Improving the food safety of fresh-cut salad products during the production process

Mónika Göb[1]*, Zsuzsanna Horváth-Mezőfi[2], Zoltán Árpád Sasvár[1], Naji Alwani[1], Lien Le Phuong Nguyen[2], Tamás Zsom[2], Géza Hitka [2]

[1]Doctoral School of Food Science, Hungarian University of Agriculture and Life Sciences, Budapest, Hungary [2]Institute of Food Science and Technology, Hungarian University of Agriculture and Life Sciences, Budapest, Hungary

***Corresponding author e-mail:** gobmonika@gmail.com

Abstract:

My research includes the examination of the production and processing parameters of fresh-cut salad products, as well as the determination of development directions that help increase the food safety of the products.

The food safety and shelf life of freshly cut salad products are greatly influenced by the conditions of raw material storage, preparation, cleaning, cutting, washing, drying, semi-finished product storage, and packaging.

With the experiment, I analysed how effective the washing process of the tested salad products is from a food safety point of view and to what extent it influences the microbiological parameters of the final product.

The main conclusions of the study were drawn from the microbiological test results of the finished products (Total bacterial count, Enterobacteriaceae, Escherichia coli O157:H7).

Based on the obtained test results, it can be concluded that adherence to the predetermined temperature and washing parameters and proper hygienic conditions preserves the good quality of the finished product and increases its food safety.

Keywords: Food safety, Lettuce, GMP, GHP

Introduction

The role of fresh-cut salad products in modern nutrition is becoming increasingly important worldwide. The demand for fresh salads and salad mix preparations of various compositions continues to grow. One of the primary reasons for this is that plant foods, which can be included in the diet during main and smaller meals, supply the human body with essential vitamins, minerals, and fiber.

Nutrition, health, and food safety are closely interconnected. A lack of food safety can lead to a series of illnesses, some of which can be fatal. The causative agents may include viruses, bacteria, parasites, or their toxins, as well as other chemical contaminants. The production of safe food is important not only from a national economic and commercial perspective but also plays a significant role in sustainable development.

Vegetables are the foundation of a healthy diet, but according to European data, they can also pose risks as carriers of pathogenic agents and toxic substances. Contamination can occur at any stage of production, including cultivation, harvesting, storage, transportation, sale, and processing. Experiences indicate that the problem is often caused by technological shortcomings, worker negligence, or the formalities of HACCP documentation.

The cultivation of certain types of salad in Hungary in adequate quality is nearly impossible due to unpredictable weather conditions. The procurement of salad raw materials can essentially be divided into two seasons. The first is the summer season, which lasts from April to mid-November, and the second is the autumn season, spanning from mid-November to the end of March. The purchase of leafy greens during the summer season is generally limited to Hungarian producers, as well as suppliers from Germany, Poland, and the Netherlands.

Only a small quantity of raw materials arrives from Hungarian producers. The raw materials for the winter season generally come from Spain. The quality and processability of the incoming raw materials are influenced by several factors. However, it can generally be stated that temperature is one of the most important factors determining the post-harvest quality of specialty leafy vegetables. Despite the diverse botanical origins of salad vegetables, each has an optimal post-harvest temperature close to 0°C, with high relative humidity. By utilizing packaging to reduce water loss and strictly regulating temperature, a shelf life of 14 days can be achieved with high-quality products. At a storage temperature of 5°C, the shelf life is reduced to 7 days (M. Cantwell, J. Rovelo, X. Nie, and V. Rubatzky Dept; 1996).

When the cells of fresh products rupture, as occurs during cutting, chemical reactions are initiated that shorten shelf life. These chemical reactions must be minimized. The most significant factor influencing product shelf life is temperature, which affects the rate of enzymatic and other chemical reactions. It is essential to keep minimally processed fruits and vegetables at temperatures above freezing to ensure the preservation of their original flavor and color (H.R. Bolin and C.C. Huxsoll; 1991).

I conducted the experiment for both seasons. The aim of the study was to determine how effective the washing process, which is inherently linked to the processing of salad products from different seasons, is from a food safety perspective and to what extent it affects the microbiological parameters of the finished product.

Materials and Methods

The ingredients of the salads and salad mixes examined in this study were Ice Lettuce (Lactuca sativa var. capitata, 'Iceberg'), Endive (Cichorium endivia), Frisee (Cichorium endivia var. crispum), Romana (Lactuca sativa var. Romana) and Lollo Rosso (Lactuca sativa convar secalina).

The raw material was harvested 5 days before arrival, then transported in a 4 °C vacuum-cooled refrigerator on the 5th day in a truck with a cargo temperature of 5 °C to the place of processing.

The acceptance of the incoming salads was carried out through a visual inspection of quality parameters as follows: The quantity of samples examined was 12 heads of lettuce per pallet. Samples were taken from a total of 6 pallets (with a net weight of 450 – 395 kg). During the quality assessment, we checked the maturity of the sample, the compactness of the lettuce heads, the presence of any insects/foreign materials, freshness, cleanliness, product defects, leaf browning, the amount of damaged leaves, rot, and the core temperature of the raw materials.

During the evaluation, the value 1 – insufficient, cannot be used; value 2 – critical the product is considered critical for the given condition and may affect productivity or product quality. Value 3 – appropriate. This evaluation means that the product is OK for the given condition.

ICEBERG LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,5	4,3	4,0	5,0	4,3	5,0	4,5	4,5	5,0	4,3	4,3	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	3	3	3	3	2	2	3	2	3
DEGREE OF ROTTING	3	3	3	3	3	3	3	3	3	3	3	3
DAMAGED LEAF	3	3	3	3	3	3	3	2	2	3	2	2
ENDIVIA LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,8	4,8	5,0	5,0	4,7	5,0	4,7	4,8	5,0	5,0	5,1	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	2	3	2	2	3	3	3	3	3
DEGREE OF ROTTING	3	3	3	3	3	3	2	3	3	3	3	3
DAMAGED LEAF	3	3	3	2	3	3	2	3	3	3	3	3
FRISEÉ LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,5	4,5	4,0	4,0	4,3	4,0	4,3	4,2	4,5	4,3	4,5	4,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	3	3	3	3	3	3	3	3	3
DEGREE OF ROTTING	3	3	3	3	3	3	3	3	3	3	3	3
DAMAGED LEAF	3	3	3	3	3	3	3	3	3	3	3	3
ROMANA LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	5,2	5,3	5,0	5,0	5,3	5,0	5,2	5,1	5,0	5,3	5,1	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	2	3	3	2	2	2	3	2	2
DEGREE OF ROTTING	3	3	3	3	3	3	2	3	3	3	3	3
DAMAGED LEAF	3	3	3	2	3	3	2	2	2	3	2	2
LOLLO ROSSO LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,5	4,3	4,0	4,3	4,5	4,5	4,5	4,5	4,3	4,3	4,3	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	3	3	3	3	2	2	2	2	2
DEGREE OF ROTTING	3	3	3	3	3	3	3	3	3	3	3	3
DAMAGED LEAF	3	3	3	3	3	3	3	3	2	2	2	2

Table 1 Classification of raw materials received during the winter season

ICEBERG LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,8	4,5	4,8	5,0	4,8	5,0	4,5	4,5	5,0	4,5	4,3	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	3	3	3	3	3	3	3	2	3
DEGREE OF ROTTING	3	3	3	3	3	3	3	3	3	3	3	3
DAMAGED LEAF	3	3	3	3	3	3	3	3	3	3	2	2
ENDIVIA LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,8	4,8	4,8	5,0	4,7	4,8	4,7	4,8	5,0	5,0	4,8	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	2	3	2	3	3	3	3	3	2
DEGREE OF ROTTING	3	3	3	3	3	3	2	3	3	2	3	3
DAMAGED LEAF	3	3	3	2	3	3	2	3	3	2	3	2
FRISEÉ LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,5	4,5	4,0	4,0	4,3	4,0	4,3	4,2	4,5	4,3	4,5	4,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	3	3	3	3	3	3	3	3	3
DEGREE OF ROTTING	3	3	3	3	3	3	3	3	3	3	3	3
DAMAGED LEAF	3	3	3	3	3	3	3	3	3	3	3	3
ROMANA LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	5,2	5,3	5,0	5,0	5,3	5,0	5,2	5,1	5,0	5,3	5,1	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	2	3	3	2	2	2	3	2	2
DEGREE OF ROTTING	3	3	3	3	3	3	2	3	3	3	3	3
DAMAGED LEAF	3	3	3	2	3	3	2	2	2	3	2	2
LOLLO ROSSO LETTUCE RAW MATERIAL QUALIFICATION UPON ARRIVAL												
SAMPLE NR.	1	2	3	4	5	6	7	8	9	10	11	12
CORE TEMPERATURE	4,5	4,3	4,0	4,3	4,5	4,5	4,5	4,5	4,3	4,3	4,3	5,0
MATURITY	3	3	3	3	3	3	3	3	3	3	3	3
COMPACTNESS OF SALAD	3	3	3	3	3	3	3	3	3	3	3	3
INSECTS/FOREIGN MATTER	3	3	3	3	3	3	3	3	3	3	3	3
FRESHNESS	3	3	3	3	3	3	3	3	3	3	3	3
CLEANLINESS	3	3	3	3	3	3	3	3	3	3	3	3
BROWNED LEAF	3	3	3	3	3	3	3	2	2	2	2	2
DEGREE OF ROTTING	3	3	3	3	3	3	3	3	3	3	3	3
DAMAGED LEAF	3	3	3	3	3	3	3	3	2	2	2	2

Table 2. Classification of raw materials received during the summer season

The raw materials were stored in plastic crates in a refrigerated storage unit at 5°C after quality assessment until use. The quality preservation period for the salads at 5°C is a maximum of 7 days. During storage, we monitored the air temperature and humidity levels. For optimal product quality, the specified air temperature for storage was maintained between 4-8°C, while the humidity levels were kept between 70-90%.

As the first step in processing, we removed the outer leaves from the lettuce heads, cutting away any damaged parts and the core. The lettuce was then sliced using a mechanical slicer. After slicing, the product was washed.Chopping and cutting can lead to an increase in the number of mesophilic bacteria by 2.0 log10 colony-forming units (CFU) per gram in vegetables. Therefore, it is essential to minimize microbial contamination during these processes (Meltem Yesilcimen Akbas and Hülya Ölmez, 2007). To achieve this, stringent hygiene practices must be employed throughout the processing stages, including thorough cleaning of equipment, proper handling techniques, and monitoring of microbial levels. These measures help ensure the safety and quality of the final product, reducing the risk of foodborne illnesses and extending shelf life.

Freshly cut fruits and vegetables can no longer be considered low-risk from a food safety perspective. Recently, several outbreaks have been identified involving fresh-cut fruits and vegetables processed under inadequate hygiene conditions. These outbreaks highlight that the quality of water used for post-harvest washing and cooling is critical.It is well-known that disinfection is one of the most important processing steps in the production of fresh-cut vegetables, influencing the quality, safety, and shelf life of the final product. The purpose of washing is to remove contaminants, pesticide residues, and microorganisms responsible for quality deterioration, as well as to pre-cool the cut products and eliminate exudates that promote microbial growth (Maria I. Gil, Maria V. Selma, Francisco López-Gálvez, Ana Allende, 2009).

The washing process was carried out using potable water in a two-step washing system. The quality of the finished product is significantly influenced by the temperature of the wash water, which must be maintained within the range of 0.1 to 8 °C. The validation of the washing process involved conducting test analyses during normal production operations, assessing the washing line from start to finish throughout a complete production day.During the investigation, sampling was conducted 12 times with three parallel samples taken each time. The microbiological parameters examined included total plate count (TPC), Enterobacteriaceae (EB), and E. coli O157:H7 (EC). Additional parameters measured during the tests included monitoring the water temperature (°C), active chlorine content (ppm), pH level of the water using indicator paper, the quantity of washed salad products in kilograms, and the volume of fresh water used in liters. These comprehensive evaluations help ensure that the washing process is effective in reducing microbial contamination and maintaining the safety and quality of the fresh-cut products.

After washing, the product was centrifuged and then packaged according to the parameters specific to the final product. The packaging was done using OPP (oriented polypropylene) film material. Depending on the oxygen requirements of the product, packaging can be done using modified atmosphere (food-grade oxygen, carbon dioxide, nitrogen), without protective gas, or through perforation of the film.The finished products were stored at a temperature of +4 °C until delivery. This careful handling and packaging process ensures that the salads retain their freshness and quality, extending their shelf life and maintaining safety for consumers.

Picture 1. Some steps of salad processing

Sampling was conducted at various stages of the processing, including from the unprocessed raw materials, cleaned raw materials, washed/centrifuged raw materials, and the packaged final product. This comprehensive sampling approach allows for a thorough assessment of microbial quality and safety throughout the entire production process.

Microbiological testing was performed using the Petrifilm rapid method, for which I employed the following equipment and process: I prepared the Petrifilm plates for each sample, specifically the 3M Select E. coli Count Plate (SEC) – MMM 6435, the 3M Enterobacteriaceae Count Plate (EB) – MMM 6420, and the 3M Rapid Aerobic Count Plate (RAC) – MMM 6479.For the analysis, I used sterile homogenization bags into which I measured 90 ml of peptone water. From the salad sample, I weighed 10 g of material into each bag. The tools used for preparation, such as tweezers and scissors, were sterilized before use to prevent contamination.

The product in the homogenization bag was mixed with the solution by gently massaging the bag for 2 minutes to ensure that any potential microbes on the surface of the salad were transferred into the peptone water. After homogenization, for the E. coli examination, I pipetted 1 ml of the peptone water containing the salad into the center of the testing plate after lifting the cover film.

Using a plastic spreader, I immediately pressed the sample at the center of the plate with one finger to evenly distribute the testing sample within the circle formed by the cardboard plate. For the Total Plate Count (TPC) and Enterobacteriaceae examination, I prepared a dilution series in the following manner: the first dilution involved homogenizing 90 ml of peptone water with 10 g of the testing sample (salad). From this mixture, I transferred 1 ml into a separate tube containing 9 ml of peptone water, shook it well, and then took 1 ml from this tube to place into a second tube also containing 9 ml of peptone water.I continued the dilution series from the second tube, anticipating potentially higher results. Once the dilution series was complete, I pipetted 1 ml into the center of the testing plate after lifting the cover film, and after allowing it to settle, I guided the cover film back over the sample. Using the plastic spreader, I pressed down on the sample at the center to ensure an even distribution across the circle formed by the cardboard plate.The incubation conditions were as follows: E. coli was incubated at 42 ± 1 °C for 24 ± 2 hours; TPC was incubated at 35 ± 1 °C for 48 ± 3 hours; and Enterobacteriaceae was incubated at 35 ± 1 °C for 24 ± 2 hours.After incubation, the evaluation was performed using the colony counting method.

Results:

The microbiological examination of salad ingredients, semi-finished products, and packaged final products was conducted for both winter and summer season raw materials. The results from samples taken at specific points in the processing indicated that there was no significant difference in the microbiological outcomes of the final product between the winter and summer raw materials.

Test datum	Washing line	Washed product	Time sample	Total washed quantity till the sample since the last water change	Total washed quantity from the tested product (kg)	TPC fresh water	E.coli fresh water	Water able chlorine (ppm 0,1-0,5) fresh w.	Water PH fresh w.	Water PH last basin out	Water temperature (°C) fresh w.	Water temperature (°C) last basin out	Nr.
2023.02.20	1.vonal - 1. washing line 2023.02.20	Iceberg	7:15	175	175	0	<10	0,29	6	6,5	4,4	4,9	1/1, 1/2, 1/3
		Iceberg	8:10	1410	1410	6	<10	0,3	6	6,5	4,8	6,5	2/1, 2/2, 2/3
		Iceberg	9:40	2816	2816	1	<10	0,31	6	6,5	4,6	6,4	3/1, 3/2, 3/3
		Iceberg	45 min. down time 12:15:00	4250	4250	1	<10	0,32	6	6	11	7,7	4/1, 4/2, 4/3
		Completely water change. 25 mm Iceberg	14:25	380	380	0	<10	0,32	6	6	5,4/12,6	5,2	5/1, 5/2, 5/3
		Prémium	15:30	1234	854	1	<10	0,33	6	6,5	7	6,8	6/1, 6/2, 6/3
		Brasiliana	16:25	3093	396	0	<10	0,36	6	6,5	11,1	6,5	7/1, 7/2, 7/3
		Wellness mix	17:40	3731	470	2	<10	0,3	6,5	6,5	10	6,4	8/1, 8/2, 8/3
		Eisberg mix	18:55	4136	481	1	<10	0,31	6,5	6,5	6,5	6,4	9/1, 9/2, 9/3
		Family mix	20:15	5839	533	2	<10	0,36	6	6,5	6,3	7	10/1, 10/2, 10/3
		Bolero mix	21:35	9556	365	4	<10	0,32	6	6,5	6,6	7,3	11/1, 11/2, 11/3
		Betyár	22:35	8880	408	10	<10	0,3	6	6	5,3	6,5	12/1, 12/2, 12/3

Table 3 Validation of the washing line during the winter season

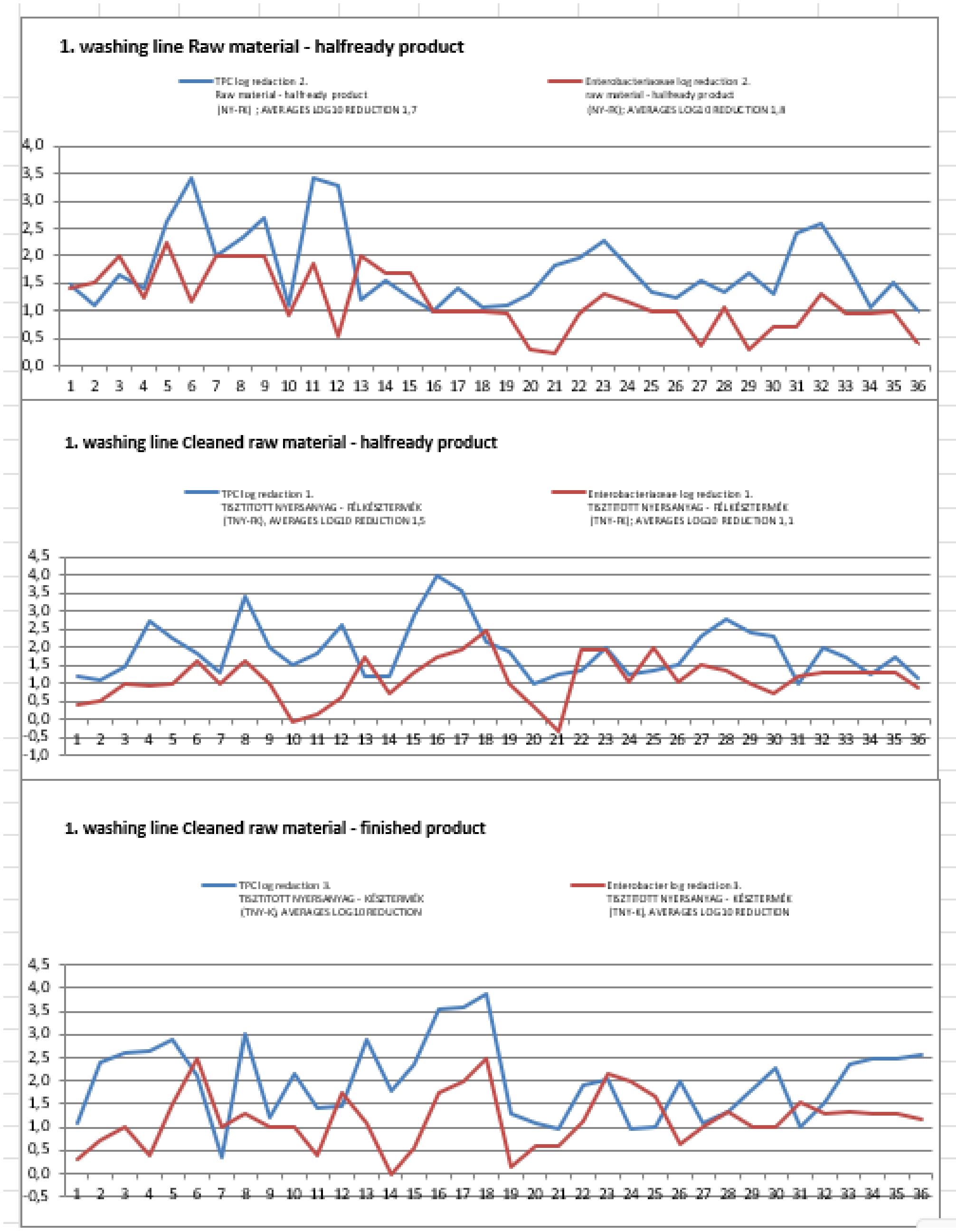

Fig. 1. Graphical representation of the results of the winter season

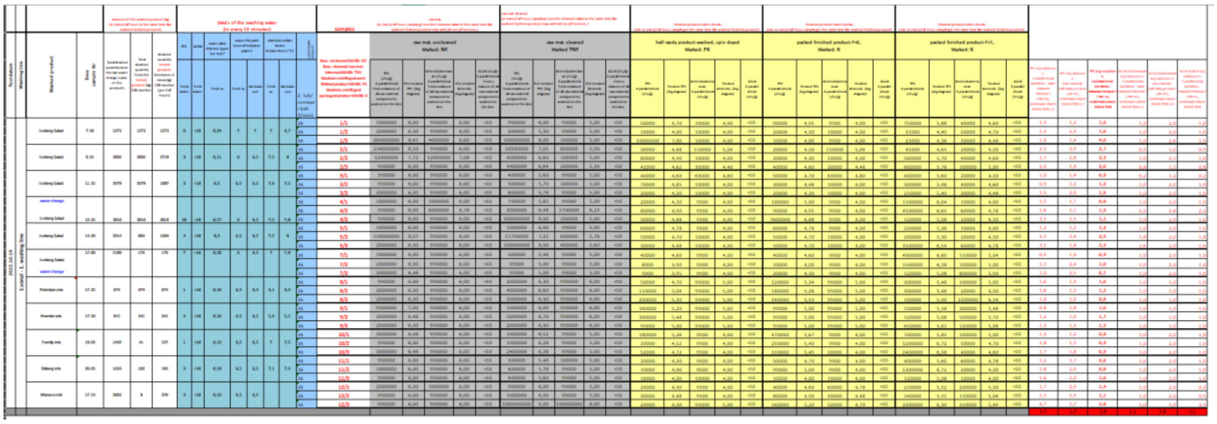

Table 4. Validation of the washing line in the summer season

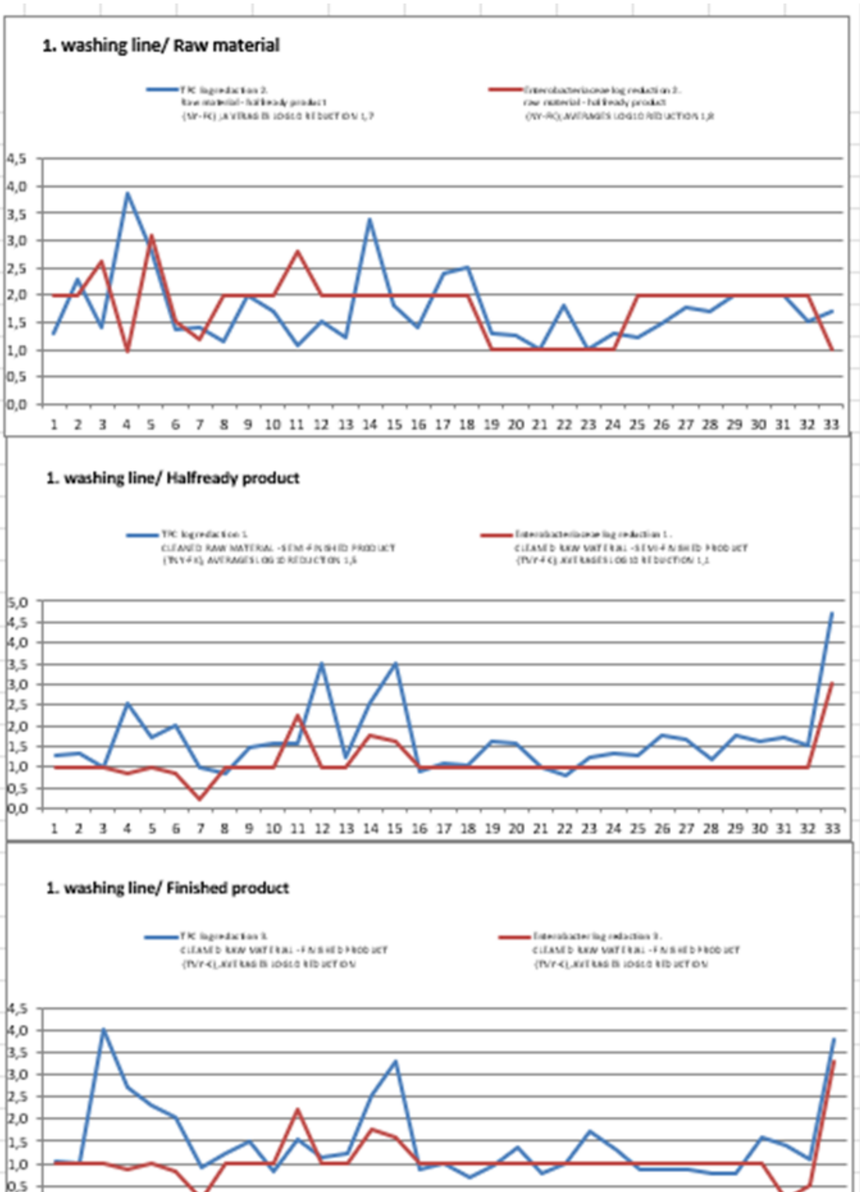

Fig. 2. Graphical representation of the results of the summer season

Conclusion:

The microbiological assessments conducted on salad ingredients, semi-finished products, and packaged final products indicate that the combination of physical and chemical treatments during washing is crucial for mitigating microbial risks. The findings confirm that both winter and summer raw materials yield similar microbiological results, emphasising the effectiveness of the adopted manufacturing technology and strict water hygiene protocols. It is evident that maintaining high hygiene standards and utilising appropriate washing techniques significantly reduce microbial loads, ensuring the safety and quality of fresh-cut products. Furthermore, the results underscore the necessity of proper storage, preparation, and processing practices to minimise the initial microbiological parameters of the raw materials.In conclusion, the implementation of rigorous hygiene measures and effective treatment processes is vital for delivering safe, high-quality fresh produce to consumers, ultimately contributing to public health and food safety.

References :

- M. Cantwell, J. Rovelo, X. Nie, and V. Rubatzky Dept (1996) SPECIALTY SALAD GREENS: POSTHARVEST PHYSIOLOGY AND SHELF – LIFE ; Acta Horticulturae 467: III International Symposium Diversification of Vegetable Crops http://dx.doi.org/10.17660/ActaHortic.1998.467.42

- H.R. BOLIN and C.C. HUXSOLL (1991) Effect of Preparation Procedures and Storage Parameters on Quality Retention of Salad-cut Lettuce BO-JOURNAL OF FOOD SCIENCE-Volume 56, No. 1, 1991

- Meltem Yesilcimen Akbas1 and Hu¨ lya O¨ lmez2∗ (2007) Effectiveness of organic acid, ozonated water and chlorine dippings on microbial reduction and storage quality of fresh-cut iceberg lettuce; Journal of the Science of Food and Agriculture J Sci Food Agric 87:2609–2616 (2007)

- Maria I. Gil, Maria V. Selma, Francisco López-Gálvez, Ana Allende (2009) Fresh-cut product sanitation and wash water disinfection: Problems and solutions International Journal of Food Microbiology 134 (2009) 37–45