

## LETTUCE (*LACTUCA SATIVA* L.) - THE NEGLECTED VEGETABLE IN THE MACE DONIAN PRODUCTION AND TRADE

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### ABSTRACT

Although vegetable production plays a significant role with over 30% of the total crop production output in the Republic of North Macedonia, only a couple of vegetables are treated with due diligence: tomato, pepper (most of it intended for processing), cucumber, and cabbage. Fifteen other vegetables can be found in different data sources, but lettuce is not among them. The only source about the cultivation area and quantity of production is the Ministry of Agriculture Forestry and Water Economy, but this information defers largely from the one that can be obtained from FAOstat. In both cases, the values are negligible low, i.e., below 20 ha in total. In this paper, we have tried to present the realistic status and trends of lettuce import, export, and consumption over ten years and deduct from there the volume and the origin of lettuce production. The results indicate that over 80% percent of the lettuce that is sold on the markets comes from uncertain cultivation practices, especially concerning food safety standards. Considering that lettuce has a tendency to accumulate nitrates, along with microbiological threats, it makes the whole picture even more complex. We propose some soil-less cultivation methods that can be easily adopted by the growers and result in more efficient and safe production.

**Key words:** soil-less cultivation, food safety, leafy vegetables.

### INTRODUCTION

Due to its specific fresh taste and nutritional values (Hamilton and Fonseca, 2010; Koyama et al., 2012), lettuce (*Lactuca sativa* L.) is among the leading vegetables grown in the world throughout the year. In the Republic of North Macedonia, its production is extensive, taking place in unheated tunnels and outdoors, in limited areas. Although there are no statistical data on production, based on the quantity placed during the year (regardless of whether it is from import or from local production), it can be concluded that there is a need and space for the improvement of technologies and the method of production in order to increase the quantities, but above all the quality of the product, all the more since it is the most significant representative of leafy vegetables, known for the accumulation of nitrates (Zandvakili et al., 2019; Bian, et al., 2020; Kappel et al., 2021). An additional risk during cultivation is microbial threats, given that lettuce is consumed directly, without prior heat treatment (Maior et al., 2022). These two significant critical points are being overcome worldwide by cultivation in soilless systems (Changmai et al., 2018).

In recent decades, there has been an intensive shift from soil cultivation to hydroponic cultivation that provides many conveniences for lettuce, such as shortened vegetation that allows for multiple production cycles throughout the year, control of the nutrient solution to reduce

nitrate in the final product (Kappel et al., 2021), and even to add trace elements that are important for human nutrition (Bian, Z., Wang et al., 2020) and for shelf life extension (Min et al., 2021). Hydroponic systems are, among other things, an appropriate response to the challenges ahead. Avgoustaki and Xydis (2020) list only a part of the problems such as elevated CO<sub>2</sub> levels, water pollution, excessive use of fertilizers, loss of fertile soils, and other environmental threats that can be minimized by this method of cultivation.

## **MATERIAL AND METHODS**

In order to conduct this analysis, a comprehensive literature review was conducted, consisting primarily of full papers and abstracts from the last two decades that discuss the production of lettuce, the critical factors affecting its quality, and the modern technologies utilized by the leading producing nations. The emphasis is thus placed on hydroponic systems. Scopus and ScienceDirect of Elsevier, ResearchGate of the same firm, and Google Scholar of the Google corporation were utilized to access databases of peer-reviewed papers.

In the analysis of the production, placement, and international trade of lettuce in the Republic of North Macedonia, the following data from the Makstat database of the State Statistics Office were utilized: foreign trade / cumulative data by tariff numbers and countries by year for import and export of lettuce and chicory (tariff number 0705) during the period from 2012 to 2021; and living standard/consumption of items per household during the same period. In the absence of statistics from public sources on lettuce output, reports on greenhouse production from 2012 to 2021 were received through a personal connection with the Ministry of Agriculture, Forestry, and Water Economy. In the initial years of the period, lettuce production statistics were expressed in terms of the number of heads produced, although some regional units were reported in terms of volume. In order to standardize the measurement units, it was assumed that a head of lettuce cultivated in our country weighs approximately 0.150 kg and that the planting density is 12 plants per square meter. The FAOstat database was utilized to assess and illustrate the lettuce production status on a global scale, as well as to compare production.

## **RESULTS AND DISCUSSION**

### **Issues with the domestic lettuce production**

The consumption of fresh cut leafy vegetables (including herbs) on the European market has increased by approximately 4% per year over the past two decades. Consequently, this food category is known as one of the most lucrative within the fruit and vegetable market. As a result of the growing trend observed over the past decade, lettuce (*Lactuca sativa* L.) and chicory (*Cichorium intybus* L.) are cultivated over a total area of 1.2 million ha, with a production of 27 million metric tons (Ronga et al., 2019). Among the top ten producers in the World is Belgium that is characterized by small area, similar to the Republic of North Macedonia (Although the Republic of North Macedonia is still a prominent vegetable producer in the region, it is gradually becoming a raw material base for the processing industry at the expense of fresh vegetable production (Popsimonova et al., 2017). The documentation of lettuce production is severely lacking. There are no records on the production of this type of vegetable, with the exception of a few localities with notable acreage (> 1 ha) that have been reported through the regional units of the Ministry of Agriculture Forestry and Water Economy (MAFWE) as presented in

Figure 1. Lettuce is grown as a typical seasonal food, with the spring and fall growing seasons being the most significant. Although in developed countries it is the number one vegetable

grown in greenhouses with up to 12 production cycles per year, in our productive and social environment it continues to be cultivated on very limited areas (literally in gardens), in walk-in tunnels, or in open field.

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Table 1 Top ten producers of lettuce and chicory in the World for 2020

	Country producer	Quantity[t]	Area [ha]	Average yield [t ha <sup>-1</sup> ]
1	China	14,318,667	606,194	23.62
2	USA	4,402,375	107,690	40.88
3	India	1,121,379	176,644	6.35
4	Spain	969,060	34,300	28.25
5	Italy	735,470	32,100	22.91
6	Japan	580,546	21,221	27.36
7	Mexico	541,804	22,270	24.33
8	Belgium	538,900	12,030	44.80
9	Turkey	520,151	23,954	21.71
10	Iran	432,070	14,377	30.05

Source: FAOSTAT, 2022



Figure 1 Offer (production + import) and demand (consumption + export) ratio  
Sources: MAKstat 2022, MAWFE 2022, own calculations

The data from the State Statistics Office indicate that the typical family purchases (local consumption in

Figure 1) between 5.0 and 6.0 kg of lettuce on an annual basis, which accounts for approximately 1.5 to 2.0% of their total purchase of fresh vegetables. It is significantly lower than the average for Europe, which is approximately 35 kg per household or 8.2 kg per individual (Maršić, 2017). Also, it is not possible to draw a conclusion about the actual consumption per person based on the data that is provided, especially taking into consideration the fact that the product is both extremely fragile and highly perishable. Bogevska et al. (2022) state that the majority of wasted food is comprised of various types of vegetables.

In general, the production of organic vegetables for fresh consumption is highly limited due to a shortage of inputs, but most importantly due to a lack of awareness regarding alternative methods and the production process (Agic et al., 2011). According to the current Registers of the Ministry of Agriculture and Forestry for organic producers, there are only two registered producers who have a few hundred square meters of lettuce production (200 m<sup>2</sup> each). These producers grow their lettuce primarily for cutting, or for the production of mixed baby salads.

Table 2 Calculation of actual lettuce production [kg]

Year	A Reported production	B Import	C Export	D Purchased on domestic market	D -(A+B) - C Presumed production	% Of the purchased (consumed) lettuce
2012	377,640	57,019	104,827	2,988,441	2,658,609	89.0
2013	361,800	51,387	18,993	2,887,383	2,493,189	86.3
2014	468,000	45,079	7,940	3,459,619	2,954,480	85.4

2015	472,500	67,901	14,571	2,471,449	1,945,619	78.7
2016	378,000	64,718	13,919	2,935,868	2,507,069	85.4
2017	374,400	83,294	15,922	2,774,238	2,332,466	84.1
2018	342,000	87,016	77,068	3,292,248	2,940,300	89.3
2019	361,800	117,159	16,676	3,402,042	2,939,759	86.4
2020	324,000	121,735	9,247	3,180,156	2,743,668	86.3
2021	342,000	170,383	32,484	3,295,415	2,815,516	85.4

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Source: SSO 2022, own calculations

To calculate the real volume of lettuce grown in the local area, we took the total quantity of lettuce sold on the market and deducted the difference between the amount of lettuce imported and exported as well as the quantity of lettuce produced and reported. According to this analysis, more than 80 percent of the lettuce that is sold commercially in North Macedonia is grown by small growers who tend to cluster in larger urban centers as presented in Table 2.

The entities that apply for direct payments through the Ministry of Agriculture “Reported production”, as per Article 49 of the Law on Agriculture and Rural Development (Official Gazette of the Republic of Macedonia No. 49/10, 53/11, 126/12 and 15/13, 69 /13, 106/13, 177/14, 25/15, 73/15 and 83/15) are obliged to meet the minimum requirements of the Good Agricultural Practice. For the rest of the growers that fall under the "presumed production" we can not be certain how they cope with the challenges that are associated with the production of lettuce and how safe their produce is. This refers to the quality of the lettuce that we consume daily in terms of microbiological safety, the accumulation of nitrates, the maintenance of sanitation in post-harvest procedures, etc. Namely, these producers represent the target group that should be informed and introduced to the production improvement and new technologies that will not only guarantee increased yields, but also a quality and safe product that can be marketed not only on the domestic market but also on the international market.

### **Hydroponics as possible solution**

In the last few decades, the production of greenhouse crops has shifted away from soil cultivation and toward soilless technologies (Rodriguez-Ortega et al., 2017). Approximately 3.5% of the world's area that is farmed under tunnels and greenhouses for the production of vegetables has adopted techniques based on hydroponic solution (FTS, NFT) or aeroponics, and this number is expected to continue growing (Sambo et al., 2019). This is attributed to the numerous benefits that this kind of production offers, as well as the more efficient use of mineral resources, which includes water (Kinoshita et al., 2016). According to Barbosa et al. (2015), in terms of water usage efficiency (WUE), lettuce that is grown in soilless systems uses 1.6 liters of water per kilogram of product. This is in contrast to soil cultivation, which requires 76 liters of water for every kilogram of product. A similar comparison is made by Kern et al. (2016), who reported an average productivity level of 53 g L<sup>-1</sup> lettuce used in hydroponic cultivation, in contrast to only 4 g L<sup>-1</sup> lettuce grown in soil. This indicates that hydroponic cultivation results in a significantly higher level of lettuce production than soil cultivation does.

Sabir & Singh (2013), in their review paper on hydroponic vegetable cultivation, make a brief reference to lettuce. They state that the primary benefits of hydroponically grown lettuce include a shorter production period (35-40 days), availability all year round, and consistency of product attributes. Because it is such a flexible and adaptable technology, hydroponics may be utilized in a wide variety of settings, ranging from low-tech production systems in rural areas or

backyards to highly sophisticated space stations. In comparison to fruit vegetables, which, because of the limited area available for the establishment of the root system, exhibit some negative consequences in growth and development, lettuce, because of its short vegetation, is capable of growing very well in all different kinds of soilless systems (Balliu et al., 2021). In general, the use of closed (recirculating), fertigation systems lowers the impact that agricultural practices have on the environment (Michelon et al., 2020).

The Ebb and Flow technique is another method of cultivating plants using hydroponics. This method involves periodically raising the level of the nutrient solution to the same level as the root system, and then allowing the solution to drain away so that the root zone can be supplied with air. It has been noticed that the delayed action of ripening hormones is caused by a lack of oxygen in the root zone in FTS systems, which are among the most extensively utilized in practice. The Ebb and Flow technique provides an improvement of the lack of oxygen in the root zone. Furthermore, the post-harvest quality of leafy vegetables cultivated in FTS systems was worse to that of vegetables grown in other systems (Conversa et al., 2021).

It can be stated that there are alternatives and technical solutions for all challenges in lettuce production, including nitrate accumulation and microbiological safety. Although hydroponic technology requires fairly expensive initial investments, adjustments and simplifications can make it adaptable to current socioeconomic and production settings. For instance, the above-mentioned technique of nutrient solution intake and outflow (Ebb and Flow) can be effectively used in the Republic of North Macedonia's prevalent small, unheated greenhouses.

## **CONCLUSIONS**

From the analysis of the production, consumption, and distribution of lettuce in the Republic of North Macedonia, the following conclusions can be drawn: the consumption of lettuce in the country is far below the recommended daily intake, which provides an opportunity to increase production; the majority (over 80%) of the lettuce offered on the market is from local production, which, with current agricultural practices, cannot guarantee the quality that end user would expect. There is considerable possibility for improvement and development in the cultivation of lettuce and leafy vegetables. However, the government should support small growers with structural measures like investments in technology, and consultancy, and there should be effective production infrastructure in place: suppliers of equipment, greenhouses, seedlings, fertilizers, etc.

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