Ferric reducing antioxidant power (FRAP) and DPPH· scavenging activity were evaluated as indicators of the antioxidant activity [1]. FRAP and DPPH· scavenging activity were respectively expressed as mg of ferrous sulfate equivalents (FSE) and mg of trolox equivalents (TE) per 100 mL of smoothie.

2.4. Statistical analysis

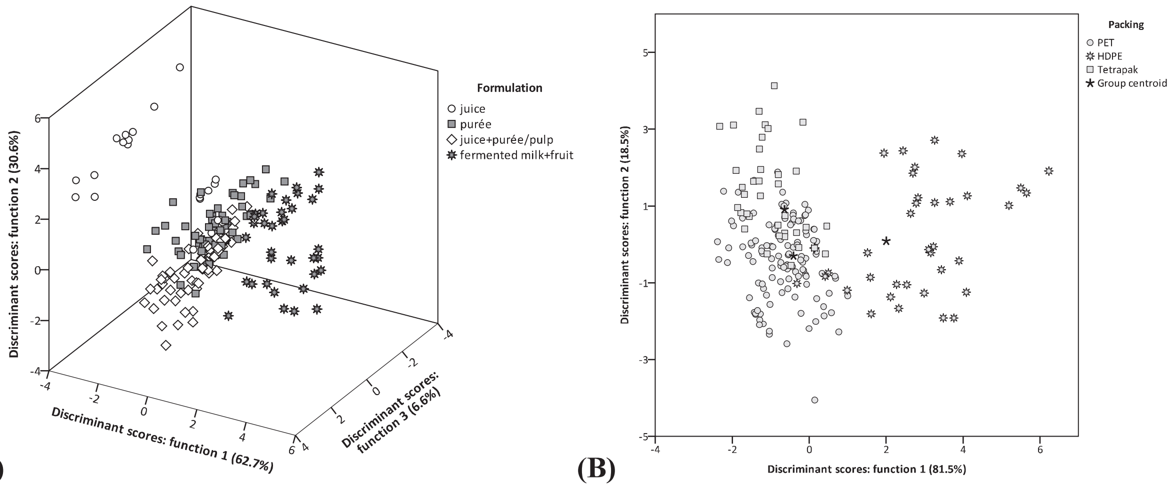
LDA was used to evaluate the association of variations in the measured parameters with, sequentially, smoothie formulation, packing type and shelf storage period. A stepwise technique, using the Wilks' λ method with the usual probabilities of F (3.84 to enter and 2.71 to remove), was applied for variable selection. With this approach, it is also possible to identify the significant variables that contribute most to the discrimination of smoothie formulation, packing type or shelf storage period. All statistical tests were performed at a 5% significance level using the SPSS software, version 22.0 (IBM Corp., Somers, New York).

3. RESULTS AND DISCUSSION

LDA was mainly applied to evaluate the effects of smoothie formulation and packing material over the analyzed parameters throughout the shelf-life of the product. Due to the variation among smoothies, the values were normalized. In this way, the classification procedures were applied to the differences occurring throughout the shelf storage, and not to the absolute values measured for each parameter.

In the discriminant model obtained to verify if a particular SF was more prone to the changes along the shelf storage period, three functions were defined as being significant (**Figure 2A**) integrating 100% of the variance (first: 62.7%; second: 30.6%; third: 6.6%). The variables selected as having discriminant ability were pH, TTA, TSS, L*, C*, Hº and flavonoids. Neither function 1, nor function 2, allowed an effective separation of the groups corresponding to each formulation. In fact the differences along time, led to a poor classification performance, classifying correctly only 59.4% of the assayed smoothies for the originally grouped cases, and 58.7% of the cross-validated cases. This indicates the inexistence of a formulation more susceptible to undergone more relevant shelf storage changes in the evaluated parameters.

A similar result was obtained in the assessment of the interaction with the packing type. The defined functions included 100% of the observed variance (first: 81.5%; second: 18.5%), selecting the same variables as in the previous LDA. Likewise, the defined functions had no ability to separate the markers corresponding to each of the assayed packing types (Figure 2B). The differences registered in the measured parameters along time were not effective to separate the assayed packing types, classifying correctly only 72.6% of the smoothies for the originally grouped cases, and 70.5% of the cross-validated cases.



(A) (B)

Figure 2. Mean scores of different SF projected for the three discriminant functions (A) and different packing types for the two discriminant functions (B).

5. CONCLUSION

A general decrease in the amount of the bioactive compounds and antioxidant activity was verified throughout smoothies' shelf storage, especially on the 21st day. This decrease was independent of fruit content, formulation and packing type, as verified in the linear discriminant analysis. Nevertheless, considering the assayed, samples the overall physicochemical quality was maintained during the entire shelf storage period. Ideally, the bioactive properties would also be maintained, but the present solutions do not seem to be sufficiently effective.

Acknowledgements
The authors are grateful to Foundation for Science and Technology (FCT, Portugal) for financial support to REQUIMTE (PEst-C/EQB/LA0006/2014) and to CIMO (UID/AGR/00690/2013). J.C.M. Barreira and R.C. Alves thank FCT, POPH-QREN and FSE for their grants (SFRH/BPD/72802/2010 and SFRH/BPD/68883/2010, respectively).

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