Emirates Journal of Food and Agriculture. 2022. 34(3): 176-179
doi: 10.9755/ejfa.2022.v34.i3.2830
http://www.ejfa.me/

RESEARCH ARTICLE

Evolution of the characteristics of the hackberry (*Celtis australis* L.) fresh flesh stored under refrigeration conditions

Esther Vidal Cascales, Joaquín Salmerón Teruel, José María Ros García*

Department of Food Science & Technology and Human Nutrition, University of Murcia, Campus de Espinardo, 30100 Murcia, Spain

ABSTRACT

The characteristics of the hackberry (*Celtis australis* L.) fresh flesh stored under refrigeration conditions during ten weeks have been investigated. The hackberries were harvested at maturity (October) in Moratalla (Spain). The flesh was obtained using a pilot scale rotational sieve. Sterile plastic containers of 150 grams were fully filled with the hackberry fresh flesh and stored at 5ºC. Three containers were sampled at time intervals (initial, 1, 2, 4, 6, 8 and 10 weeks). The following parameters were analysed in the samples of hackberry fresh flesh: physicochemical characteristics (pH, soluble solids, titratable acidity, colour, moisture and water activity) and the microbiology (bacteria, yeasts and moulds). The results indicated that the pH decreased from 6.7 (initial) to 5.1 (10 weeks) and the titratable acidity increased from 0.48 g ACA/100 g (initial) to 1.26 g ACA/100 g (10 weeks), while the other physicochemical characteristics were constants during the ten weeks of refrigerated storage. The microorganisms were the key factor to stablish the acceptability of the fresh flesh. There was only the growth of the aerobic mesophilic from 9.0 x 10^5 cfu/g (initial) to 3.5 x 10^7 (8 weeks) and 2.8 x 10^7 (10 weeks of refrigerated storage). These results are to be considered for the use of the refrigerated hackberry fresh flesh as a natural ingredient at both domestic and industrial level.

Keywords: Hackberry; Characteristics; Storage; Refrigeration; *Celtis australis*

INTRODUCTION

The hackberry is the fruit from a tree with scientific name *Celtis australis* L. The hackberry trees grow in the forest and their fruits are wild (Magni and Caudullo, 2016). The economic importance of its cultivation has not yet been established, although, considering the interesting characteristics of the hackberries (Demir et al., 2002; Ota et al., 2017; Vidal-Cascales et al., 2021), its cultivation in orchards for controlled production would indeed have economic interest.

The fruits and the leaves of *Celtis australis* have compounds active against human diseases (Demir et al., 2002; Magni and Caudullo, 2016; Ota et al., 2017), and the fruits have also food uses since, at maturity, the flesh -the edible part- is very sweet (Vidal-Cascales et al., 2021). Ota et al. (2017) reported that hackberries may be a useful ingredient in natural products confection due to their high amounts of sugars, fibre and antioxidants. This would be considered of interest for its use as a sweeting agent with antioxidant characteristics by the food industry (Vidal-Cascales et al., 2021). In this sense, it is required knowledge on the shelf-life of the flesh, being a first step its refrigerated storage.

The objective of this research is to get knowledge on the evolution of the hackberries fresh flesh during its refrigerated storage. With this purpose the physicochemical characteristics (pH, soluble solids, titratable acidity, colour, moisture and water activity) and the microbiology (bacteria, yeasts and moulds) were investigated. The shelf-life has been established, as a basis for the use of the hackberry fresh flesh as ingredient in domestic and industrial food applications.

MATERIALS AND METHODS

Geographical origin and harvesting of the fresh hackberry

The hackberry fruits (Fig. 1) were harvested in October 2018, being pick up from wild trees growing in the forests

***Corresponding author:**
José María Ros García, Department of Food Science & Technology and Human Nutrition, University of Murcia, Campus de Espinardo, 30100 Murcia, Spain. **E-mail:** jmros@um.es

Received: 14 September 2021; **Accepted:** 27 February 2022

of Moratalla (38° 11' N, 1° 53' W, altitude: 700-800 m), Spain. More details were published previously (Vidal-Cascales et al., 2021).

Processing of the fresh hackberries and cold storage

Hackberries were fractionated using a pilot scale rotational sieve (Fig. 2), which produced the hackberry fresh flesh (Fig. 3 and 4) and a residue of peels and stones. The sieve used has a diameter hole of 0.2 mm. Then sterile plastic containers of 150 grams were fully filled with the hackberry fresh flesh and stored at 5ºC. Three containers were sampled at time intervals (initial, 1, 2, 4, 6, 8 and 10 weeks).

Physicochemical characteristics of the hackberry fresh flesh

The pH (pHmeter), soluble solids (refractometer), titratable acidity (titration), colour (Minolta reflectance colorimeter), moisture (oven dehydration) and water activity (Novasina) were measured as reported by Vidal-Cascales and Ros-García (2020).

Fig 1. The hackberry (*Celtis australis* L.) fruits.

Fig 2. A view of the pilot scale rotational sieve.

Microbiology

The microbiological analysis was carried out according to standardized procedures: Aerobic mesophilic (ISO 4833-2: 2013), *Escherichia coli* (ISO 16649-1: 2018), total coliforms (ISO 4832: 2006), *Staphylococcus spp* (ISO 6888-1:2000/A2: 2019), *Listeria monocytogenes* (ISO 11290-1: 2017), *Salmonella spp* (ISO 6579-1: 2017), moulds and yeasts (ISO 21527-1: 2008).

Table 1: Evolution of the physicochemical characteristics of the hackberry fresh flesh stored under refrigeration conditions (5ºC) up to 10 weeks

	Initial	1	2	4	6	8	10
pH	6.7	6.4	6.3	5.9	5.7	5.6	5.1
Soluble solids (ºBrix)	50.0	50.1	50.0	49.9	50.0	50.0	50.1
Acidity (g ACA/100 g)	0.48	0.60	0.75	0.84	0.87	1.02	1.26
Colour L*	20.1	20.0	20.0	20.1	20.2	20.1	20.1
a*	4.0	3.9	3.9	4.0	4.1	4.0	3.9
b*	-4.9	-5.0	-4.9	-4.9	-4.9	-5.0	-5.1
Moisture (%)	46.2	46.1	46.1	46.3	46.2	46.1	46.1
Water activity	0.86	0.86	0.85	0.86	0.87	0.86	0.86

Average values of three analyses. The standard deviations are not shown since for all analyses the coefficients of variation are less than 5%. ACA: Anhydrous Citric Acid.

Fig 3. A view of the 0.2 mm sieve with the hackberry fresh flesh.

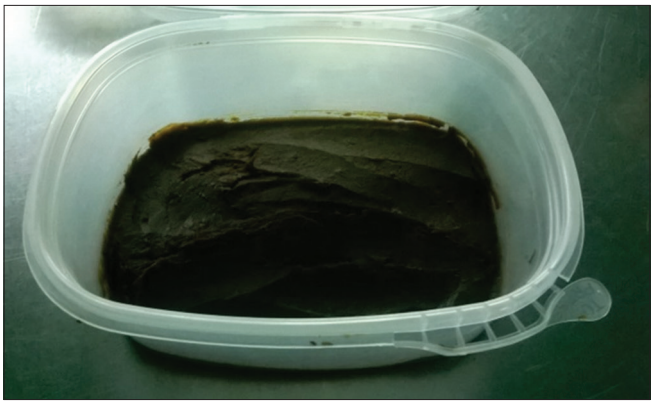

Fig 4. The hackberry fresh flesh to be stored under refrigeration conditions.

Table 2: Evolution of the microbiological characteristics (cfu/g) of the hackberry fresh flesh stored under refrigeration conditions (5ºC) up to 10 weeks

	Initial	1	2	4	6	8	10
Aerobic mesophilic	9.0×10^5	3.9×10^6	5.2×10^6	5.5×10^6	6.9×10^6	3.5×10^7	2.8×10^7
Escherichia coli	<10	<10	<10	<10	<10	<10	<10
Total coliforms	1.4×10^4	1.4×10^4	1.2×10^4	7.8×10^3	4.7×10^3	2.4×10^3	1.3×10^3
Staphylococcus spp	<10	<10	<10	<10	<10	<10	<10
Listeria monocytog.	0	0	0	0	0	0	0
Salmonella spp	0	0	0	0	0	0	0
Moulds and yeasts	1.4×10^5	1.2×10^5	1.1×10^5	6.6×10^4	2.9×10^4	2.5×10^4	1.4×10^4

Average values of three analyses. The standard deviations are not shown since for all analyses the coefficients of variation are less than 5%.

Statistical analysis

The results as average values of three analyses are shown in the tables. The standard deviations are not shown since for all analyses the coefficients of variation are less than 5%. All extractions and measures were made in triplicate. The computer program used was Excel (Microsoft Office 2019).

RESULTS AND DISCUSSION

The reason for conducting this study was to get knowledge on the evolution of the hackberries fresh flesh during its refrigerated storage. The physicochemical characteristics and the microbiology were investigated, focussing in the shelf-life, as a basis for the use of the hackberry fresh flesh as ingredient in domestic and industrial food applications.

The Table 1 shows the evolution of the physicochemical characteristics of the hackberry fresh flesh stored under refrigeration conditions (5ºC) up to ten weeks. The pH of the hackberry fresh flesh and the titratable acidity changed during the cold storage. The titratable acidity increased from 0.48 g ACA/100 g (initial) to 1.26 g ACA/100 g (10 weeks), and the directly related physicochemical characteristic -the pH- decreased from 6.7 (initial) to 5.1 (10 weeks). The other physicochemical characteristics (soluble solids, colour, moisture and water activity) keep constants during the ten weeks of cold storage. The moderate acidification of the hackberry fresh flesh stored under refrigeration conditions suggest some fermentation, as was confirmed by the microbiological analyses.

The Table 2 shows the evolution of the microbiological characteristics of the hackberry fresh flesh stored under refrigeration conditions (5ºC) up to ten weeks. The main microbiological result is that there was an increase of the aerobic mesophilic population from $9.0\text{x}10^5$ cfu/g (initial) to $2.8\text{x}10^7$ cfu/g (10 weeks). All other microorganism populations decreased or are absent. The total coliforms decreased from $1.4\text{x}10^4$ cfu/g (initial) to $1.3\text{x}10^3$ cfu/g (10 weeks) and the moulds and yeasts decreased from $1.4\text{x}10^5$ cfu/g (initial) to $1.4\text{x}10^4$ cfu/g (10 weeks). The population of *Escherichia coli*, *Staphylococcus aureus* and other *Staphylococcus* species were always present at low values (<10 cfu/g), while *Listeria monocytogenes*, other *Listeria* species and *Salmonella* species were always absent (0 cfu/g). To the best of our knowledge, there are no similar studies on hackberry fresh flesh to make a discussion based in a comparison of previously reported hackberry results. Janzantti et al. (2014) reported a shelf-life period of eight to twelve weeks for passion fruit fresh pulp stored under refrigeration conditions, being the pulp microbiologically safe. Comparing with the hackberry, the passion fruit fresh pulp is much more acid (5.1-6.3 g ACA/100 g, da Silva Araújo et al., 2017) which permit a longer shelf-life under refrigeration.

Finally, the scope of the results of this research was that according to the microbiological results, the hackberry fresh flesh stored under refrigeration conditions (5ºC) up to six weeks can be considered a safe food, due to the fact that there was an increase of one logarithmic cycle in the population of aerobic mesophilic and a decrease or absence of the other microorganism populations. This is enough to use the hackberry fresh flesh as natural ingredient at both domestic and industrial level, which has an impact on the future producers of this crop.

CONCLUSIONS

The hackberry fresh flesh stored under refrigeration conditions (5ºC) for up to six weeks can be considered a safe food. This is enough to use the hackberry fresh flesh as natural ingredient at both domestic and industrial level.

ACKNOWLEDGEMENT

The authors received no financial support for the research, authorship, and/or publication of this article; only the use of the laboratory facilities at Food Technology, University of Murcia (Spain), what they appreciate.

Authors' contributions

This manuscript contains the main results of Joaquín Salmerón Teruel's degree thesis. This degree thesis

was carried out by Joaquín at the University of Murcia (Spain), under the direction of Dr. José María Ros García, who design the research, and the technical assistance of Esther Vidal Cascales. Joaquín and Esther carried out the work at laboratory level taking samples, making the physicochemical and microbiological analyses and also the statistical analysis of the data. Finally, the manuscript has been prepared by the three authors.

REFERENCES

da Silva Araújo, L., E. M. R. Costa, T. L. Soares, I. S. dos Santos and O. N. de Jesus. 2017. Effect of time and storage conditions on the physical and physico-chemical characteristics of the pulp of yellow and purple passion fruit. Food Sci. Technol. 37: 500-506.

Demir, F., H. Dogan, M. Ozcan and H. Haciseferogullari. 2002. Nutritional and physical properties of hackberry (*Celtis australis* L.). J. Food Eng. 54: 241-247.

ISO 4832. 2006. Microbiology of Food and Animal Feeding Stuffs--Horizontal Method for the Enumeration of Coliforms.

ISO 4833-2. 2013. Microbiology of the Food Chain--Horizontal Method for the Enumeration of Microorganism.

ISO 6579-1. 2017. Microbiology of the Food Chain Horizontal Method for the Detection, Enumeration and Serotyping of *Salmonella* Part 1: Detection of *Salmonella* spp.

ISO 6888-1:2000/A2. 2019. Microbiology of Food and Animal Feeding Stuffs Horizontal Method for the Enumeration of Coagulase-positive Staphylococci (*Staphylococcus aureus* and other Species).

ISO 11290-1. 2017. Microbiology of the Food Chain--Horizontal Method for the Detection and Enumeration of *Listeria monocytogenes* and of *Listeria* spp.

ISO 16649-1. 2018. Microbiology of the Food Chain--Horizontal Method for the Enumeration of Beta-glucuronidase-Positive *Escherichia coli*.

ISO 21527-1. 2008. Microbiology of Food and Animal Feeding Stuffs--Horizontal Method for the Enumeration of Yeasts and Moulds.

Janzantti, N. S., G. C. Santos and M. Monteiro. 2014. Shelf life of fresh and pasteurized organic passion fruit (*Passiflora edulis F. flavicarpa* Deg.) pulp. J. Food Process Preserv. 38: 262-270.

Magni, D. and G. Caudullo. 2016. *Celtis australis* in Europe: Distribution, habitat, usage and threats. In: San-Miguel-Ayanz, J., D. de Rigo, G. Caudullo, T. Houston Durrant and A. Mauri (Eds.), European Atlas of Forest Tree Species. Publications Officielles de l'Union Européenne, Luxembourg, p. e0145f9+.

Ota, A., A. Miklavcic-Višnjevec, R. Vidrih, Z. Prgomet, M. Necemer, J. Hribar, N. Gunde-Cimerman, S. Smole-Možina, M. Bucar-Miklavcic and N. Poklar-Ulrih, 2017. Nutritional, antioxidative, and antimicrobial analysis of the Mediterranean hackberry (*Celtis australis* L.). Food Sci. Nutr. 5: 160-170.

Vidal Cascales, E. and J. M. Ros García. 2020. Characteristics of the raw fruit, industrial pulp, and commercial jam elaborated with Spanish quince (*Cydonia oblonga* Miller). Emir. J. Food Agric. 32: 623-633.

Vidal-Cascales, E., D. Prencipe, C. Nocentini, R. López-Sánchez and J. M. Ros-García. 2021. Characteristics and composition of hackberries (*Celtis australis* L.) from Mediterranean forests. Emir. J. Food Agric. 33: 37-44.