

FATIME BAJRAKTARI, IDRIZ KOVAČI, ALBERTA TAHIRI, PAJTIM
RRUSTEMI, ANITA CUCOVIĆ

**STRATEGIES FOR REDUCING FRUIT AND VEGETABLE WASTE
FROM SUPERMARKETS IN THE CONTEXT OF ENVIRONMENTAL
PROTECTION. CASE STUDY KOSOVO**

S u m m a r y

Background. Fruit and vegetable waste is an issue that should be addressed in the context of food policy. Apart from surplus inventory and customer behavior, the most frequent reason for fruit and vegetable waste in retail is a shortage of trained food handling personnel. To prevent waste, fruit and vegetables need to be handled and stored carefully. The purpose of the research was to survey workers in the fruit and vegetable departments of supermarkets in Kosovo in order to learn about their experiences, the reasons behind their perceptions of product waste and methods for reducing fruit and vegetable waste, while ensuring environmental protection.

Results and conclusions. According to the findings, the majority of employees have higher education; they are 25 years old on average and have worked for the company for at least a year; there is no discernible relationship between age and job experience. Supermarkets in Kosovo employ fewer permanent workers than supermarkets in European countries. Apples, pears, plums and small fruit like raspberries and strawberries were considered by personnel to be the best-selling fruit. The vegetables that were sold included potatoes, tomatoes, onions, peppers, spinach and cucumbers, which are essential in Kosovo's cuisine and are perceived as the best-selling and the most often consumed products. Perhaps because these kinds of foodstuffs were so widely available, their handling was associated with waste. Donating and using them in the food industry are two ways to prevent the loss of fruit and vegetables that are in good shape.

Keywords: fruit and vegetable waste; environmental protection; waste reduction strategies

*Dr F. Bajraktari ORCID: 0009-0009-2514-0222, Faculty of Technology and Technical Science, "St. Kliment Ohridski" University of Bitola, Dimitar Vlahov bb, 1400 Veles, Macedonia; Prof. Asoc. dr I. Kovači ORCID: 0000-0002-3728-4532, Faculty of Tourism and Environment, Tourism and Hotel Management, University of Applied Sciences in Ferizaj, Ferizaj, 70000, Kosovo, Prof. Asoc. Dr A. Tahiri ORCID: 0000-0003-3626-4481, Faculty of Management in Tourism, Hospitality and Environment, University "Haxhi Zeka" Pejë, UÇK 30000, Pejë, Kosovo; Dr Pajtim Rrustemi, Faculty of Technology and Technical Science, "St. Kliment Ohridski" University of Bitola, Dimitar Vlahov bb, 1400 Veles, Macedonia; Prof. Ass. dr A. Cucović ORCID: 0000-0003-2324-4422, Faculty of Business Management, Faculty of Business, University "Haxhi Zeka" Pejë, UÇK 30000, Pejë, Kosovo.
Kontakt e-mail: alberta.tahiri@unhz.eu
Corresponding Author e-mail: idriz.kovaci@ushaf.net*

Introduction

The fruit and vegetable sector generates large quantities of waste, which is mainly produced before reaching consumers due to high production and the non-fulfillment of retail sellers' quality standards [17]. Due to its high biodegradability, fruit and vegetable waste poses environmental challenges, a loss of biomass and valuable nutrients, as well as economic losses for companies [22]. To reduce waste from fruit and vegetables, various strategies can be applied such as: reuse, recycling and its utilization by the food industry [14]. Because of the high value of waste and influence on the environment, managing fruit and vegetable waste is a crucial issue that modern society must address [16]. Food waste has recently drawn more attention from global policymakers in a variety of disciplines. The reduction of food waste from fruit and vegetables can positively impact food security and mitigate climate changes [3].

Economically developed nations have concentrated on quantifying and characterizing food waste [6]. Although the suggested quantification approaches are costly, Kosovo and other middle- and low-income nations cannot afford them. From farm to table, a third of all food meant for human consumption is believed to be lost or squandered. The decision to remove food that is still nutritious and suitable for human consumption is referred to as food waste [4]. The process of selling prepared dishes in retail, the conduct of wholesale and retail vendors, and the final consumer's activities at home, are the main factors influencing this action. Agricultural production, post-harvest management, storage, processing, distribution and consumption are the five sources of food waste [2].

Although there are problems with fruit and vegetable waste worldwide, the precise causes differ from nation to nation and even from city to city, depending on the infrastructure, customer profiles and the type of production [18]. The final stages of the food supply chain, including gastronomy and hospitality, as well as the production stages, account for a larger percentage of fruit and vegetable waste [5]. Additionally, quality standards, product quality laws, production surpluses and economic variables, all contribute to fruit and vegetable waste during the agricultural phase [8]. However, about 25 % of their waste is produced during the distribution phase of these products, which are represented by businesses and retail food stores [19]. Fruit and vegetable waste is also caused by the inefficiencies of the food supply chain, poor logistics and infrastructure, a lack of technology, a lack of knowledge and management skills among supply chain participants, and limited market accessibility soon after harvest [15]. There are fewer fruit and vegetables that are available for human consumption, and their high cost is a result of their loss and waste production [10].

Minimizing waste will require optimizing the effectiveness of the whole food supply chain, including the identification of crucial points brought on by incorrect handling and a lack of adequate cold transport and cold logistics facilities [19]. Since the morphological, compositional and physiological features of fruit and vegetables vary greatly, they are categorized into groups that need distinct treatments to preserve their quality and increase their shelf life after harvest [21]. Environmental factors including temperature, light and air have an impact on the organoleptic and functional quality of fruit and vegetables. Vapor pressure deficiency and carbon dioxide enrichment have a smaller impact [13]. When fresh fruit and vegetables are handled carelessly, they become contaminated with dangerous germs, viruses that cause food to decay [11]. Finding the factors that affect food waste in Kosovo's fruit and vegetable departments of supermarkets, as well as methods for reducing waste in the interest of sustainable development and environmental protection were the goals of this study.

Material and methods

This study was conducted between September and November 2024 in 15 supermarkets in Kosovo. Supermarket employees were chosen and willingly took part in the study at random. Since personnel handle products like fruit and vegetables on a daily basis, we decided to ask them. The employees were given 15 printed survey questions to complete, and they were also asked to observe the items and the way in which they were exposed to customers, including their management. Regarding the level of education and experience in handling food, some of the questions were personal.

Data analysis

A grounded theory approach, which involves methodically classifying qualitative data and developing a formal model or theory for the responses, was used to examine the data using an inductive approach. Frequencies and percentages were used to perform a descriptive analysis of the data gathered from the survey. OriginPro software from OriginLab Corporation was utilized to statistically analyze the relationship between employees' age and work experience.

Results and discussion

Characteristics of this study area

Modern and traditional trading systems are the two categories of food product retailers in Kosovo. Modern systems include: self-service stores (supermarkets), whereas the traditional system includes: markets where fruit and vegetables are sold in an open environment. Modern welfare offers services to populations with medium and high

income, while the traditional system is preferred for caring for populations with low income.

The attributes of the employees who were surveyed

Eighty-five percent of the surveyed personnel in the fruit and vegetable sector of the surveyed supermarkets were female. Their age ranged from 22 to 45 years, with an average age of 25 years. The educational level of the personnel was high school (35.8 %) and higher education (university degree) (64.2 %). Among the surveyed employees, no significant correlation ($p < 0.05$) was found between age and work experience in the company. There were 78 % of respondents who had at least one year of experience working in the fruit and vegetables section, however, experience varied from one month to three years. Experience and length of service determined how important age was.

Employee training on food handling

One of the best ways to reduce food waste is through training, which also improves the knowledge of food workers. The study showed that supermarkets that offer more training for their personnel are large chains of supermarkets. The training that employees receive is provided by supervisors, and the topics it includes are storage, packaging and shelving. Supermarket employees generally receive only one to two trainings per year. The treatment of workers in the food sector should be regulated and made mandatory to avoid food waste, specifically fruit and vegetable waste.

Fruit and vegetables most often sold in Kosovo supermarkets

The best-selling fruit in the studied supermarkets, according to the perception of those responsible for the fruit and vegetable sector, are apples, pears, plums, as well as small fruit like strawberries and raspberries (Table 1), different varieties. Vegetables for sale included potatoes, tomatoes, peppers, spinach and cucumbers. This comparative perception along with the existing data from the production and consumption statistics presented by the Ministry of Agriculture, Forestry and Rural Development and ASK (Kosovo Agency of Statistics) through the green report shows that the aforementioned fruit and vegetables are fruit and vegetables with high national consumption rates (Table 2). The survey also identified the high consumption of grapes, bananas, watermelons and melons (Table 1). Consumption in recent years has included fruit from exports that is considered "fresh" in the local market such as mango, avocado, pineapple and kiwi.

Fruit most often discarded in Kosovo supermarkets

As shown in Table 3, 17 different fruit varieties that were thrown away for various reasons were mentioned by the employees who participated in the survey. Of these, 14 were identified as being thrown away frequently, and four were regularly exploited in five trade chains: mango, avocado, pineapple and kiwi. Bananas were mentioned only in a few supermarkets. Fruit that constantly generates waste was also recorded, along with imported fruit with high costs such as mango, avocado, pineapple, and sometimes even kiwi.

Table 1. Fruit that employees consider to be best-sellers in supermarkets

Tabela 1. Owoce, które pracownicy uważają za najlepiej sprzedające się w supermarketach

Fruit / Owoc	[%]
Apple / Jabłko	26.52 ± 10.05
Pear / Gruszka	16.48 ± 5.32
Plum / Śliwka	12.37 ± 4.21
Grape / Winogrono	11.78 ± 3.11
Strawberry / Truskawka	10.24 ± 2.87
Raspberry / Malina	8.65 ± 2.12
Watermelon / Arbuz	8.04 ± 1.98
Melon / Melon	5.92 ± 1.22

Table 2. Some fruit that is most often cultivated and consumed in Kosovo

Tabela 2. Niektóre z najczęściej uprawianych i spożywanych owoców w Kosowie

Fruit / Owoc	Consumption per capita / Konsumpcja per capita [kg]	National production / Krajowa produkcja [tona]
Apple / Jabłko	18.7 ± 5.92	40,028 ± 15.85
Plum / Śliwka	6.9 ± 2.67	13,284 ± 5.65
Raspberry / Malina	3.4 ± 2.10	6,740 ± 2.85
Pear / Gruszka	2.8 ± 2.10	5,649 ± 2.55
Strawberry / Truskawka	1.7 ± 0.95	1,686 ± 1.10
Quince / Pigwa	1.3 ± 0.95	1,329 ± 1.10
Sour cherry / Wiśnia kwaśna	1.2 ± 0.90	779 ± 70.35
Chokeberry / Aronia	2.1 ± 1.67	728 ± 70.35
Blueberry / Jagoda	1.9 ± 1.24	596 ± 50.25
Sweet cherry / Wiśnia słodka	1.8 ± 1.24	561 ± 50.25
Peach / Brzoskwinia	1.5 ± 1.12	320 ± 30.25

Blackberry / Jeżyna	1.2 ± 0.80	251 ± 20.55
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Explanatory notes / objaśnienia:

Data obtained from ASK (2023) and MBPZHR / Dane pochodzą z ASK (2023) i MBPZHR

Strawberries and grapes were local fruit that was most often discarded by customers, primarily due to their delicacy and rapid spoilage, while imported fruit like mango, avocado, pineapple, kiwi and pomegranate are thrown away and generate waste due to their cost (Table 3). The consumer typically handles fruit to determine its level of maturity; if it is too soft, it is already overripe, and the customer does not select it.

Table 3. Fruit that is most often discarded and the main causes

Tabela 3. Owoce najczęściej wyrzucane i główne przyczyny

Fruit / Owoc	Most often wasted / Najczęściej marnowane [%]	Little sale for cost / Niska cena sprzedaży [%]	Delicate fruit / Delikatny owoc [%]	Bruised by clients / Uszkodzony przez klienta [%]
Strawberry / truskawka	24.66 ± 10.25	24.65 ± 10.25	29.88 ± 10.25	11.21 ± 4.55
Grape / Winogrona	18.31 ± 6.35	17.56 ± 6.25	13.32 ± 4.75	7.22 ± 3.25
Peach / Gruszka	13.45 ± 4.75		16.79 ± 5.25	26.56 ± 10.25
Plum / Śliwka	12.46 ± 4.55	16.73 ± 5.85	10.21 ± 4.25	12.43 ± 4.55
Sweet cherry / Słodka wiśnia	11.32 ± 4.55			13.95 ± 4.75
Chokeberry / Aronia	5.21 ± 2.85		4.11 ± 2.55	11.87 ± 4.55
Raspberry / Truskawka	4.67 ± 2.35	2.78 ± 1.10		
Pear / Gruszka	3.22 ± 1.65	2.56 ± 1.10	7.12 ± 3.25	2.04 ± 1.10
Quince / Pigwa	3.22 ± 1.65	4.23 ± 2.25	2.13 ± 1.10	1.02 ± 0.25
Watermelon / Arbuz	2.13 ± 1.10			5.23 ± 1.55
Melon / Melon	2.06 ± 1.10		1.61 ± 0.95	4.98 ± 1.55
Mango / Mango	0.86 ± 0.25	0.99 ± 0.25	3.23 ± 1.10	
Avocado / Awokado		6.93 ± 3.25	1.61 ± 1.10	
Pineapple / Ananas		2.97 ± 1.10		
Kiwi / Kiwi		1.98 ± 1.10		
Pomegranate / Granat		1.98 ± 1.10	1.61 ± 1.10	
Banana / Banan		1.98 ± 1.10	4.84 ± 2.35	

Peach is the third most often wasted fruit, as shown by the figures –13.45 % (Table 3), and the employees perceived the reason for its waste as a delicate fruit that spoils quickly and is handled by consumers. Its waste was not considered to be related to cost but to storage conditions. Of the cultivated and consumed grapes in Kosovo,

61 % is sold for fresh consumption, and its condition deteriorates easily due to the pathogenic infection that is facilitated by the moisture content. The table grape was identified in five supply chains as fruit with a high percentage of waste, and in four of the stores, this rate was accompanied by a relatively high cost and manipulation of the consumer. Small fruit like raspberries, strawberries and chokeberries is also considered popular fruit in supermarkets, as well as cultivated in Kosovo, while imported fruit includes pomegranate and bananas.

The employees questioned believe, as far as the generation of waste from these fruit types is concerned, that they are difficult to store due to their delicateness, and their price also relatively affects this issue (Table 3). A number of factors, including temperature, humidity, packing, storage, exposure, handling and personnel's and customers' ignorance, can affect the amount of fruit and vegetables that are wasted in supermarkets. According to some personnel, the low sales of pears, peaches and plums might be attributed to their comparatively high cost, which leads to their waste. Meanwhile, customers may perceive watermelons and melons to be delicate and prone to bruises. Despite the fact that they are frequently damaged by customer handling, apples were hardly ever identified as a disposable product, maybe because of their resilience (Table 3).

Vegetable waste in Kosovo supermarkets

The top selling products in supermarkets in Kosovo were potatoes, tomatoes, onions, peppers, spinach and cucumbers (Table 4), which have high levels of annual per capita consumption (Table 5). Potatoes, tomatoes, onions, peppers and cucumbers are common ingredients in the Kosovan diet. The high carbohydrate content in potatoes makes this product one of the main components of the Kosovan diet. Twelve vegetables with frequent losses were identified as sensitive items that should be conserved in the survey that asked employees about their perceptions of the vegetables being discarded most often (Table 6). There are many farming areas in Kosovo, and it has been calculated that each person consumes 20.12 kg of different tomato kinds annually (Table 5).

Table 4. The most popular vegetables in Kosovo's supermarkets

Tabela 4. Najpopularniejsze warzywa w supermarketach w Kosowie

Vegetable / Warzywo	[%]
Potato / Ziemniak	26.52±10.52
Tomato / Pomidor	19.23±6.75
Onion / Cebula	16.22±5.25
Pepper / Papryka	14.41±4.35
Spinach / Szpinak	7.25±3.65

Cucumber / Ogórek	6.32±3.25
Cabbage / Kapusta	5.17±3.15
Lettuce / Sałata	2.51±1.85
Carrot / Marchewka	2.43±1.85

Table 5. Data on the production of vegetables grown and sold in Kosovo

Tabela 5. Dane dotyczące produkcji warzyw uprawianych i sprzedawanych w Kosowie

Vegetable / Warzywo	Consumption per capita / Konsumpcja per capita [kg]	National production / Krajowa produkcja [tona]
Potato / Ziemniak	20.6 ± 6.75	75,500 ± 21.25
Pepper / Papryka	17.5 ± 5.65	55,353 ± 18.65
Cabbage / Kapusta	11.2 ± 4.45	25,546 ± 8.25
Pumpkin / Dynia	9.32 ± 3.65	22,551 ± 7.85
Tomato /Pomidor	8.94 ± 3.65	20,206 ± 7.85
Onion / Cebula	8.23 ± 3.65	19,190 ± 6.75
Cucumber / Ogórek	5.64 ± 2.45	8,973 ± 5.65
Carrot /Marchew	2.32 ± 1.85	1,770 ± 0.85
Spinach / Szpinak	2.00 ± 1.65	1,557 ± 0.85
Lettuce / Sałata	1.23 ± 1.10	708 ± 35.65

Explanatory notes / objaśnienia:

Data obtained from ASK (2023) and MBPZHR / Dane pochodzą z ASK (2023) i MBPZHR

Across all supply chains, tomatoes are the vegetable with the highest percentage of residues and the only one that is typically seen as requiring careful handling. Inappropriate environmental conditions or infections developed by fungi and different bacteria can create a variety of issues with tomatoes that are stored; the right circumstances depend on the type.

Food regulations pertaining to advertising to attract more consumers, as well as a lack of coordination between the quantity received and the amount that may be sold, may be the cause of the irresponsible handling of fruit and vegetables at the supermarket level. Fruit and vegetables with higher costs are offered to showcase a greater variety, unsuitable storage conditions and a lack of trained personnel in the fruit and vegetable sector, their improper distribution, being openly exposed or their misuse by consumers.

Even within the same supermarket, the amount of waste from fruit and vegetables varies between sectors, hence external factors, such as environmental factors, personnel behavior and various specific aspects should have a significant impact. These fac-

tors should be studied in detail to develop strategies to prevent losses and waste from fruit and vegetables.

Table 6. Vegetables that cause the most waste in Kosovo supermarkets

Tabela 6. Warzywa, z których powstaje najwięcej odpadów w supermarketach w Kosowie

Vegetable / Warzywo	Most wasted / Najczęściej marnowane [%]	Delicate vegetable / Delikatne warzywo [%]
Tomato /pomidor	39.24±16.78	73.42±20.45
Cucumber / Ogórek	15.31±5.65	11.72±4.65
Lettuce / Sałata	10.32±4.65	9.56±3.95
Spinach / Szpinak	9.45±4.35	5.00±2.65
Pepper / Papryka	8.21±3.95	3.81±1.95
Parsley / Pietruszka	6.32±3.25	3.81±1.95
Broccoli / Brokuł	5.37±2.95	2.54±1.10
Cabbage / Kapusta	4.61±2.65	2.54±1.10
Onion / Cebula	2.85±1.95	2.54±1.10
Pumpkin / Dynia	1.89±1.10	2.00±1.10
Carrot / Marchew	1.72±0.95	1.69±0.95
Potato / ziemniak	1.63±0.95	1.50±0.95

Environmental impact of fruit and vegetable waste

Fruit and vegetable waste is a major threat to the environment due to its high production and harmful effects on the ecosystem. Inadequate treatment of fruit and vegetable waste resulting from production, distribution and consumer activities releases significant amounts of organic matter and nutrients [1]. These waste materials decompose, generating greenhouse gases like CH₄ and causing climate change.

Furthermore, by releasing nutrient-rich discharge into water bodies, fruit and vegetable waste adds to water pollution by causing eutrophication and harming aquatic life [17]. Composting provides a solution by promoting aerobic decomposition, lowering CH₄ emissions and producing nutrient-rich compost, which enhances soil health and agricultural productivity [12]. Other management strategies are proposed to address these problems, including reducing waste at the source through better collection practices and consumer awareness campaigns.

Strategies for managing fruit and vegetables to avoid losses and waste

A variety of solutions can be created to reduce fruit and vegetable waste in supermarket chains, as seen in Figure 1. Since prevention through proper management enables a decrease in operational expenses, and consequently, an increase in the company's profitability, it will always be the most popular approach [7]. The employees responded in an affirmative manner when asked if there was a record of the quantity of fruit and vegetables thrown out, however, they did not offer any proof of a loss control procedure [10]. The products sold by five retail chains include ripe or inadequately aesthetically pleasing fruit, natural fruit juices and pre-cut fruit that is ready to eat [20]. As part of their marketing plan, they also have a special day where they sell fruit and vegetables at a discount.

Insights identified strategies to avoid food waste in various supermarket chains. It was found that when some excess fruit and vegetables were not sold, yet they were in a state of optimal ripeness, they were given as gifts to consumers who could not afford to buy them [9]. Kosovo, as a new country in Europe, does not have food banks to donate a percentage of food, specifically fruit and vegetables. The supply of safe and nutritious food presents advantages for companies, such as increasing storage space and saving costs in terms of the time required for food disposal. Donation also allows a company to advertise its actions. Tax incentives and an increase in awareness that it is inappropriate to waste food from a social, economic and environmental perspective occurred later. Perhaps the most suitable strategy to reduce waste from fruit and vegetables is their utilization by the food industries to produce value-added food products.

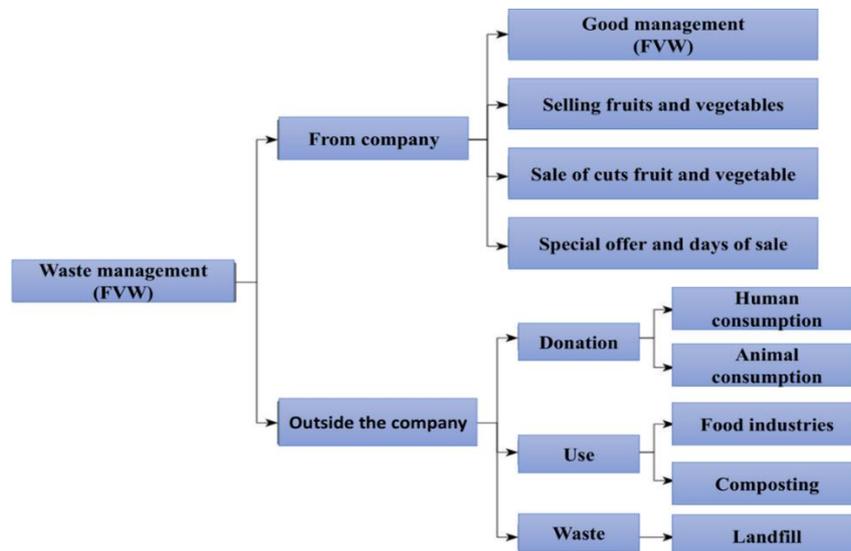


Figure 1. Some strategies for reducing fruit and vegetable waste in supermarkets

Rycina 1. Niektóre strategie ograniczania marnowania owoców i warzyw w supermarketach

Conclusions

1. Worldwide need, preventing food waste – more especially, waste from fruit and vegetables – has several advantages, including a decreased environmental impact, increased economic benefits and support for food security.
2. Harvesting practices, transportation strategies, storage conditions and administrative considerations like personnel organization and training that oversee these perishable goods throughout the supply chain are all part of the complex problem of fruit and vegetable waste.
3. A consumer's subjective choice of fruit and vegetables in retail establishments is influenced by sensory factors like color, taste and texture; the acceptability of products would be affected if these qualities were lost.
4. Professional preparation is necessary while handling fruit and vegetables because each one requires particular environmental conditions, including relative humidity, temperature, gas composition and pressure to preserve the product quality and shelf life. Given the high value of fruit and vegetable waste and its impact on the environment, managing this waste is a crucial issue that modern civilization must address.
5. Fruit and vegetable waste is challenging, as some of its sorts have high water content. However, various waste management strategies can be effectively implemented. In their midst, the ideal strategy maximizes the use of fruit and vegetable waste as sources of valuable compounds, such as nutrients and water. Utilizing fruit and vegetable waste processing in the food sector would lessen the negative effect of waste on the environment and possibly even make it a valuable resource for the business.

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**STRATEGIE REDUKCJI ODPADÓW OWOCOWYCH I WARZYWNYCH
W SUPERMARKETACH W KONTEKŚCIE OCHRONY ŚRODOWISKA.
STUDIUM PRZYPADKU KOSOWO**

Streszczenie

Wprowadzenie. Marnowanie owoców i warzyw to problem, który należy rozwiązać w kontekście polityki żywnościowej. Oprócz nadwyżek zapasów i zachowań klientów, najczęstszą przyczyną marnowania owoców i warzyw w handlu detalicznym jest niedobór przeszkolonego personelu do obrotu żywnością. Aby zapobiec marnowaniu, owoce i warzywa muszą być ostrożnie traktowane i przechowywane. Celem badania było przeprowadzenie ankiety wśród pracowników działów warzywnych supermarketów w Kosowie w celu poznania ich doświadczeń, powodów stojących za postrzeganiem przez nich marnowania produktów oraz metod ograniczania marnowania owoców i warzyw przy jednoczesnym zachowaniu ochrony środowiska.

Wyniki i wnioski. Zgodnie z wynikami większość pracowników ma wyższe wykształcenie, mają średnio 25 lat i pracują w firmie co najmniej od roku. Nie stwierdzono wyraźnego związku pomiędzy wiekiem a doświadczeniem zawodowym. Supermarkety w Kosowie zatrudniają na stałe mniej pracowników niż supermarkety w krajach europejskich. Jabłka, gruszki, śliwki i małe owoce, takie jak maliny i truskawki, były uważane przez personel za najlepiej sprzedające się owoce. Sprzedawane warzywa obejmowały ziemniaki, pomidory, cebulę, paprykę, szpinak i ogórki, które są niezbędne w kuchni Kosowa i są postrzegane jako najlepiej sprzedające się i najczęściej spożywanych. Być może dlatego, że tego rodzaju produkty były szeroko dostępne, ich obrót wiązał się z marnotrawstwem. Darowanie i wykorzystywanie ich w przemyśle spożywczym to dwa sposoby zapobiegania marnowaniu owoców i warzyw charakteryzujących się właściwą jakością.

Słowa kluczowe: odpady z owoców i warzyw, ochrona środowiska, strategie ograniczania odpadów 