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Quality Attributes of Four Kale Cultivars Grown in a High Tunnel Ecological Farming System

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SHORT COMMUNICATION

Abstract
The leafy green vegetables are rich sources of antioxidants, minerals, vitamins and dietary fiber, which cannot be produced by the human body, the only way for assimilation being by food ingestion. One of the best sources of these kinds of nutrients, among the Brassicas vegetables, is kale. Dry matter content of kale is important not only for fresh consumption, but also for preserving and processing of leaves. In Romania kale is less cultivated, but present in several areas of Transylvania and the interest for its production and consumption is growing. The aim of the present research was to establish the influence of cultivar on quality attributes of kale cultivated in a high tunnel ecological farming. Four kale cultivars (Red Siberian, Black Tuscany, Dwarf curled and Scarlet) cultivated in an organic farming system were evaluated for quality attributes including dry matter, total soluble solids and insoluble fiber contents. The highest dry matter content in leaves was revealed by Scarlet cultivar, followed by Black Tuscany and Dwarf curled cultivars. Dwarf Curled recorded the highest insoluble fiber content (8.66 mg/100 g fresh matter), while Red Siberian recorded the highest total soluble solids (8.4%) in comparison with Black Tuscany. The assimilation of analyzed quality attributes in kale was influenced by the cultivar. Among the studied cultivars, Red Siberian revealed the highest total soluble solids content and good insoluble fiber content. Kale offers an abundance of nutrients that support health, thus its cultivation should be of current intereset in amonh the producers and consumers.

Keywords: *Brassica oleracea*; dry matter; fiber; high tunnel; kale; organic vegetable.

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INTRODUCTION

Greeny vegetables participate in people's food all year round, both fresh and canned. For a balanced diet, researchers estimate for an adult, a consumption of 75 g/day green vegetables, respectively 27 kg annually, of which 80% of the consumption should be in winter (Berar et al., 2012). The content of vegetables in minerals and vitamins can be influenced by the cultivation system, a net advantage of organic crops (Balcău, 2012; Korus, 2020).

Kale has recently received attention from the health and nutrition departments due to its nutrient profile (Ayaz et al., 2006; USDA, 2015). According to its fiber content, kale is one of the vegetables recommended in preventing and treating digestive diseases (Maciejak and Kosmala, 2019). Dry matter content of kale is important not only for fresh consumption, but also for preserving and processing of leaves (Ötles and Ozgoz, 2014). Available data confirm that consumer perception places kale at the top of healthy food lists.

Several studies show that diets high in probiotics and micronutrients and low in calories play an important role in supporting gut health, with the potential to prevent obesity (Dumas at al., 2006; Ley et al., 2005; Wu at al., 2011). Among the vegetables eaten fresh, kale has the fiber values between 1.39 and 8.36 mg/100 g (Emebu and Anyika, 2011; Manchali et al., 2012; Sikora and Bodziarczyk, 2012).

Due to its high fiber content, kale reduces the incidence of cancer and heart disease (Slavin and Lloyd, 2012), regulates peripheral blood circulation (Otles and Ozgoz, 2014). Oeven more, due to its low calorie content, the vegetable reduces cholesterol (de Vogel et al., 2005), being essential in diets for reducing the body weight (Ello-Martin et al., 2007; Rolls et al., 2015). Other health benefits associated with regular intake of kale are: antigenotoxic activity (Goncalves, 2012), anticancer activity (Han, 2014), protection of the cardiovascular system and gastrointestinal tract (Kim et al., 2017). The American Institute for Cancer Research concluded that kale – through its high fiber content, reduces the occurrence of various types of cancer. Another significant role of fiber presence in kale is to regulate the gastrointestinal tract (Maciejak and Kosmala, 2019).

Accumulation and distribution of dry matter and solutes depends on the variety, plant age, growing conditions and fertilization; for example, Guiu in 2009, determined that dry matter, total soluble solids and insoluble fiber contents was affected by the cultivar used. In that research, crude fiber content ranged between 7.7% at Gigante I-915 and 10.5% at Manteiga I-916.

The aim of the present research was to establish the influence of cultivar on the quality attributes of kale cultivated in a high tunnel ecological farming (Balcau et al., 2012), in order to promote the cultivation and the consumtion of this vegetable, as there are numerous ways to consume kale: raw, boiled, steamed, braised, sautée, as tasty side dish, or added to a smoothie, all providing a range of nutrients and offer numerous possible health benefits.

MATERIALS AND METHODS

The experiment was based on four kale cultivars, appreciated and cultivated for their leaves, as follows: Tuscan Black, Siberian Red, Dwarf Curled, Scarlet. Tuscan Black is the ultimate kale variety originating from Tuscany, often referred to as Palm Kale or Black Tuscan Kale. A non-heading variety, the robust plants will produce rich, succulent, tasty, dark green leaves, including throughout the harshest winters. Plants can grow up to 70-90 cm tall. A spring sowing and a late summer sowing will keep the Kale for the best part of a year. Harvest can start 90 days after sowing. Siberian Red is a smooth, green, purple leaves. Mature plants are medium-tall (90 cm) and leaves are tender compared to other kales. It is best for salads and light cooking. It can be harvested 90 days after sowing. Dwarf Curled plants are very compact, growing up to only 30-45 cm tall, but with delicate, succulent, tightly curled leaves. This kale is easy to grow, and quite appropriate for containers, given its compact size. It is a cold hardy kale, proper also for summer planting- for fall and winter harvest, but it will also produce well in summer from early spring plantings. Harvest can start 60 days after sowing. Scarlet kale has striking red and purple leaves, rich in antioxidants, vitamins, and minerals, thus as beneficial as it is beautiful. Its bold flavor, with a slightly peppery bite, can elevate a variety of dishes from salads to soups. Easy to grow, the seeds thrive in cooler weather and are resilient to frost, making them a versatile option for extending the growing season. Harvest can start 70-80 days after sowing.

The research was performed in 2022 in a high tunnel, located in Băbuțiu village – Cluj County; the experiment was held at the organic farm „Colina Farms", in an organic system, in the greenhouse (Figure 1). The experiment took into consideration fresh samples of leaves which were dried up before testing and 1 g of dry product was used to determine the fiber content and 5 g of dry product was used to determine the dry substance.

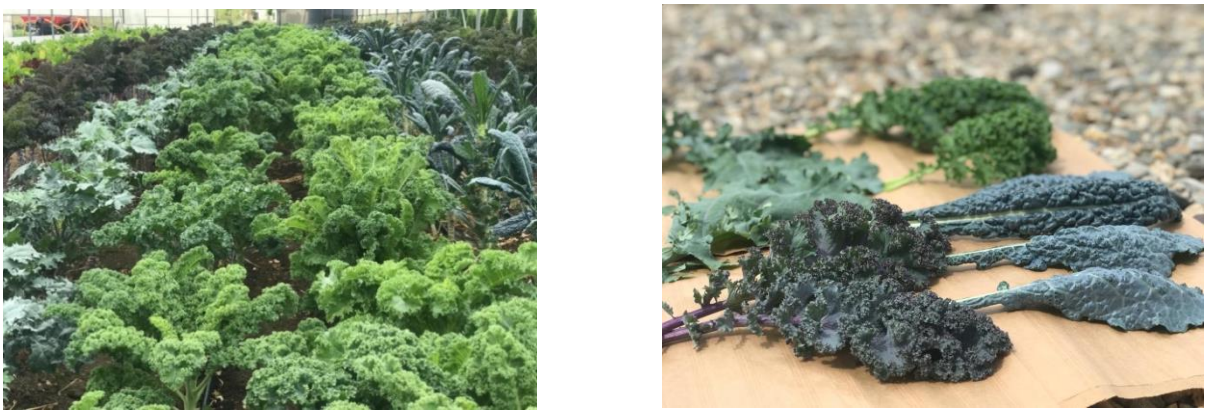

Figure 1. The four kale cultivars studied (Scarlet, Siberian Red, Dwarf Curled, Tuscan Black)(original).

The determinations were made in the Horticulture laboratory of the Faculty of Horticulture and Business in Rural Development. A thermosetting electric oven was used to determine the overall dry matter in kale leaves (Bota, 2013). The soluble dry matter was obtained using the Zeiss portable (handheld) refractometer (Figure 2). The determination of soluble dry matter using hand refractometers includes the following stages of work: checking the working accuracy of the apparatus; determination of soluble dry matter; correction of results depending on the temperature- the correction consists of adding 0.07 for each extra degree above 20 °C or subtracting the same value if the temperature is below 20 °C; the working temperature was 20.30° C, thus the reading was directly noted.

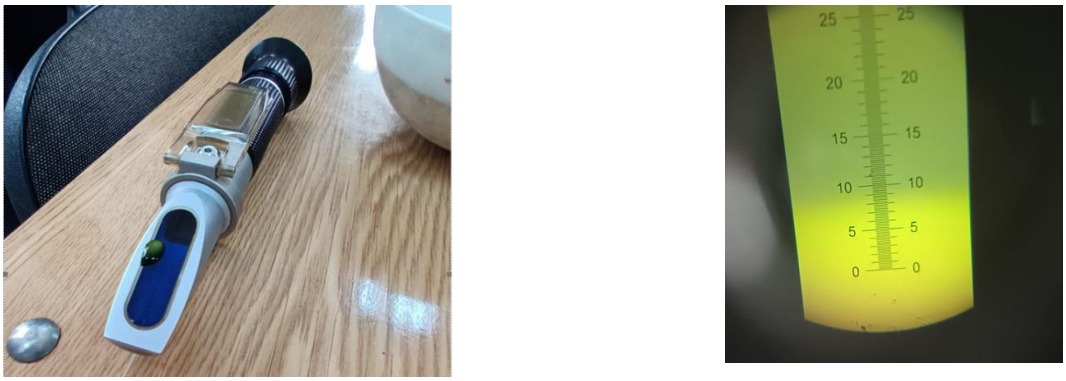

Figure 2. Refractometer with sample and sample reading (original).

Insoluble dry matter reflects the amount of crude fiber in kale leaves. The criterion of the method is to solubilize all nutrient components except cellulose, by successive boiling with solutions of sulphuric acid (12,5%) and sodium hydroxide (12,5%). The residue was filtered, dried, calcined and weighed. The equipment used was the FIBERTEC system (Figure 3), consisting of: cold extractor 1021 with a capacity of 6 samples/series, used to degrease samples with a content greater than (10%) fat and hot analyzer 2010 with a capacity of 6 samples/hour, used for hydrolysis of samples with sulfuric acid and sodium hydroxide solutions.

Figure 3. Sample fiber extractor (original).

RESULTS AND DISCUSSIONS

The content in total dry mass may vary depending on agro-ecological conditions, growth and variation of moisture in the leaves. The determined values were noted in Table 1. Analyzing the obtained values, the variety with the highest concentration in dry mass (29.1%) was Scarlet, with a statistically insignificant difference from the control (Tuscan Black, 26.1%). The other cultivars recorded distinctly significant negative differences, with values of 10.4% for Siberian Red and 16.9% for the curled Dwarf variety.

The Red Siberian variety distinguished by the highest concentration in soluble dry matter (Table 2) with a value of 8.4%, ensuring a statistically significant difference from the control (Tuscan Black), which also had the lowest value (6.28%). The Scarlet variety (with 17.18%) had no statistically insured difference from the control, while the Dwarf curled variety registered statistically insured difference with a value of 7.88%.

Table 1. The content in total dry mass (%) in kale cultivars

Cultivar	Dried Mass Total (%)	Relative Quantity	Difference ± mg/100 g	Significance
Red Siberian	10.4[a]	39.8	-15.7	00
Dwarf Curled	16.9[b]	64.8	-9.2	00
Scarlet	29.1[c]	111.5	3	-
Tuscan Black (Mt)	26.1[c]	100	-	Mt
DL (p 5 %)		3.88		
DL (p 1 %)		7.12		
DL (p 0,1 %)		11.77		
DS		3.88-3.89		

Note: Different letters between cultivars denote significant differences (Duncan test, $p < 0.05$). Different letters between susceptible and resistant cultivars denote significant differences (LSD test, $P < 0.05$).

Table 2. The content in soluble dry matter (%) in kale cultivars

Cultivar	Dried Soluble Mass (%)	Relative Quantity	Difference ± mg/100 g	Significance
Red Siberian	8.40[ab]	133.7	2.12	*
Dwarf Curled	7.88[b]	125.4	1.60	*
Scarlet	7.18[b]	114.3	0.90	-
Tuscan Black (Mt)	6.28[a]	100	0	Mt
DL (p 5 %)		1.44		
DL (p 1 %)		2.65		
DL (p 0,1 %)		5.87		
DS		1.44-1.45		

The insoluble dry matter (fibre) content (Table 3) of the four kale cultivars investigated, differed according to the cultivar. The sample chosen as control was Black Tuscany variety, because is now one of the most cultivated types of kale, with values of 6.68 mg/100 g of fresh product. There were no statistically assured differences between the control and the Siberian Red variety, while the curled Dwarf and Scarlet varieties showed differences of 1.98 mg/100 g and 1.82 mg/100, respectively, distinctly significantly positive.

Table 3. The content in insoluble dry matter (fiber) in kale cultivars

Cultivar	Total Fiber (mg/100g)	Relative Fiber Quantity	Difference ± mg/100g	Significance
Red Siberian	6.79[a]	101.6	0.10	-
Dwarf Curled	8.66[b]	129.6	1.98	**
Scarlet	8.50[b]	127.2	1.82	**
Black Tuscan (Mt)	6.68[a]	100	-	-
DL (p 5 %)		0.82		
DL (p 1 %)		1.50		
DL (p 0,1 %)		3.33		
DS		0.82-0.82		

The results obtained in this research were similar to those obtained by Charlo et al. (2008) who tested 25 genotypes, among which six showed more than 30% crude protein: HS-20 (32.56%), Comum (31.70%), Couve de Arthur Nogueira 2 (31.16%), Pires 2 de Campinas (30.63%), Manteiga I-916 (30.36%), and Manteiga de Ribeirão Pires I-2446 (30.03%). In relation to crude fiber, the highest percentage was seen in the genotype Manteiga de Mococa (10.92%), differing significantly from the other genotypes studied. Singh et al. (2008) determined an average fiber content from 0.60 to 3.62 g/100 g of fresh product at their study on kale cultivars, these values were slightly lower than those obtained in this research. Regarding dry matter content, results were similar in both experiments.

Kale can be good for adding fiber and antioxidants to the human diet, with various health benefits that include managing blood pressure and boosting digestive health, some even considering it a “super-food”. The cultivar should be chosen accordingly to the nutritional content and quality attributes, but also considering the crop interval and harvest time.

CONCLUSIONS

This research proves that kale is a vegetable rich in dry matter, fibers and its use in diets brings all the benefits of eating such type of vegetables. All followed traits, during this experiment were influenced by the used cultivar. Based on the results obtained, it can be noted that the kale cultivar with the highest values in terms of total dry matter was Scarlet, with 26.1%, while the highest value for insoluble dry matter content was recorded by the Dwarf curled variety, with 8.66%. Siberian Red variety had the highest value in terms of soluble dry matter, of 8.40% respectively. These results were similar or higher compared to what other authors determined in their experiments.

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Conflicts of Interest

The authors declare that they do not have any conflict of interest.

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