Cost price of edible films and coatings for fresh fruit and vegetables

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Abstract. Scientific studies on determining the cost price of edible films and coatings for fresh fruits and vegetables have not been established in the scientific literature. The purpose of this article is to examine cost price of various edible films and coatings for some fresh fruits and vegetables. The descriptive-analytical method is used to fulfill the aim - the theoretical aspects of the researched scientific field are investigated on the basis of a current literature survey. The collected information is summarized and analyzed using a systematic approach; an analytical approach; a study of the works of authors in the field; a comparative analysis and an observational method. In the scientific study, the cost price of edible films and coatings for fresh fruits and vegetables of randomly selected scientific developments was calculated, and three groups according to cost price were presented. In conclusion, opportunities for future research on the cost price of edible films and coatings are presented.

1 Introduction

Edible films and coatings are a thin layer applied to the surface of various food products that preserve the quality and extend the shelf life of food. The difference between edible films and edible coatings is the method of preparation and the method of application. Edible coatings are applied directly to the surface of the food product by dipping or spraying, followed by a drying process. Edible films are made by spreading the polymer solution onto a solid surface by casting, followed by drying and then applied to the food [1].

Fresh fruits and vegetables have a natural shell in the form of a peel, which is covered with a cuticle that protects it from adverse external influences. These natural barriers regulate the exchange of oxygen, carbon dioxide and water, reducing the loss of volatile flavor and aroma substances, which can be improved with the application of edible films and coatings [2].

The preservation of the quality of fresh fruits and vegetables is important for the food industry, which is important for consumer acceptance, which affects economic value. Edible films and coatings of food products (including fresh fruits and vegetables) perform the main function of protecting them from biological, physical and chemical hazards, supporting the logistical aspects of distribution and delaying changes during storage of fresh fruits and vegetables [3].

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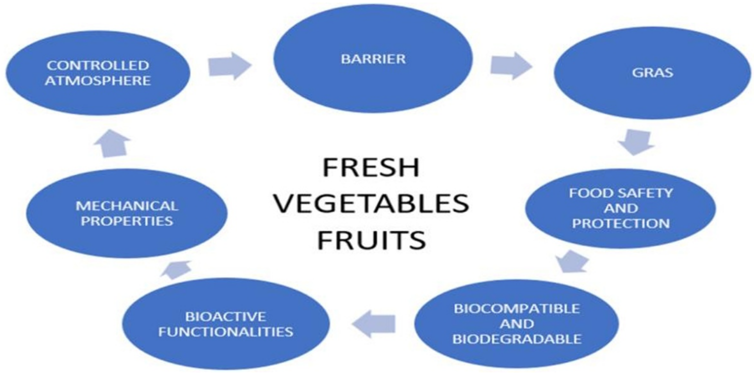

Fig. 1. Major functionalities of edible films and coatings for fresh fruit and vegetable [Adapted from 4].

Edible films and coatings are protective barriers that provide a controlled atmosphere for fresh fruits and vegetables, thus preserving quality and extending their shelf life. The main functions of edible films and coatings (Figure 1) for fresh fruits and vegetables are related to their protection during transportation, various manipulations, mechanical damage and UV radiation. In addition, edible films and coatings possess barrier properties against moisture, resulting in the minimization of water vapor transmission to prevent dehydration of fresh fruits and vegetables; a gas barrier that controls the levels of oxygen and carbon dioxide as they pass through protective layer; barrier for volatile organic compounds, protecting against vapors and loss of aromas, pigments, etc. Edible films and coatings extend the shelf life of fresh fruits and vegetables, with some exhibiting antimicrobial and antifungal properties and acting as probiotics. In addition, edible films and coatings for biodegradable, melting above 40◦C without decomposition, waterproof, easily emulsifiable, non-sticky and efficient drying.

Edible films and coatings preserve the quality of fresh fruits and vegetables, minimally affecting their texture, taste and color. The composition of edible films and coatings is formed from economical, well-characterized components that are safe for consumers under GRAS [4].

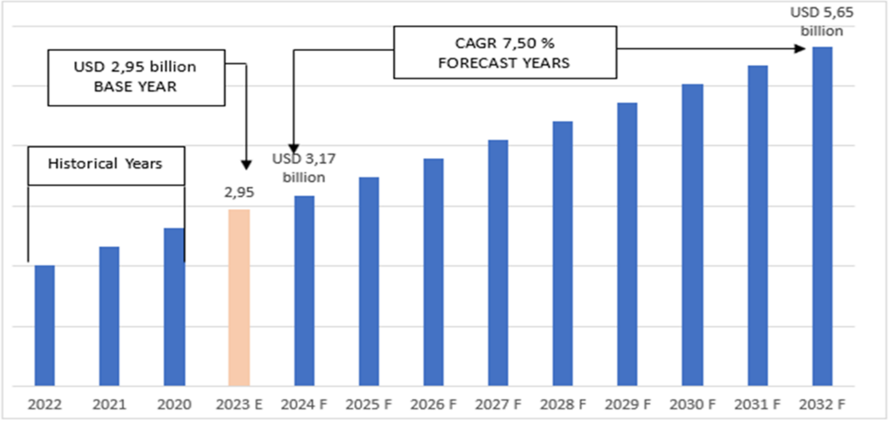

Fig. 2. Edible films and coatings market size in the period 2022-2032 [Adapted from 5].

The global edible films and coatings market size is valued at US$ 2.95 billion in 2023 (Figure 2). It is expected to rise to US$ 5.65 billion in 2032, growing at a CAGR of 7.5%

during the forecast period (2024-32). A trend in consumer demand is to increasingly look for natural, sustainable and ecologically clean food products. Edible films and coatings are created from biodegradable components (proteins, lipids and polysaccharides) that meet these criteria, leading to their demand by manufacturers, traders and consumers [5].

Cost price is an important economic indicator for evaluating economic activity and a means of regulating the production process. It is a main factor for analyzing the activities of enterprises and directly affects the management decisions made. Its relationship with the efficiency of production, with its quality and with the price of the offered products is indisputable. Therefore, its significance in the modern competitive environment is extremely great. Cost price is an economic value category expressing production relations of general economic and socioeconomic significance based on the monetary expression of costs sufficient to carry out simple reproduction. The definition highlights several more important characteristics of cost price. They can be systematized and presented in the following directions: it is an economic category and as such expresses production relations; part of the value of the products of labor is; is measured in value; expresses production relations with general economic and socioeconomic significance; measures and values costs summarized according to certain criteria; estimates costs that are sufficient to carry out simple reproduction; is determined during the production of the product; between it and the costs, incl. production costs are ascertained in direct and inverse relationships [6].

Edible films and coatings preserve the quality and extend the shelf life of various types of fresh fruits and vegetables [7-11]. The properties and good functionality of edible films and coatings and their positive impact on fresh fruits and vegetables will increase the size of the market in the long term, which is a prerequisite for research in the field. In the scientific literature, there is a lack of in-depth scientific data regarding the cost price of edible films and coatings, which is the reason for the present study.

The purpose of this article is to examine cost price of various edible films and coatings for some fresh fruits and vegetables.

The descriptive-analytical method is used to fulfill the aim - the theoretical aspects of the researched scientific field are investigated on the basis of a current literature survey. The collected information is summarized and analyzed using a systematic approach; an analytical approach; a study of the works of authors in the field; a comparative analysis and an observational method.

2 Results and discussion

2.1 Edible films and coatings for some fresh fruits and vegetables

Edible films and coatings and their application for fresh fruits and vegetables are presented in the subsection. The composition of edible films and coatings is systematized and summarized in a table at the end of the subsection.

A study evaluated the impact of edibles coatings on reducing weight losses by retarding ripening of tomatoes, thereby increasing their shelf life and preserving their quality. Tomatoes were coated by the dipping method with different concentrations of chitosan. The effect of chitosan edible coating on TSS, pH, titratable acidity, shrinkage and lycopene content of tomatoes were studied over a period of 30 days at room temperature. The study found that chitosan-coated tomatoes were firmer, had higher titratable acidity and were less rotting. On the 20th day of tomato storage, the lowest TSS value (5.1% Brix) was recorded in 2.5% chitosan and the highest TSS value (6.8% Brix) for the control sample. The tomato control sample showed rapid deterioration from day 20 on storage for comparison of the coating on domatite, which delays ripening and extends the shelf life to 30 days. The results concluded that the application of 2.5% chitosan coating resulted in a better extension of the storage life of tomatoes compared to 0.5%, 1%, 2% chitosan coatings [12].

A scientific study investigated the effect of edible coatings for carrots at room temperature during storage, which were packed in polyethylene bags. Physico-chemical parameters were evaluated in the study and sensory characteristics at 4-day intervals over a 20-day storage period. Different concentrations in the composition of edible coatings show a significant influence on the storage life of carrots. After the study it was found that edible coating (T9 - 2% chitosan in 0.25N HCl and

0.50 mL glycerol + polyethylene packaging) has the most effective results according to the indicators - vitamin C content, total soluble solids, titratable acidity, pH, beta-carotene and sensory parameters - texture, taste, aroma, color, as the coated punches have minimal weight loss during storage. Edible coatings applied increase the shelf life of carrots, which is good information for producers [13].

In a study, grapes were coated with four different edible films and coatings - the first with 1% chitosan (T1), the second with 2% calcium chloride (T2), the third with 1% chitosan, 2% calcium chloride (T3) and the last with a mixture of 1% chitosan, 2% calcium chloride, 0.2% citric acid, 0.1% ascorbic acid (T4). Grapes applied with different edible coatings are stored at two temperature conditions - room temperature (28 ºC ±3) for 12 days or at cool temperature (4 ºC ±1) for 90 days. During the course of the study, a significant reduction in weight loss was found in the coated samples compared to the uncoated control samples (T0). Edible coating of calcium chloride (T2) has a significant influence on the maintenance of grape quality (total soluble solids (TSS), hardness, titratable acidity, sensory and microbiological evaluation - total plate count, psychrophilic bacteria count and mold and yeast count) during storage in both temperature regimes – room temperature (28ºC ±3) and at cool temperature (4ºC ±1) [14].

Cucumbers have nutritional value but high moisture content, which is associated with reduced shelf life. This encourages research into the possibility of edible films and coatings maintaining their quality and increasing their shelf life. The study determined the effect of the edible coating (a total of 80 mL of moringa oil and 20 g of beeswax) on the quality of fresh cucumber at different temperatures (at 4, 10 and 22 °C) of storage for 27 days of storage and their comparison with the uncoated (control) samples. The results show that the edible coating preserves important nutrients such as vitamin C, firmness, sugar content, acidity, slows the decrease in pH, maintains color intensity and significantly reduces weight loss, as well as extends the shelf life. Cucumber quality was affected by changes in temperature, with lower temperatures having more beneficial effects [15].

Mandarins are treated with various edible coatings to slow the loss of valuable nutrients after harvest. The tangerines were covered with edible coating in different composition - paraffin wax (100%, 75% and 50%), mustard oil, aloe vera, turmeric paste and control sample (no coverage). The quality of mandarins was studied under room conditions 18±2 °C and 52.41±14.35% relative humidity at 7, 14 and 21 days. From the experiment it was found that edible coating (75% paraffin wax) recorded the lowest value physiological weight loss for 7, 14 and 21 days respectively by 3.10%, 4.83% and 10.33%, highest titratable acidity (0.68%), highest juice content (46.33%) and percentage of salable fruit (81.73%). This implies its use for storage of tangerine in a room conditions (18±2°C and 52.41±14.35% RH) [16].

A study evaluated the effect of edible coatings of carboxymethyl cellulose (CMC), low methoxyl pectin (LMP), persian gum (PG) and tragacanth gum (TG) on the physicochemical parameters of strawberries during their storage period at 4 °C and 80% RH for 16 days. The results demonstrated significantly less weight loss and decay for strawberries with edible surface coatings compared to control samples. Edible coatings preserve the content of ascorbic acid, total phenolics and anthocyanins in the fruit during storage. Strawberries coated with TG and CMC showed the lowest weight loss (3.65%) and decay (32.66%) on the 16th day of storage, respectively. There was no significant difference between the coated and control samples in terms of strawberry firmness and color during storage. The comparison between different coatings by TOPSIS analysis showed that (CMC) edible coating was the best in reducing the weight loss and preserving the nutritional components of strawberries during the storage period [17].

Another study evaluated the effect of edible gelatin and aloe vera coatings on the physicochemical, microbial and sensory parameters of fresh-cut kiwifruit stored at 4±1°C and 70-75% RH for 12 days. Kiwi slices were coated with edible coatings of gelatin and/or Aleo vera gel of different compositions and compared to control samples. The study evaluated various quality parameters such as weight loss, firmness, total soluble solids, vitamin C, pH, titratable acidity, microbial load and sensory properties during storage. The best results were obtained in the firmness indicator and in the panel test for preferences, with edible coating of gelatin and Aleovera gel (5:100) and edible coating of Aleo vera. Large differences were observed in the quality parameters in favor of edible coatings for fresh cut kiwi fruits compared to the control sample. Edible coating of gelatin and Aleo vera gel (5:100) had a significant effect on maintenance of weight loss loss of fresh-cut kiwifruit, as well as extending shelf life. The same samples had the best microbiological quality results and were ranked highest points by sensory parameters [18].

Eggplants have valuable nutrients that, along with weight loss, affect their strength and quality after harvest. The influence of an edible beeswax coating on eggplant quality preservation was investigated. Eggplant was coated with a 3% beeswax solution by melting an appropriate amount of wax in commercial oil (Frytol®) at low temperature and stored at 10°C for 17 days. The coating significantly reduced weight loss, preserved strength and delayed color changes. Beeswax coating had no effect on total phenolics or antioxidant capacity [19].

The plum has a limited shelf life due to rotting and mechanical damage, which is a prerequisite for studies with edible coatings applied to the surface of the fruit. Plums were treated with different edible coatings such as Semperfresh™ (1:3), plant wax (1:5) and shellac-based wax (2:3) (main coating component:water), and the control sample was dipped in water (control sample), with samples stored at 20 ± 2 °C and 90 ± 2% RH. The study evaluated the quality of stored plums regarding changes in firmness, physiological (weight loss, respiration and ethylene release levels) and biochemical characteristics (total antioxidant activity, malondialdehyde and pectin content methylesterase activity) at 3-day intervals for a period of 15 days. The edible shellac coating showed best results in maintaining firmness (~67% higher), quality and post-harvest life of plum up to 15 days [20].

Various edible coatings of blends of candelilla wax, gum arabic, jojoba oil and pomegranate polyphenols are formulated to preserve the shelf life quality of pears. The pears were analyzed for physicochemical and sensory parameters during 30 days of storage at room temperature. Covered pears, with the designation T13 (candelilla wax 3%, gum arabic 4%, jojoba oil 0.15% and pomegranate polyphenols 0.015%) preserve quality and extend shelf life (weight loss) by minimizing physico-chemical changes (total soluble solids, appearance changes, firmness, pH values) and sensory properties (odor, flavor, and texture) for 4 weeks [21].

Table 1 presents summary table about edible films and coatings for some fresh fruits and vegetables. In the methodological part of some of the studies, the solvents are not reflected, but they are presented in the table, in view of the possibility of calculating the costs in the next subsection depending on the nature of the main components of the edible films and coatings.

Table 1. Summary table about edible films and coatings for some fresh fruits and vegetables. Source: Own research.

Main components of edible films and coatings	Additional components of edible films and coatings	Type of fresh fruits and vegetables	Obtained results	Storage conditions	Authors
2.5% chitosan (EFC1)	0.6% acetic acid 25% glycerol 1M sodium hydroxide (1 ml) 70.9% distilled water	tomatoes	preserves the quality (TSS, pH, titratable acidity, lycopene content) and extends the shelf life	at room temperature for 30 days	Sree, et, al., 2020
2% chitosan (EFC2)	(1ml) 0.25N HCl and 0.50 mL glycerol + polyethylene packaging 96.5%distilled water	carrots	preserves the quality (vitamin C content, TSS, titratable acidity, pH, beta-carotene) and sensory parameters (texture, taste, aroma, color) and minimal weight loss during storage	at room temperature for 20-days	Sadiq, et, al., 2019
2% calcium chloride (EFC3)	98% distilled water	grapes	preserves the quality (total soluble solids (TSS), firmness, titratable acidity, sensory and microbiological evaluation - total plate count, psychrophilic bacteria count and mold and yeast count) and reduction in weight loss	at room temperature (28 ºC ±3) for 12 days at cool temperature (4 ºC ±1) for 90 days	Abdelaal, et, al., 2022
80 mL of moringa oil and 20 g of beeswax (EFC4)	-	cucumbers	preserves the quality (vitamin C, firmness, sugar content, acidity, slows the decrease in pH, maintains color intensity), reduces weight loss and extends the shelf life	4, 10 and 22 °C of storage for 27 days	Al-Rashdi, et, al., 2024
75% paraffin wax (EFC5)	25% toluene	mandarins	preserves the quality (titratable acidity, juice content), lowest value physiological weight loss and percentage of salable fruit	room conditions 18±2 ℃ and 52.41±14.35% relative humidity at 7, 14 and 21 days	Barsha, et, al., 2021
1% Carboxymethyl cellulose (CMC) (EFC6)	30% glycerol 69% distilled water	strawberries	preserves the quality (content of ascorbic acid, total phenolics and anthocyanins) and reduction in weight loss	4 °C and 80% relative humidity for 16 days	Khodaei, et, al., 2021
Gelatin (5g) Aloe vera gel (100 ml) (EFC7)	-	fresh-cut kiwifruit	preserves the quality (physicochemical, microbial and sensory parameters) and reduction in weight loss	4±1°C and 70-75% RH for 12 days	Elabd and Gomma, 2018,
3% beeswax (EFC8)	97% commercial oil (Frytol®)	eggplants	preserves the quality (strength and delayed color changes) reduced weight loss	10°C for 17 days	Dadzie, et, al., 2023
40% shellac-based wax coating (EFC9)	60% distilled water	plums	preserves firmness, physiological (weight loss, respiration and ethylene release levels) and biochemical characteristics (total antioxidant activity, malondialdehyde and pectin content methylesterase activity)	20 ± 2 °C и 90 ± 2% for 15 days relative humidity	Kumar, et, al., 2018
candelilla wax 3%, gum arabic 4%, jojoba oil 0.15% and pomegranate polyphenols 0.015% (EFC10)	92,83% distilled water	pears	preserve quality and extend shelf life (weight loss) minimizing physico-chemical changes (total soluble solids, appearance changes, firmness, pH values) and sensory properties (odor, flavor, and texture) for 4 weeks	30 days of storage at room temperature	Cruz, et, al., 2015

Table 1 shows that the edible films and coatings with different composition of the used components are observed, and the wide variety of fresh fruits and vegetables on which the edible films and coatings are applied is also visible. In addition, the obtained results of edible films and coatings applied to fresh fruits and vegetables, related to quality preservation and extension of the storage period at different temperatures and relative air humidity, are presented in a synthesized form. In the case of the mentioned edible films and coatings, there are no attempts to calculate their cost price, which will be done in the next subsection of this scientific article.

2.2 Results about cost price of edible films and coatings for fresh fruit and vegetables

As already mentioned, cost price is an important economic category for any business organization, showing the costs that an enterprise incurs to produce a product or offer a service to a certain market. In addition, it can be said that the cost price performs several important functions from business point of view, including: 1) it allows to determine the exact amount of production costs and the added value generated by the relevant business unit; 2) has the role of a basis for determining the market price of the product/service; 3) allows to determine the break-even point, which is a guarantee for the existence of the business organization on the market; 4) outlines the main guidelines of the process of planning and forecasting income and expenses from business activity, which in turn determines the estimated financial result (the amount of profit or loss), etc. Cost price as an economic category is of different types according to the costs included; according to field of application; main business activity of the enterprise, etc. According to the included costs, it can be production (technological) cost price and based on full cost. The first one includes all production costs for converting raw materials into a finished product, while the second includes also administrative costs, as well as those necessary for the product market sale (Figure 3). In turn, production costs can be direct and indirect, as well as variable and fixed costs. Direct costs are those that, at the time of their occurrence, can be directly attributed to the cost of the product or service, while indirect costs are indirectly attributed by allocation on a predetermined basis. Fixed costs are not affected by production volume and remain relatively constant, while variable costs are directly related to volume and vary with it.

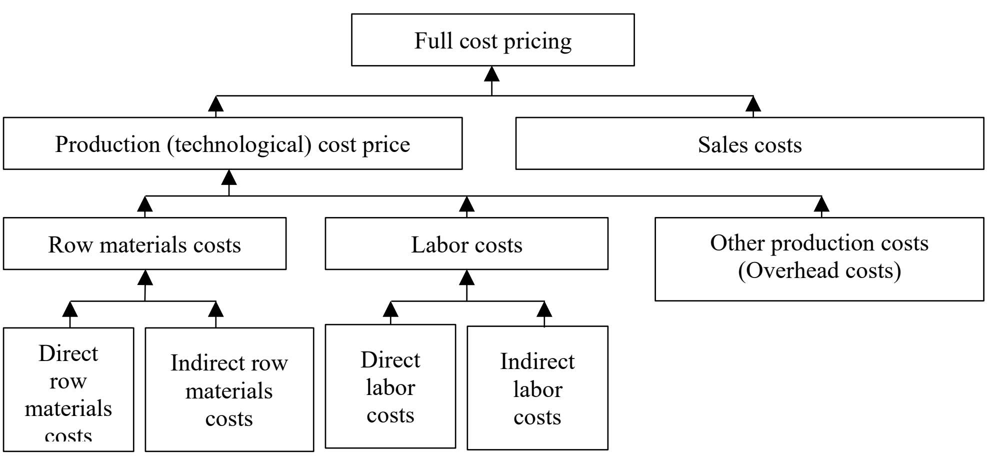

Fig. 3. Types of cost price according to the costs involved.

As Rachman and Rachman [22] explain, there are two main methods for calculating production costs - full costing and variable costing method. In contrast to the full costing method, the variable costing method is known as a direct method of calculation, since all costs (fixed and variable) for the production of the product are included as an element of the cost price at the time of their occurrence. Thus, accounted fixed costs are not charged to finished goods inventory that have not been sold, but are considered costs in the period incurred [23]. In order to determine the full cost of edible films and coatings, it is necessary to thoroughly study the process of their production and realization. A number of authors pay attention in their studies to various aspects of the production process. For example, Sree et al. [12] review the creation of chitosan in detail, paying attention to the combination of manual and automated processes for its extraction from shrimp shells and subsequent processing including demineralization, deproteinization and deacetylation. Sadiq et al. [13] represent the process of applying chitosan to carrots, making it clear that running water, drying the carrots, sorting and post-treatment are required for this purpose. Abdelaal et al. [14] analyze the stages for the production of edible films and coatings and the raw materials required for the purpose, including Chitosan, Calcium chloride, Glycerol, Citric acid, Ascorbic acid, Glacial acetic, Sterilized distilled water, etc., along with accompanying processes such as stirring and dissolving. In turn, Al-Rashdi et al. [15] consider the process of creating a coating for cucumbers from Moringa oil and Beeswax, using a beaker and oven at a temperature of 120 °C for 5 minutes, which implies the cost of electricity, along with the mechanical processes of cleaning the vegetables. In their study, Barsha et al. [16] study the application of edible films and coatings to mandarin oranges, the application process being performed by immersing the fruit in a beaker for 5 minutes and subsequently drying them at room temperature. Khodaei et al. [17] focus attention on the process of coating strawberries by dissolving the hydrocolloids powders in distilled water, mixing film-forming solutions; centrifugation to separate the water-insoluble fraction; rinsing the fruit with distilled water; natural evaporation of the remaining water at room temperature; immersion in the coating solutions and subsequent drying. In addition, emphasis is also placed on the need for polyethylene terephthalate (PET) clamshell containers and a refrigerator for long-term storage. Application of gelatin solution for the preparation of edible films and coatings is investigated by Elabd and Gomma [18], who, in addition to the necessary raw materials such as Aloe vera leaves, Distilled water, Sodium hypochlorite, etc. bring out some processes as basic. These are cutting, soaking, extraction, cleaning, grinding, filtering, pasteurizing, heating, pressurizing and drying at room temperature. And this method also requires polyethylene terephthalate for packaging and a refrigerator for subsequent storage.

Based on the above information, the following components can be deduced when calculating the cost price of edible films and coatings with their main characteristics and the peculiarities of the technology used for production, application, storage, etc.:

Direct materials costs. Direct material costs include the value of all raw materials required to produce the film/ coating at the respective quantities and due to material consumption rate. In order to correctly relate to the unit of calculation (a unit of fruit or vegetable), it is appropriate to make: first, the cost price calculation for a predefined quantity of solution, for example 100 ml., and second, cost price calculation for relevant product, based on the consumption rate for its covering. In this case, the consumption rate depends on 1) the size of the fruit/vegetable and 2) the number of applied coating layers.

Indirect material costs. This category includes auxiliary materials that are not directly part of the film/ coating, but ensure its correct application according to the technology used, for example distilled and/or running water for cleaning. The amount of indirect material costs depends on factors such as the volume of fruit/vegetables processed; cleaning time, degree of contamination; the cleaning technology used (mechanical or automated), etc.

Direct labor costs. As it became clear, a large part of the processes of production and application of the film/ coating on the products is the result of human labor. In relation to the production of films/ coatings, such processes are stirring; dissolution; mixing, filtering, etc. These costs can be directly related to the cost of a unit of production (e.g. 100 ml of roofing solution), based on information on labor productivity per unit of time (e.g., produced amount of solution in 1 hour).

Indirect labor costs. Indirect labor costs can be attributed to those costs related to the processes of subsequent application of the film/ coating on the respective fruits/vegetables. This includes performing cleaning processes; sorting; immersion; soaked, as assigned staff are usually paid according to the time worked. Their amount depends on the quality of the products; the application technology used, etc. In case the final product is the roofing solution, and its application on fruits/ vegetables is carried out at the contracting company, the indirect labor costs will be calculated by contracting company in the cost price of the ready-to-sell production in the form of processed fruits and vegetables. If the application is carried out at the manufacturer of the film/ coating and the final product is fruits/ vegetables with an already applied film/ coating, then these indirect labor costs are included in the cost price of the edible film/ coating.

Other production costs. This category includes the costs of electricity powering ovens, grinders, refrigerators, blenders and other production equipment; the cost of transporting samples to certified laboratories; the costs of depreciation and maintenance of the production premises, etc.

The natural processes of drying, evaporation, etc. are not related to specific production costs, with the exception of the need to provide the appropriate space and suitable conditions for their implementation, which can qualify them as "overhead production costs".

For the purposes of the present research, the direct production costs included in the cost price of edible films/ coatings are of interest, due to their relatively objective nature, while the administrative costs and sales costs depend mostly on the strategic features of the organization, on market orientation, pursued goals, etc. At the same time, indirect production costs (indirect material and indirect labor costs) are dependent on enterprise-specific factors related to production technology, that is why their scope and allocation base is difficult to be typologized. Having in mind that, Table 2 presents the partial manufacturing cost price of edible films/ coatings based solely on direct costs.

Table 2. Total direct production costs of edible films and coatings for fresh fruits and vegetables. Source: Own research

Code of edible films and coatings	Main components of edible films and coatings	relative proportion per 100 g/ml coating	Average cost of components per 100 g/ml/euro	Total costs per 100 g/ml of edible films and coatings/euro	Labor cost for 100 ml/g	Total direct costs (production and labor)
				Direct production costs	Direct labor costs	
EFC1	Chitosan	0,025	2,413 €	0,060 €	0,518 €	0,889 €
	Acetic acid	0,006	0,593 €	0,004 €		
	Glycerol	0,25	0,757 €	0,189 €		
	1M sodium hydroxide	0,01	3,451 €	0,035 €		
	Distilled water	0,709	0,118 €	0,083 €		
EFC2	Chitosan	0,02	2,413 €	0,048 €	0,518 €	0,715 €
	0.25N HCl	0,01	3,119 €	0,031 €		
	Glycerol	0,005	0,757 €	0,004 €		
	Distilled water	0,965	0,118 €	0,113 €		
EFC3	Calcium chloride	0,02	1,462 €	0,029 €	0,518 €	0,663 €
	Distilled water	0,98	0,118 €	0,115 €		
EFC4	Moringa oil	0,8	32,626 €	26,100 €	0,518 €	26,78 €
	Beeswax	0,2	0,803 €	0,161 €		
EFC5	Paraffin wax	0,75	0,752 €	0,564 €	0,518 €	1,276 €
	Toluene	0,25	0,777 €	0,194 €		
EFC6	Carboxymethyl cellulose	0,01	9,081 €	0,091 €	0,518 €	0,917 €
	Glycerol	0,3	0,757 €	0,227 €		
	Distilled water	0,69	0,118 €	0,081 €		
EFC7	Gelatin	0,05	3,937 €	0,197 €	0,518 €	2,702 €
	Aloe vera gel	0,95	2,091 €	1,987 €		
EFC8	Beeswax	0,03	0,803 €	0,024 €	0,518 €	0,835 €
	Commercial oil (Frytol®)	0,97	0,302 €	0,293 €		
EFC9	Shellac wax	0,4	2,025 €	0,810 €	0,518 €	1,399 €
	Distilled water	0,6	0,118 €	0,071 €		
EFC10	Candelilla wax	0,03	5,317 €	0,160 €	0,518 €	1,003 €
	Gum arabic	0,04	4,735 €	0,189 €		
	Jojoba oil	0,0015	17,435 €	0,026 €		
	Pomegranate polyphenols	0,00015	1,856 €	0,000 €		
	Distilled water	0,9283	0,118 €	0,109 €		

Direct labor costs have been determined based on the following assumptions: average gross salary of a laboratory technician in Bulgaria – BGN 1,500 (766.94 Euro), social and health insurance paid by the employer: 18.92%; working days per month: 22; nominal duration of a working day: 8 hours; hourly productivity: 1000 ml. edible film/ coating (this productivity is assumed to be the same for all coating types considered).

2.3 Discussion about the cost price of edible films and coatings for some fresh fruits and vegetables

Based on the calculations, the considered edible films and coatings can be grouped into three groups according to their cost price (Figure 4). Group 1 includes films/ coatings with a cost price below 1 euro per 100 ml. - EFC1, EFC2, EFC3, EFC6 and EFC8. They are produced on the basis of chitosan, glycerol, calcium chloride or beeswax. The second group includes those with a cost price between 1 and 2 euros - EFC5, EFC9 and EFC10. The basis of their composition are ingredients such as paraffin wax, toluene, shellac wax, candelilla wax, gum Arabic. The third group includes films/ coatings with a cost price over 2 euros, incl. EFC4 and EFC7, produced on the basis of moringa oil and Aloe vera gel. Given the accepted assumption that direct labor costs are the same for different types of coatings, the calculated cost price correlates with direct material costs - the higher they are, the higher the cost price of the product is, and the share of labor costs falls.

<table>
<tr><td></td><td></td><td colspan="2">cost price over 2 euros</td><td></td><td></td></tr>
<tr><td></td><td></td><td>EFC4</td><td>EFC7</td><td></td><td></td></tr>
<tr><td></td><td colspan="4">cost price between 1 and 2 euros</td><td></td></tr>
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<tr><td colspan="6">cost price below 1 euro</td></tr>
<tr><td>EFC1</td><td>EFC2</td><td colspan="2">EFC3</td><td>EFC6</td><td>EFC8</td></tr>
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Fig. 4. Grouping of edible films and coatings for fresh fruit and vegetables by cost price per 100 ml.

In this regard, the following conclusions and recommendations can be made to manufacturers of edible films/ coatings:

1. Manufacturers of films/ coatings of the first group should strive to minimize labor costs through measures to increase labor productivity, which will reflect on a reduction of product cost price. Appropriate measures are paying staff according to the quantity produced; optimization of the implemented work processes; replacing manual processes with automated ones and looking for economies of scale.
2. Manufacturers of group 2 films and coatings should focus their attention on product positioning through various marketing strategies due to more expensive product. It is also suitable for them to include in their activity the processes of applying the coating on fruits and vegetables, forming a greater added value for customers and, accordingly, a better quality of the finished product.
3. Manufacturers of group 3 films/ coatings should also emphasize on product positioning in the market. For them, it is more appropriate to pay for labor on the basis of time worked in order to achieve the highest quality. Given the expensive materials used in the product, it is important to look for opportunities to diversify material supplies.

3 Conclusions

In the scientific study, the cost price of edible films and coatings for fresh fruits and vegetables of randomly selected scientific developments was calculated. Edible films and coatings are grouped into three groups according to cost: with a cost price below 1 euro per 100 ml. - EFC1, EFC2, EFC3, EFC6 and EFC8; cost price between 1 and 2 euros - EFC5, EFC9 and EFC10; cost price over 2 euros, incl. EFC4 and EFC7. The obtained results and their grouping give opportunities to make recommendations regarding the activities of the manufacturers of edible films and coatings.

Future research could be aimed at calculating the cost price of edible films and coatings composed of lower cost components. In addition, research can also be done to calculate the cost price of edible films and coatings with different composition for a particular food product. Future research could also be done on the creation and development of a cost price model for edible films and coatings that would be useful in their implementation in production and creating an opportunity to calculate the economic efficiency of their use.

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