Quality Traits of Some Cauliflower Cultivars Grown in the "Valle dell' Ofanto" Area (Italy) as Affected by Post-Harvest Storage

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Abstract

Some quality characteristics of the "Valle dell'Ofanto" cauliflower, that has been recently appointed the certification of collective brand, were investigated at Gaudiano (41°03'N; 15°42'E, Southern Italy, Basilicata Region). Six white head cauliflower cultivars, characterized by a different length of the crop cycle (2 early, 2 medium and 2 late), were studied. The above cultivars were transplanted in open field at the middle of August 2004 and harvested from the middle of October 2004 to the end of March 2005. At harvest time, yield traits and head sizes of cauliflowers were measured. Among the qualitative traits, color, weight loss, total soluble solids, nitrate and vitamin C content were assessed on the fresh florets and after a storage period lasting 15 days at 0°C and 95% R.H. The "Valle dell'Ofanto" cauliflower was characterized by a high content in sugars and vitamin C, even if significant differences in some qualitative parameters (e.g., vitamin C and nitrate content) were affected by cultivars and crop cycle length. On the other hand, the storage at controlled temperature and R.H. did not substantially change the qualitative characteristics of the heads, but caused only a slight increase of dry matter and soluble solids levels, especially in those cultivars more susceptible to weight loss.

INTRODUCTION

Brassica vegetables are to be considered functional foods, being rich in biologically active compounds, such as glucosinolates and vitamin C; these compounds are involved in the prevention of chronic-degenerative diseases. Therefore, a consumption of vegetables with high level of these nutraceutical compounds, such as cauliflower (*Brassica oleracea* L. var. *botrytis* L.), is recommended (Galgano et al., 2007; Lennie, 2001; Salunkhe and Kadam, 1998; Volden et al., 2009). However, the nutritional quality of the vegetables depends not only on the nutrients content when harvested, but also on pedoclimatic conditions, cultivar, harvesting time, besides the changes occurring during postharvest handling, storage conditions, processing and preparation (Galgano et al., 2007).

In the countries of the European Union, cauliflower occupies an important position in the production of fresh and frozen vegetables (Gębczyński and Kmiecik, 2007).

The cauliflower crop expresses a strong preference for deep, permeable soils, even slightly clayey and provided with a good structure (Bianco, 1990); these are the conditions that characterize the flatter lands of the Ofanto valley ("Valle dell'Ofanto"), located in the extreme Northeastern area of the Basilicata region, namely in the province of Potenza, in the areas of Lavello, Melfi and Palazzo San Gervasio, where the cultivation of cauliflower is actually widespread.

The main harvesting period for cauliflower falls between November and mid December, resulting in an oversupply of product on the market and then forcing the farmers to sell their produce at very low prices (Dhall et al., 2010). Post-harvest conditions can also influence the quality of cauliflower; in particular, the loss of quality can be important when the cauliflower is stored at room temperature. Hence, is necessary to store cauliflower at recommended storage conditions, such as 0°C and 90-95% R.H.; these thermo-hygrometric conditions generally maintain a good quality of cauliflower for 4 weeks (Dhall et al., 2010; Ekman and Golding, 2006; Grzegorzewska and Kosson, 2007).

The aim of this research was to evaluate the qualitative characteristics of "Valle dell'Ofanto" white cauliflower, which has been recently appointed the certification of collective brand, in relationship with genotype and postharvest storage.

MATERIALS AND METHODS

Cauliflower Sampling and Storage

The field experiments were carried out in the years 2004 and 2005 in Basilicata, a region in Southern Italy, at Gaudiano di Lavello (Potenza province) (41°03'N; 15°42'E; 180 m a.s.l.) using cauliflower crop grown on a sandy-silt soil. Crop transplantation took place on August 2nd, 2004 by using seedlings at the stage of 3rd-4th true leaf; a density of 2.35 plants m^{-2} was realized according a double rows layout planting. Six white head cauliflower hybrid (F_1) cultivars, characterized by a different length of the crop cycle (2 early, 'Fremont' and 'Nautilus'; 2 medium, 'Escale' and 'Meridien'; 2 late, 'Cafano' and 'Abruzzi'), were compared. A randomized block design with three replicates was followed setting the cultivars in field plots of 25.5 m^{-2}.

The harvests were performed from October 12th, 2004 through March 31st, 2005 according to the ripening time of the tested cultivars.

For each harvest time, samplings of 10 heads for each plot were analyzed for the following qualitative traits: color, weight loss, total soluble solids, nitrates and vitamin C content. Analyses were carried out on the fresh florets and after a storage period lasting 15 days at 0°C and 95% R.H.

Analyses

Total soluble solids (TSS) content was assessed at 20°C by using an Abbe refractometer (Carl Zeiss, Jena, Germany) and expressed as °Brix (AOAC, 1990). Color was measured on the cauliflower surface using a Minolta Chroma meter CR-300 with a D 65 illuminant, using CIELAB L*, a*, b* values. Weight loss was estimated gravimetrically, weighing all the samples after each storage period, and expressed as percentage of the initial sample weight. Vitamin C content was assessed by HPLC according to the method proposed by Galgano et al. (2002) and reported as mg vitamin C/100 g fresh product. For nitrate analysis, 10 g of sample were added to 190 mL of distilled water and then homogenized for 10 min. After filtration, 10 mL of filtrate were transferred to a 50 mL volumetric flask and brought up to volume with distilled water. Afterwards, an aliquot of this solution was analyzed according to Santamaria et al. (1999) using a Dionex ionic chromatograph mod. DX120. In order to study the effect of cultivar and storage and their interactions on the quality cauliflower, all collected data were statistically processed by analysis of variance (ANOVA); Student-Newman-Keuls (SNK) test and Least Significant Difference (LSD) test were also performed for the comparison of means. All statistical procedures were computed using the statistical package SAS (ver. 9.1., 2005).

RESULTS AND DISCUSSION

The analysis of variance related to the effect of cultivar and storage on the cauliflower, according to the chosen chemical parameters, is reported in Table 1. Some qualitative parameters discriminated the cultivars; in particular, after 15 days of storage at 0°C and 95% R.H. a different TSS content was assessed in cauliflower according to the crop cycle length, with values significantly higher in late than early and medium cultivar. Furthermore, this parameter showed also a significant increase after storage, then the significant interactive effect of "cultivar x storage" on TSS of cauliflower was influenced both by genotype and storage (Fig. 1).

The vitamin C content found in the studied cauliflower was within the range reported in literature for this vegetable (Tarrago-Trani et al., 2012; Volden et al., 2009) and the variability of this chemical parameter could be linked to cultivar rather than the crop cycle length and storage. In fact, the significant interactive effect of cultivar x storage on the vitamin C level in cauliflower was influenced only by genotype (Fig. 2). Vitamin C resulted to be present at the highest level in the Fremont cultivar (91.4 mg/ 100 g), followed by the 'Abruzzi' cultivar (80.6 mg/100 g). As far as the vitamin C content assessed in the other genotypes, its value did not show significant differences among the cultivars, with a mean value of about 64 mg/100 g, similar to that reported in the literature (Lisiewska and Kmiecik, 1996). The highest concentration in vitamin C found in the early cultivar Fremont resulted to be associated with the highest nitrate concentration assessed in the samples, as also observed by Mauria et al. (1992). Conversely, a negative correlation between vitamin C and nitrate levels was observed by Lisiewska and Kmiecik (1996).

The nitrate content found in the studied crop was consistent with the values that classify the cauliflower as a vegetable at low accumulation capacity (values ranging from 200 to 500 ppm) (Santamaria et al., 1999). High levels of nitrite and nitrates in foods can be harmful to health; these moieties are precursors of the carcinogenic N-nitroso compounds and can also convert haemoglobin into methaemoglobin, thus reducing the bioavailability of vitamin A. Although the nitrate level in Brassica vegetables is generally low, the amount of ingestion of these harmful compounds cannot be considered potentially negligible, due to the fact that these vegetables are often consumed in large quantities (Leszczyńska et al., 2009).

The reduced levels of nitrates found in the cultivar harvested later in the season can be associated with the prolongation of the crop cycle over a period of increasing daylight, thus with higher radiation availability. In fact it is well known that this factor contributes to the reduction of nitrate accumulation in the edible parts of vegetables, enhancing the nitrate reductase activity (Amr and Hadidi, 2001; Santamaria et al., 1997).

After 15 days of storage of cauliflower at 0°C and 95% R.H., weight loss showed statistically significant variations according to the genotype; in particular, the highest value was recorded in the 'Cafano' late cultivar (14.9%), and the lowest in the 'Escale' (5.8%), 'Meridien' (5.4%) and 'Abruzzi' (7.5%) late cultivars, showing that this parameter may depend on the genotype, rather than on the crop cycle length. On the other hand, 'Nautilus' and 'Fremont' showed an intermediate decrease of weight loss, with respect to all the other genotypes.

Considering the color coordinates, non-significant differences in terms of lightness (L*) and yellowness (b*) values according to storage time were found, while after 15 days of storage a significant increase of redness (parameter a*) ($P< 0.01$) was recorded, being in this latter case also significant the interactive effect "cultivar × storage" ($P<0.05$) (Fig. 3). Moreover, with respect to the other colorimetric parameters, the lightness intensity was mainly affected by the crop cycle length, showing values significantly higher in the late than in the early and medium cultivars, while for the a* parameter only the late 'Abruzzi' cultivar showed a value significantly higher than all the other cauliflower and for the b* parameter a significant value higher than all the other genotypes was recorded for the cultivar 'Meridien'. These latter colorimetric parameters seem to be more dependent on the cultivar rather than on the crop cycle length.

CONCLUSIONS

The "Valle dell'Ofanto" white cauliflower was characterized by a high content of vitamin C, in comparison with the mean values reported in literature for this vegetable. However, significant differences in some qualitative parameters (e.g., vitamin C, TSS and nitrate content) were affected by cultivars and crop cycle length. Moreover, the storage at controlled temperature (0°C) and R.H. (95%) did not substantially change the qualitative characteristics of the heads, but caused only a slight increase of a*, dry matter and TSS levels, especially in those cultivars more susceptible to weight loss.

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Tables

Table 1. Effect of cultivar and storage on some physico-chemical parameters of cauliflower.

Treatments	Crop cycle	Parameters						
		Weight loss (%)	TSS[1] (°Brix)	Nitrates (ppm)	Vitamin C (mg/100 g)	Color parameters		
						L*	a*	b*
Cultivar [2]								
Fremont	Early	13.5 b	5.2 c	337 a	91.4 a	79.0 b	-5.5 b	23.9 b
Nautilus	Early	11.6 b	5.1 c	320 a	67.3 c	79.5 b	-5.7 b	24.0 b
Escale	Medium	5.8 c	5.7 b	160 b	58.7 c	79.5 b	-5.4 b	29.0 a
Meridien	Medium	5.4 c	5.8 b	152 b	62.8 c	80.7ab	-5.4 b	21.2 b
Cafano	Late	14.9 a	5.7 b	120 b	67.4 c	82.1 a	-5.5 b	23.7 b
Abruzzi	Late	7.5 c	6.7 a	125 b	80.6 b	82.4 a	-4.7 a	23.0 b
F values [3]		*7.85***	*3.97**	*12.1***	*29.5***	*6.03***	*3.62**	*15.33***
df [4]		*5*	*5*	*5*	*5*	*5*	*5*	*5*
Storage								
Fresh		-	5.6	205	71.5	80.5	-5.7	24.1
Stored		9.8	5.9	199	71.3	80.6	-5.1	24.2
F values [3]		-	*4.40**	*1.12*^{ns}	*0.01*^{ns}	*0.01*^{ns}	*20.01***	*0.04*^{ns}
df [4]		-	*1*	*1*	*1*	*1*	*1*	*1*
Cultivar × Storage								
F values [3]		-	*6.38***	*2.24*^{ns}	*13.1***	*0.83*^{ns}	*3.48**	*0.81*^{ns}
df [4]		-	*5*	*5*	*5*	*5*	*5*	*5*

[1] TSS = Total Soluble Solids.
[2] Means in each column followed by the same letters are significantly different at P ≤ 0.05 according to SNK Test.
[3] * = Significant at P≤0.05; ** = significant at P≤0.01 P; ns = not significant.
[4] *df* = degrees of freedom.

Figures

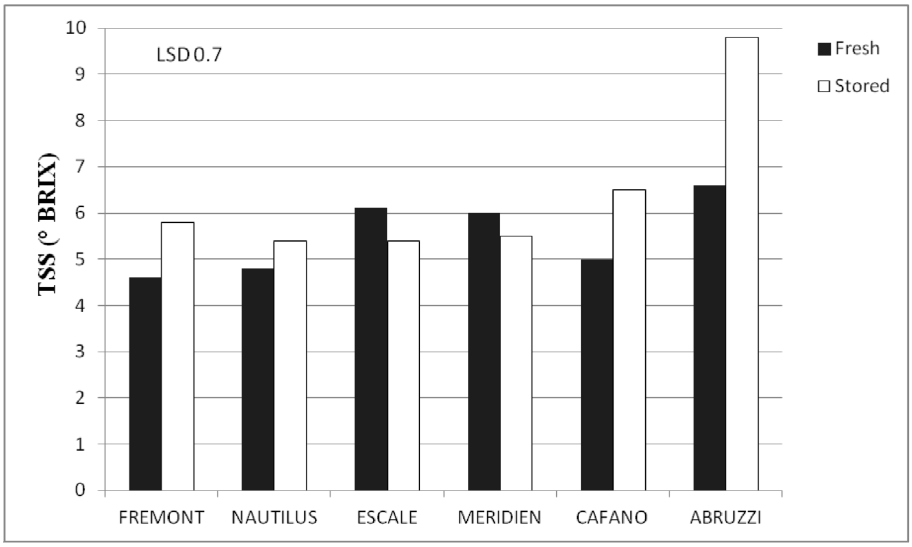

Fig. 1. Interactive effect of *cultivar x storage* on TSS level in cauliflower.

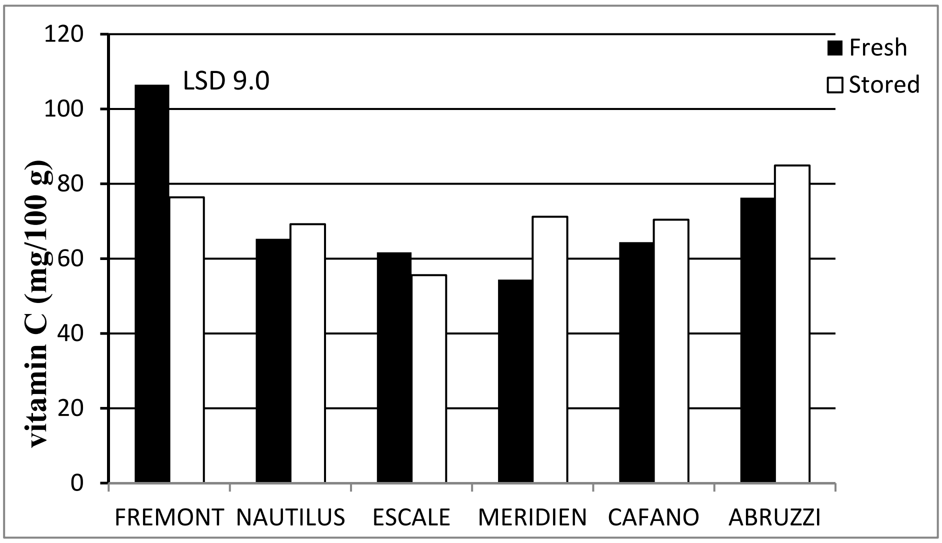

Fig. 2. Interactive effect of *cultivar x storage* on the vitamin C content in cauliflower.

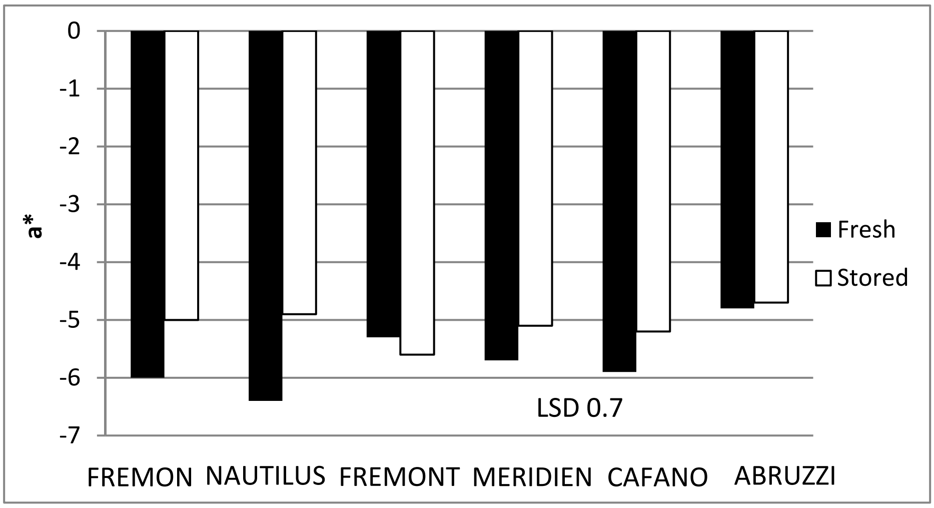

Fig. 3. Interactive effect of *cultivar x storage* on cauliflower colour (parameter a*).