NUTRITIONAL VALUE AND CHEMICAL COMPOSITION OF PURSLANE LEAVES IN RELATION TO HARVESTING STAGE

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NPA Natural products application: Health, Cosmetic and Food Online Edition 4-5 Feb 2021

GSRT GENERAL SECRETARIAT FOR RESEARCH AND TECHNOLOGY

The PRIMA programme is supported and funded under Horizon 2020, the Framework European Union's Programme for Research and Innovation

INTRODUCTION

- *Portulaca oleracea* L. belonging to the Portulacaceae family is an invasive weed with a widespread distribution through the word
- Its edible plant parts have been acknowledged to the Mediterranean diet due to its high nutritional value especially for their high concentration in omega-3 fatty acids
- Equally, leaves and stems present a valuable mineral and macronutrient profile whereas phenolic compounds and oleracein derivatives of purslane leaves have been attributed with antioxidant properties
- Many researches have pointed out that the effects of cultivation practices, environmental conditions and genetic variation could significantly affect the the nutritional value and chemical composition of the aerial parts of purslane
- In this research, we studied the effect of harvesting stage (29, 43, 52 days after sowing (DAS)) on the nutritional value and chemical composition of purslane edible plant parts

MATERIALS

- The trial was carried out at the experimental field of the University of Thessaly, in Larissa during the summer of 2016. Seeds of common purslane (*Portulaca oleracea* L.) were obtained from Hortus Sementi Srl. (Budrio, Italy) and were sown directly in soil on 06/06/2016
- Prior to sowing, a base dressing of 100 kg/ha with 10-10-10 fertilizer (N-P-K) was applied, whereas irrigation was applied with sprinklers at regular intervals (once a week, starting on the day of sowing) and no pesticides or other agrochemicals were applied during cultivation. Harvesting took place at three different growth stages, namely on 05/07/2016 (29 days after sowing (DAS)), on 19/07/2016 (43 DAS), and on 28/07/2016 (52 DAS)
- After each harvesting stage, the aerial plant parts were divided in stems and leaves in which fresh samples of plant tissues were placed in a forced-air oven, and dry weight was recorded after drying the samples at 70 °C until constant weight
- Batch samples of fresh plant tissues were stored at −80 °C and were then lyophilized. The lyophilized samples were ground to powder with a pestle and mortar, and were put in plastic air-sealed bags and stored at −80 °C until further analysis

METHOLOGY

- Nutritional compounds of the samples were analyzed (moisture, fat, ash, proteins and carbohydrates) following the Association of Analytical Communities (AOAC) procedures
- Tocopherols were determined in the lyophilized samples using a high performance liquid chromatography system coupled to a fluorescence detector using the internal standard method for quantification
- Free sugars composition was evaluated by using a HPLC system coupled with a refraction index detector, organic acid identification was peformed by Ultra-Fast Liquid Chromatography coupled with a Diode-Array Detector (UFLC-DAD) and fatty acids were determined by gas-liquid chromatography with flame ionization detection
- Phenolic compounds and oleracein derivatives were evaluated using an ultra-performance liquid chromatography (UPLC) system equipped with a diode array detector coupled to an electrospray ionization mass spectrometry detector (MS)

Image 1. *Portulaca oleracea* L. cultivation at the experimental field

RESULTS

Table 1. Composition in tocopherols (μg/100 g fw) and sugars (g/100 g fw) of purslane stems and leaves in relation to harvesting stage (mean ± SD)

Harvest Stage (DAS) *	Plant Part	α-Tocopherol	β-Tocopherol	γ-Tocopherol	δ-Tocopherol	Total Tocopherols
29	Leaves	215 ± 4b	14.0 ± 0.7b	140.7 ± 0.1a	9.6 ± 0.5b	380 ± 4b
43	Leaves	197 ± 3c	12.4 ± 0.2b	87.7 ± 0.2c	5.1 ± 0.2c	302 ± 2c
52	Leaves	327 ± 3a	44 ± 2a	97 ± 8b	13.5 ± 0.5a	481 ± 9a

* DAS: days after sowing; Different Latin letters (a–c) in the same column refer to significant differences between harvest stages for the same plant part (stems or leaves) at $p = 0.05$. ** Comparison of means of different plant parts (stems and leaves) from the same harvest was performed with Student's *t*-test at $p = 0.05$.

Table 2. Composition in organic acids (g/100 g fw) of purslane stems and leaves in relation to harvesting stage (mean ± SD)

Harvest Stage (DAS) *	Plant Part	Oxalic Acid	Quinic Acid	Malic Acid	Citric Acid	Total Organic Acids
29	Leaves	6.2 ± 0.1b	6.82 ± 0.01c	3.00 ± 0.03a	3.26 ± 0.01a	19.2 ± 0.1b
43	Leaves	5.7 ± 0.1c	8.4 ± 0.2b	1.90 ± 0.04b	1.53 ± 0.02b¥	17.6 ± 0.1c
52	Leaves	8.6 ± 0.2a	16.8 ± 0.5a	1.67 ± 0.01c	3.24 ± 0.03a	30.3 ± 0.2a

* DAS: days after sowing; Different Latin letters (a–c) in the same column refer to significant differences between harvest stages for the same plant part (stems or leaves) at $p = 0.05$. ** Comparison of means of different plant parts (stems and leaves) from the same harvest was performed with Student's *t*-test at $p = 0.05$.

Table 3. Composition in sugars (g/100 g fw) of purslane stems and leaves in relation to harvesting stage (mean ± SD)

Harvest Stage (DAS) *	Plant Part	Fructose	Glucose	Sucrose	Trehalose	Total Sugars
29	Leaves	0.11 ± 0.01b	0.041 ± 0.002c	nd	0.012 ± 0.001c	0.160 ± 0.007b
43	Leaves	0.183 ± 0.007a	0.113 ± 0.002a	0.009 ± 0.001a	0.026 ± 0.001b	0.330 ± 0.009a
52	Leaves	0.179 ± 0.007a	0.100 ± 0.001b	0.014 ± 0.001a	0.041 ± 0.001a	0.330 ± 0.008a

nd: not detected; * DAS: days after sowing; Different Latin letters (a–c) in the same column refer to significant differences between harvest stages for the same plant part (stems or leaves) at $p = 0.05$. ** Comparison of means of different plant parts (stems and leaves) from the same harvest was performed with Student's *t*-test at $p = 0.05$.

Table 4. Quantification of phenolic compounds and oleracein derivatives in purslane stems and leaves (mg/100 g dried weight (dw)) in relation to harvesting stage (mean ± SD)

Phenolic compound	Harvest Stage (DAS) *		
	29	43	52
Oleracein C[A]	143 ± 5a	21.2 ± 0.3c	102 ± 2b
Sinapic acid hexoside[C]	22.1 ± 0.7a	nd	nd
Oleracein A[A]	103 ± 2a	8.2 ± 0.1c	34.9 ± 0.8b
TPCOD	268 ± 6a	29.3 ± 0.4c	137 ± 3b

nd: not detected; * DAS: days after sowing; Different Latin letters (a–c) in the same column refer to significant differences between harvest stages for the same plant part (stems or leaves) at $p = 0.05$. ** Comparison of means of different plant parts (stems and leaves) from the same harvest was performed with Student's *t*-test at $p = 0.05$.

- The highest moisture content was recorded at 29 and 43 DAS and decreased at 52 DAS, whereas stems contained more water at 43 DAS. Also, fat content didn't have any significant difference between the harvesting stages and protein content was highest at the last harvest (52 DAS)
- Regarding to the macronutrient content (ash and carbohydrates) and energetic value the highest content was observed at the last harvest, while purslane's stem at 29 DAS presented the highest content in ash, carbohydrates and energetic value
- Leaves had the highest moisture content at the first harvesting stage and contained more fat and proteins at 29 DAS whereas stems had a higher content of carbohydrates, ash and energetic value at the same harvesting stage
- Leaves recorded significantly higher amounts in individual tocopherols and total tocopherols regardless of the harvesting time in comparison with the stems who presented the highest content at the first harvesting stage (29 DAS)
- Purslane's stems part had significantly a higher content of fructose, glucose, sucrose and total free sugars than leaves regardless of the harvesting stage
- Organic acid content in leaves contained mostly Quinic and oxalic acids at all the harvesting stages, whereas stems contained oxalic, Quinic and malic acid at the first harvesting stage (29 DAS)
- Fatty acid content differed significantly between the two plant parts, in particularly leaves had the highest content of palmitic and linoleic acids at 29 DAS, whereas α-linolenic acid contributed the most for the overall fatty acid profile of the stems for the first two harvesting stages
- The highest polyunsaturated fatty acids (PUFA)/saturated fatty acids (SFA) ratio and the lowest n6/n3 ratio were recorded at the first harvesting stage (29 DAS) for both plant parts respectively
- Leaves contained significantly higher amounts of individual and total phenolic compounds and oleracein derivatives compared to stems regardless of the harvesting stage. Also, harvesting at 29 DAS resulted in significantly higher contents of phenolic compounds and olarecein derivatives especially in the case of leaves

Table 5. Fatty acid composition (%) of the studied purslane stems and leaves (mean ± SD) in relation to harvesting stage

Fatty acids	Harvest Stage (DAS) *		
	29	43	52
C6:0	0.024 ± 0.001c	0.067 ± 0.001b	0.220 ± 0.001a
C8:0	0.032 ± 0.003c	0.039 ± 0.001b	0.095 ± 0.007a
C10:0	0.052 ± 0.001b	0.051 ± 0.001b	0.125 ± 0.007a
C12:0	0.81 ± 0.02c	0.867 ± 0.001b	1.37 ± 0.04a
C14:0	0.736 ± 0.002c	0.77 ± 0.01b	1.24 ± 0.01a
C15:0	0.49 ± 0.01b	0.420 ± 0.003c	0.75 ± 0.01a
C16:0	9.8 ± 0.1c	10.83 ± 0.01b	12.39 ± 0.03a
C16:1	0.52 ± 0.01b	0.48 ± 0.01c	0.730 ± 0.001a
C17:0	0.15 ± 0.01c	0.159 ± 0.005b	0.265 ± 0.007a
C18:0	2.52 ± 0.05c	2.72 ± 0.01b	3.89 ± 0.06a
C18:1n9c+t	5.29 ± 0.05b	4.65 ± 0.04c	6.4 ± 0.1a
C18:2n6c	11.40 ± 0.08c	11.63 ± 0.02b	14.81 ± 0.02a
C18:3n3	54.92 ± 0.08a	54.34 ± 0.03a	35.4 ± 0.1b
C20:0	1.79 ± 0.01b	1.80 ± 0.01b	2.95 ± 0.03a
C20:1CIS-11	0.08 ± 0.01c	0.11 ± 0.01b	0.140 ± 0.001a¥
C20:3n3+C21:0	0.155 ± 0.004c	0.195 ± 0.004b	0.32 ± 0.02a
C20:5n3	0.051 ± 0.003a	0.042 ± 0.001b	0.040 ± 0.001b
C22:0	9.0 ± 0.3b	8.62 ± 0.09c	15.0 ± 0.2a
C23:0	0.20 ± 0.01b	0.15 ± 0.01c	0.31 ± 0.01a
C24:0	2.04 ± 0.08b	2.05 ± 0.01b	3.61 ± 0.04a
Total SFA (% of total FA)	27.58 ± 0.06c	28.5 ± 0.1b	42.2 ± 0.3a
Total MUFA (% of total FA)	5.89 ± 0.05b	5.25 ± 0.06c	7.3 ± 0.1a¥
Total PUFA (% of total FA)	66.53 ± 0.01a	66.21 ± 0.04b	50.5 ± 0.2c
PUFA/SFA	2.412 ± 0.003a	2.319 ± 0.007b	1.196 ± 0.009c
n6/n3	0.207 ± 0.001c	0.213 ± 0.001b	0.414 ± 0.002a

* DAS: days after sowing; ¥: no significant difference was observed between plant parts. Caproic acid (C6:0); Caprylic acid (C8:0); Capric acid (C10:0); Lauric acid (C12:0); Myristic acid (C14:0); Pentadecylic acid (C15:0); Palmitic acid (C16:0); Palmitoleic acid (C16:1); Margaric acid (C17:0); Stearic acid (C18:0); Oleic acid (C18:1n9); Linoleic acid (C18:2n6c); α-Linolenic acid (C18:3n3); Arachidic acid (C20:0); Eicosenoic acid (C20:1CIS-11); Eicosatrienoic acid (C20:3n3); Heneicosylic acid (C21:0); Eicosapentaeonic acid (C20:5n3); Behenic acid (C22:0); Tricosylic acid (C23:0); Lignoceric acid (C24:0); SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; n6/n3: omega-6/omega-3 fatty acids. Different Latin letters (a–c) in the same row refer to significant differences between harvest stages for the same plant part (stems or leaves) at $p = 0.05$. ** Comparison of means of different plant parts (stems and leaves) from the same harvest was performed with Student's *t*-test at $p = 0.05$.

Table 6. Nutritional value (g/100 g fresh weight (fw)) and energetic value (kcal/100 g fw) of purslane stems and leaves in relation to harvesting stage (mean ± SD)

Harvest Stage (DAS) *	Plant Part	Moisture (%)	Fat	Proteins	Ash	Carbohydrates	Energy
29	Leaves	91.00 ± 0.49a	0.157 ± 0.001b	1.57 ± 0.02c	2.14 ± 0.05b	5.13 ± 0.02c	43.2 ± 0.1c
43	Leaves	90.81 ± 0.16a	0.148 ± 0.002b	1.91 ± 0.01b	1.89 ± 0.05c	5.25 ± 0.03b	45.70 ± 0.02b
52	Leaves	88.16 ± 0.41b	0.230 ± 0.001a	2.96 ± 0.04a	2.40 ± 0.06a	6.2 ± 0.1a	61.3 ± 0.1a

* DAS: days after sowing. Different Latin letters (a–c) in the same column refer to significant differences between harvest stages for the same plant part (stems or leaves) at $p = 0.05$. ** Comparison of means of different plant parts (stems and leaves) from the same harvest was performed with Student's *t*-test at $p = 0.05$.

CONCLUSIONS

- According to the results of the study, there was recorded a significant interaction between plants part of purslane and the different harvesting stages for all the tested parameters
- Leaves contained higher amounts of macronutrients than stems in case of 52 DAS, while the isoform α-tocopherol increased at 52 DAS resulting in the highest overall tocopherol content
- Related to the oxalic acid and total organic acids content the highest content was recorded in the leaves especially at the last harvesting stage (52 DAS), whereas glucose and fructose were the main sugars detected in which stems had a higher concentration compared to the leaves
- Phenolic compounds and oleracein derivatives were also detected in plant parts with oleraceins A and C being the main compounds regardless of the harvesting stage
- Early harvesting stage could increase the nutritional value through increasing the content of valuable compounds, whereas at the same time contents of anti-nutritional compounds are reduced respectively

RECOMMENDATIONS

- The extensive chemical variation observed in the plant parts of purslane could be a useful indicator for the identification and the classification of different *Portulaca* taxa based on its chemical profile
- The high ratio of polyunsaturated fatty acids (PUFA)/saturated fatty acids (SFA) and the low n6/n3 fatty acid recorded in stems and leaves of purslane could be exploited further as a source of high nutritional value
- Further studies are needed to be carried out in order find out the ideal cultivation practices, environmental conditions and genetic factors attributed to a high nutritional value and an abundant chemical composition of the purslane

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ACKNOWLEDGMENTS

- The project is funded by the General Secretariat for Research and Technology of the Ministry of Development and Investments under the PRIMA Programme. PRIMA is an Art.185 initiative supported and co-funded under Horizon 2020, the European Union's Programme for Research and Innovation (Prima2019-11). The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES to CIMO (UIDB/00690/2020); for the financial support within the scope of the Project PRIMA Section 2 - Multi-topic 2019: VALUEFARM (PRIMA/0009/2019); and L. Barros, M.I. Dias and Â. Fernandes thank FCT, P.I., through the institutional scientific employment program-contract for their contacts.