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Edible Wild Flowers: An Innovative but Ancient Food †

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Abstract: Edible flowers are often more mentioned in connection with biologically active substances and their presence is today frequent in supermarket. The main factor that determines their use is the appearance, so particular attention must be paid to the shelf life. Flowers must be protected from desiccation and their quality preserved, so the aims of this study were to evaluate the shelf life of the spontaneous edible flowers *Glebionis segetum*, *Malva sylvestris*, and *Tropaeolum majus* and *Papaver rhoeas* detect the presence of major polyphenols. The flowers have been packaged with polypropylene (PP) bags and then stored in a refrigerator at +4 ± 1 °C. Samples were tested in the dark and in the presence of light for 12 days. Gas composition, weight loss and colour have been registered once the packages have been opened; antioxidant activity, total phenols and enzymatic analyses were performed. The light has always a negative influence, the weight loss was limited and the gas composition did not change significantly during shelf life, with different variation in the studied samples. The highest variation in color parameters was found in control samples, while the extracts from *G. segetum* showed the highest antioxidant activity, polyphenol content and it was the most resistant but it had also the highest weight loss. Also enzymatic results pointed out the PP as best packaging film if considered in the dark. *P. rhoeas* was characterized by extreme fragility, *M. sylvestris* was not able to tolerate low temperatures and *T. majus* changed its color progressively with the time.

Keywords: visual quality; shelf life; lightening; color; reactive oxygen species (ROS), enzyme activity

1. Introduction

Edible flowers are highly perishable, with short shelf life of 2–5 days after harvest, however their market is becoming more important like demonstrated by the increasing number of recipe books, magazine articles, and websites that encourage people to use them.

The potential number of suitable species is very high (over 1000) and some species are also present in the spontaneous flora of the Mediterranean environment.

Thanks to their exotic aroma, delicate flavour and visual appeal, their consumption is increasing involving consumer in buying various types of edible flowers prompted for their health benefits since they are a good source of phytochemicals, including phenolic compounds [1].

As example the leaves of *Tropaeolum. majus* (garden nasturtium) have been used in folk medicine against cardiovascular disorders, urinary tract infections, asthma, constipation. Anticancer activity has been attributed to the extracts from the plant and recent studies have shown that the *T. majus* flowers are excellent sources of lutein and provitamin A and *β*-carotene [2]. *T. majus* is a herbaceous annual plant of the *Tropaeolaceae* family, a native plant of the Andes in South America, that its adaptability to different climates has helped its dissemination throughout the world.

When plants are exposed to stress condition, reactive oxygen species (ROS) such as superoxide (O_2^-), hydrogen peroxide (H_2O_2), singlet oxygen (O_2) and hydroxyl radical (OH^-) concentration increase inside plant tissues [3]. Resistant plants usually use antioxidants to reduce the detrimental effects on plant cells. In addition, enzymes such as catalase (CAT), glutathione peroxidase (GPX), superoxide dismutase (SOD) and others which are existing in the cells are used to scavenge ROS [4].

The unavoidable exposure to light during the time that edible flowers are on sale influenced the evolution of the quality parameters of this product, producing a stress in vegetables cell. The influence of light on the quality of minimally processed vegetables has been demonstrated, either for the effect on synthesis or changes in pigments, or on the metabolic activity of the packaged product which makes exposure to light a determining factor in their shelf life [5].

Following as expressed until now, the aim of the study was to understand the shelf life of *Glebionis segetum*, *Malva sylvestris*, *Tropaeolum majus* and *Papaver rhoeas* edible flowers, looking at chemical and qualitative characteristics, as well as enzymatic changes in their charge due to storage conditions.

2. Methods

Wild flowers were picked up in the rural area's surroundings the urban area of Catania. Flowers were selected and then were placed in PET trays. Each tray were packed in ordinary atmosphere using polypropylene (PP) films with OTR 20,000 cc/m^2/24 h), a MACRO perforated PP was used as Control. Samples were stored in two refrigerator at +4 ± 1 °C, one kept in the dark, while the second was with an internal light made by a "COLD LIGHT 6500 K" LED lamp, to simulate the sales conditions.

The headspace gas composition and fresh weight loss (FWL) were expressed as reported by Rizzo et al. [6]. Analysis were on three replicate at each sampling time. Each package was labeled and weighed at the beginning of the storage period and then at each sampling time (3, 6, 9 and 12 d) and weighed before opening the container for further analysis. Color was measured by a digital camera, and images processed through Image-Pro® Plus 7.0 software (Media Cybernetics 70 Inc., Rockville, USA). Extract were obtained according to Pires et al. [7], and the determinations of total phenols content (TPC) and antioxidant activity (AA) were determined following respectively the previous study of Gonzalez et al. [8] and Hatano et al. [9], with slight modifications.

The SOD (SOD; EC 1.15.1.1) activity was assayed by monitoring the inhibition of photochemical reduction of Nitro Blue Tetrazolium (NBT) according to the method of Giannopolitis and Ries [10]. The CAT (CAT; EC 1.11.1.6) was analyzed according to Aguilera et al. [11]. The GPX (GPX; EC 1.11.1.7) activity was measured using the method described by Ruley et al. [12].

Analyses were carried out on three replicate at each sampling time. All results were presented as the mean ± S.E. The statistical analyses were performed using CoStat version 6.311 (CoHortSoftware, Monterey, CA, USA); one-way ANOVA was used. The differences between the means were determined using Tukey's test ($P < 0.05$).

3. Results and Discussion

The light radiation emitted by the lamps used in the controlled temperature cells had the following technical characteristics: visible 4800 VIS (lux); 20.02 RAD, 0 UVA, 0.2 UVB, 1.4 UVC (W m-2); 124.6 PAR (µmol). Results are reported as Light PP or C when samples are stored under light and in PP film or as Control without any plastic film, and Dark PP or C for samples stored in the dark in the same packaging conditions reported above.

As every plant product also edible flowers are subjected to natural weight loss, and it is greater as higher is their respiration rate. Although many papers studied nutritional composition of edible wild flowers [7,13,14] any study on their shelf life was found, especially with indication on weight loss, respiration rate or color parameter; moreover, in cited papers the high varieties of available flowers makes difficult any comparison among them. All flowers finished their shelf life at 9 days

(Figure 1). Glebionis is the heavier flowers, and the higher decrease is observed at just after 3 days, in samples stored under Light in PP films (88%), while the Light control was similar to Dark PP (62%) with the only exception after 3 days. The Malva kept under Light control reached a loss of 68%, the same samples stored in Dark PP film saved the 42% of the starting weight. In Tropaleoum the differences between light and dark storage were less evident with samples kept under Light in PP showing a 25–30% higher weight loss then both samples stored in the Dark although not different statistically. Papaver has petal very thin and sensitive, changes were not statistically significant (Figure 1).

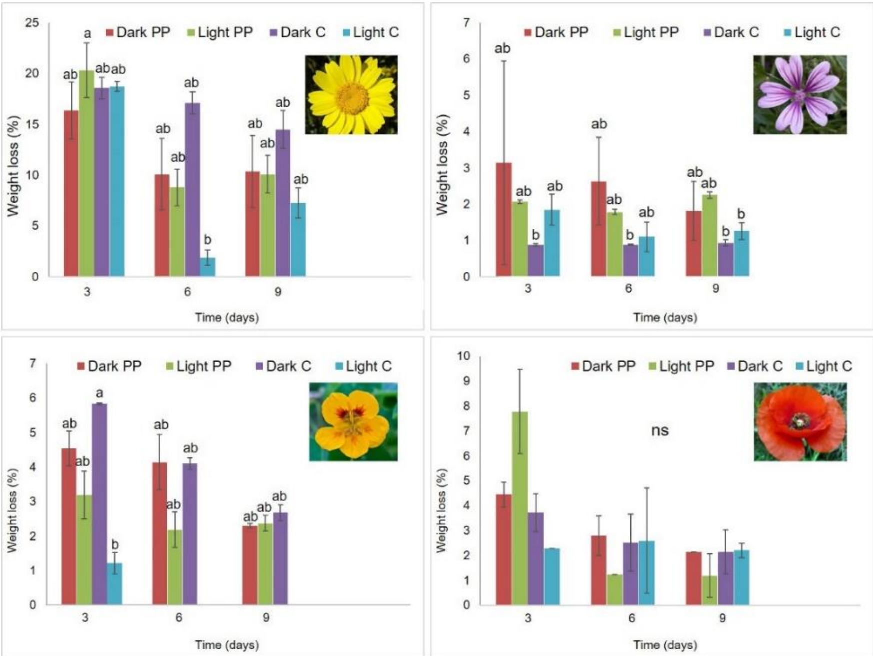

Figure 1. Effect of the packaging during the 12 days of storage on the weight loss (%) of Glebionis, Malva, Tropaeolum, and Papaver. Values are means ±SE (n = 3). Columns denoted with the same letters are not significantly different, as determined by Tukey's test ($P < 0.05$).

In Figure 2 the concentrations of CO_2 of packed samples are reported. The PP film allows some exchange of CO_2 with the external atmosphere, so what can be observed in Glebionis is that the CO_2 concentration is always higher in samples kept in the Dark; the same trend is evident in Malva, while the opposite was detected in Tropaleoum and Papaver samples under Light. The colour is an important organoleptic property of edible flowers. In Figure 3 are reported the colour parameters which changed more during the study, in particular the Intensity of the colour for Glebionis and Malva appeared more stable, while the Hue (the correct word to use to refer to just the pure spectrum colors) for Tropaleoum and Papapaver showed the highest changes especially in samples under Light. Considering the TPC it's higher in Glebionis (1.56 ± 0.44 mg/100 g) and smaller in Papaver (0.92 ± 0.46 mg/100 g) more similar among the other flowers with a medium value of 0.94 ± 0.42 mg/100 g. Results in TPC are confirmed by AA for the Glebionis with the highest value 79.55 ± 17.7% while the lowest AA% is got by Malva (55.86 ± 9.5).

In edible flowers and derived products, the activity of some enzymes affects their quality [15]. The light has severely damaged the petals of all species; the flowers, in fact, in these conditions could not reach the twelfth day. SOD, CAT; APX and GPX are important enzymes that play a crucial role in antioxidant defense. ROS accumulation causes oxidative injury, accelerating senescence progression and various senescence-associated disorders. The results showed that the CAT activity decrease in Malva and Papaver PP Dark at the end of the trial. No significant differences between treatments in Tropaleoum and Glebionis (Figure 4A). Balasundram et al. [16] reported that plants cope with stress by stimulating the formation of polyphenols and antioxidant activities. The GPX activity showed highest values in Glebionis and Papaver PP compared to Control flowers (Figure

4B). Increase in the SOD activity was observed in Malva and Glebionis PP. Trend opposite in other two species (Figure 4C). An increased level of SOD suggests a plant protective mechanism against oxidative stress [17]. To counteract the oxidants, the antioxidant system attempts to boost endogenous antioxidants to protect cells from oxidative damage, which includes antioxidant enzymes such as SOD and GPX [18].

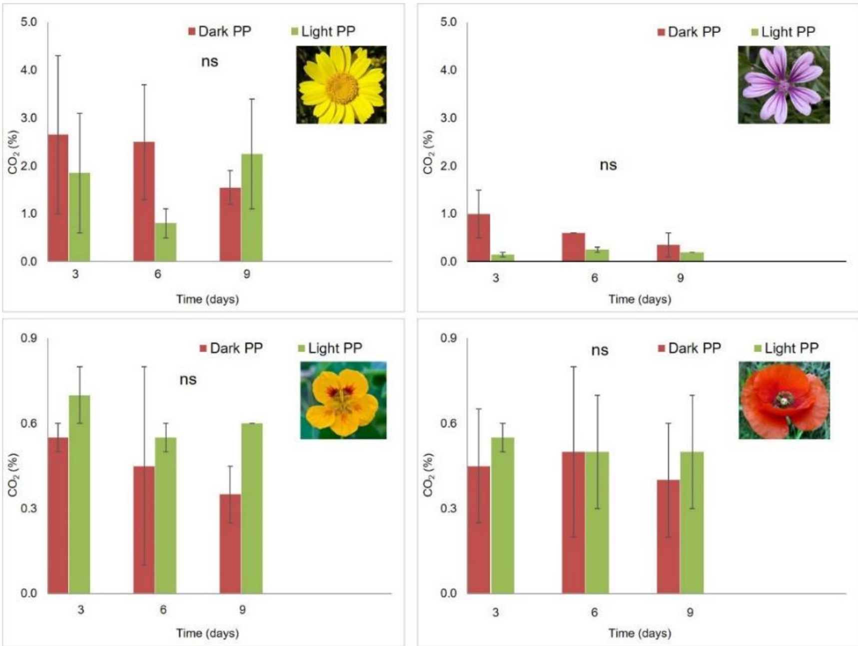

Figure 2. Carbon dioxide respiration rate during the 12 days of storage of Glebionis, Malva, Tropaeolum, and Papaver. Values are means ±SE (n = 3). Columns denoted with the same letters are not significantly different, as determined by Tukey's test ($P < 0.05$).

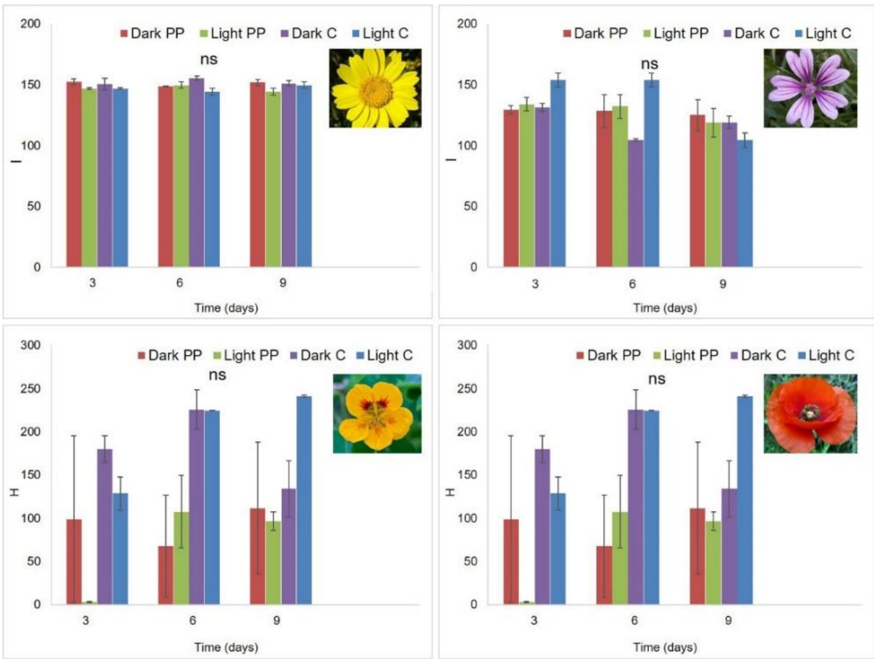

Figure 3. Effect of the packaging on colour parameter Intensity and Hue during the 12 days of storage of Glebionis, Malva, Tropaeolum, and Papaver. Values are means ±SE (n = 3). Columns denoted with the same letters are not significantly different, as determined by Tukey's test ($P < 0.05$).

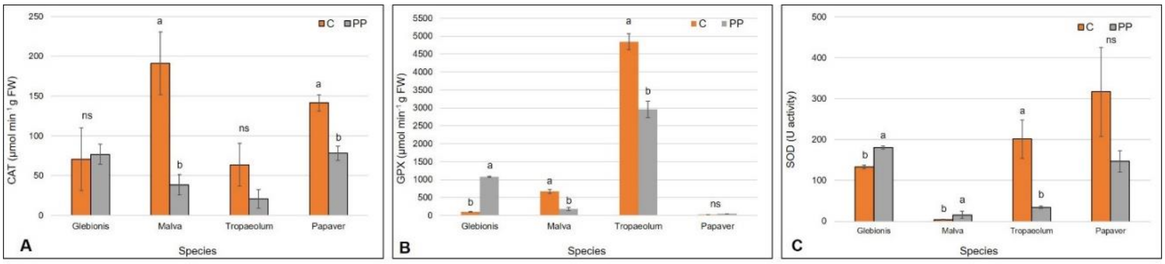

Figure 4. Effect of the packaging at the end of the trial on CAT (**A**), GPX (**B**), and SOD (**C**) activity in flowers of Glebionis, Malva, Tropaeolum, and Papaver. Values are means ±SE ($n = 3$). For each species, columns denoted with the same letters are not significantly different, as determined by Tukey's test ($P < 0.05$).

The results has shown that the extract of Glebionis inhibits the increase in oxidative stress, characterized by the elevation of SOD and GPX levels. The scavenging capacity diminished during flower conservation due to antioxidant enzyme activity decrease and high ROS accumulation. This suggest that the balance between ROS production and antioxidant enzymes activity had been destroyed, causing extensive senescence of flower tissues [19].

4. Conclusions

In conclusion edible wild flowers are highly perishable, compared with other types of flowers, because their stems are cut very short and they are stored without additional water supply. The PP packaging and refrigerated storage in the dark are the best solutions to keep the highest quality for 9 days, although weight loss could be severe in Glebionis as well as the light damaged Papaver and Tropaleoum. TPC and AA measured at the beginning of the study were related with the diminishing scavenging capacity observed after 9 days, caused by the conservation's stress and measurable with and the increase in ROS.

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Conflicts of Interest: The authors declare that there are no conflicts of interest.

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