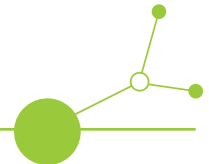


D.1.4.1 Report on readiness of market at transnational level



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INTRODUCTION

Bioeconomy is an important concept of economic development, which is supported at the highest political levels. Nevertheless, its effective implementation requires action also at the level of local markets, where new products form by-products and wastes (B+W) generated in new value chains can be found. The aim of the TeBiCE project is to increase the efficiency of the public and private sectors in adopting circular economy solutions, ensuring a more efficient market for by-products and waste from primary production and agri-food processing in the CE area. This can be achieved, among others, by creating, identifying and promoting new value chains based on innovative technologies and new business models, generating a new products and more efficient and competitive economy. A readiness of market at transnational level report included the analysis of new value chains in Italy, Slovenia, Germany, Poland, Slovensko and Österreich.

The report was designed to assess the market for the introduction of new products form by-products and wastes (B+W) in the primary production and agri-food processing sectors. For this purpose, sources and quantities of by-products and waste that can be used as a raw material for new product on the market have been identified and estimated. In the next step, the quantities of new value-added products that could appear on the market were identified and estimated. The analysis also included an estimate of the prices of selected new products, the possibility of prices change in time and the amount of income that the products could generate currently and in the next 5 and 20 years. Subsequently, the value chains were aggregated according to the sector from which the by-products and waste material can be obtain and were studied according to PESTEL analysis. PESTEL involved the description of factors from the political, economic, social, technological, environmental and legal environment affecting the enterprise. The comprehensive nature of this analysis allowed that it could also be used to describe new and innovative areas of economic activity, e.g. new products and value chains. The highest number of by-product and waste production sites and the highest amount of generated by-products and waste was identified in Germany (CCB - PP4) and it was wood waste, the highest market price (30 000 Euro/Mg) was found for new type of filaments for 3D-printing from micro-parts S&F (SUA - PP9). The oil industry was the most frequently chosen sector. Other sectors where new value chains can be created or existing value chains modified are the fruit industry, wine industry, grain and milling industry, wood industry, hemp industry and vegetable industry. The most frequent in main barriers in B+W supply for new business and use and main stimulants in B+W supply for new business and use were economic factors on national/global scale.



1. List of partners involved in a task implementation

ITALY

- Venetian Agency for Innovation in the Primary Sector - Veneto Agricoltura - AVISP, (PP-1; LP)
- Fraunhofer Italia Research scarl - Innovation Engineering Center - FHI, (PP-3)

SLOVENIJA

- National Institute of Chemistry - NIC, (PP-2)

GERMANY

- Chemie-Cluster Bayern GmbH - CCB, (PP-4)

POLAND

- University of Warmia and Mazury in Olsztyn - UWM, (PP-5)
- Kujawsko-Pomorskie Voivodeship - KPV, (PP-6)

SLOVENSKO

- Slovak University of Agriculture in Nitra - SUA, (PP-9)

ÖSTERREICH

- Carinthia UAS - non-profit limited liability company - CUAS, (PP-8)



2. Italian value chains

2.1. High added value molecules from dairy and wine by-products

As part of the regional value chain, AVISP (LP-1) proposed the use of by-product and waste (B+W) from the dairy industry (whey) to produce proteins, osmotised water and sugars (Table 1). Whey was produced in 115 plants in an amount of approximately 1,016,036 t/year, at an average price of 12.5 €/t. It was assumed that the products obtained could be energy tablets and food supplements. The current market price of these products was 4,000 €/t. Unfortunately, this new product is not available on the market for now. However, it is expected that in 5 and 20 years its amount could be 3,250 and 13,000 t/year, respectively. Moreover, there could be other products from whey (recycled water and sugars) for the food market and nutraceuticals, at prices of 100 and 14,000 €/t, respectively. Unfortunately, these new products are not available on the market yet. However, it is expected that in 5 and 20 years, the amount of recycled water could be 175,000 and 700,000 t/year, respectively, and in the case of sugars for the food market and nutraceuticals, the amount could be 12,500 and 50,000 t/year.

Table. 1. Selected elements of the value chain characteristics in the field of high added value molecules from dairy and wine by-products

Source and name of by-product and waste (B+W)	Number B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Current market price of the new product (€/t)	Actual amount of the new product (t/year)	Predicted amount of the new product in next 5 years (t/year)	Predicted amount of the new product in next 20 years (t/year)
Dairy industry								
whey->proteins	115	1,016,036	12.5	energy tablets, food supplements	4,000	0	3,250	13,000
whey->osmotised water	115	1,016,036	12.5	recycled water	100	0	175,000	700,000
whey->sugars	115	1,016,036	12.5	sugars for food market and nutraceuticals	14,000	0	12,500	50,000
Wine Industry								
Lees	328	75,000	10	Polyphenols, pigments (anthocyanin), tartaric acid	1,750		100	300
				tartaric acid	580	1,500	2,500	5,000
Vinasses	328	225,000	120	Polyphenols, pigments (anthocyanin), tartaric acid	1,750		225	500

Another by-product and waste were lees and vinasses produced in 328 plants in quantities of 75,000 and 225,000 t/year, respectively, with an average price of 10 and 120 €/t (Table 2). It was assumed that the obtained products could be polyphenols, pigments (anthocyanin), tartaric acid. The current market price of polyphenols, pigments (anthocyanin) was 1,750 €/t, and in the case of tartaric acid it was 580 €/t. The current amount of tartaric acid produced from less was estimated at 1,500 t/year. However, the estimated amount of this product in 5 and 20 years could be 2,500 and 5,000 t/year, respectively. In turn, the amount



of polyphenols, pigments (anthocyanin) from lees in 5 and 20 years could be 100 and 300 t/year, respectively. In the case of obtaining this new product from vinasses, these values could be higher: 225 and 500 t/year, respectively.

Within the value chain related to whey, the main directions and trends in use of this B+W include, among others: nutraceuticals, recycle, food market/nutraceuticals (Table 2). However, the main barriers/restrictions in B+W supply for new business and use include the development of dedicated consortium and plants while regulatory and standard aspects do not request particular implementation. Within the value chain for lees and vinasses, the main directions and trends in use of this B+W include spirits, ethanol, biogas, feed. The main barriers/restrictions include technological implementation, knowledge and capital cost. It was found that the availability of all three B+Ws is high.

Table. 2. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business in the field of high added value molecules from dairy and wine by-products

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
whey->proteins	high	nutraceuticals	development of dedicated consortium and plants
whey->osmotised water	high	recycle	development of dedicated consortium and plants
whey->sugars	high	food market/ nutraceuticals	development of dedicated consortium and plants
Lees	high	ethanol, biogas, feed	technological implementation/ knowledge/ capital cost
Vinasses	high	spirits, ethanol, biogas, feed	technological implementation/ knowledge/capital cost

* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W

The market analysis of new products identified in all value chains was carried out based on the following assumptions. An increase in product prices of 3% per year was assumed. The analysis took into account discounted cash flow with a 5% discount rate. The sensitivity analysis took into account a 20% estimation error expressed as error bars in each plot.

The highest unit price was found for sugars for the food market and nutraceuticals, 14,000 €/t (Figure 1). The expected revenue from the sale of these products was also the highest (Figure 2). The second group of products with a higher initial price were energy tablets and food supplements (4,000 €/t), but the revenues from their sales were not as high as for the first group.

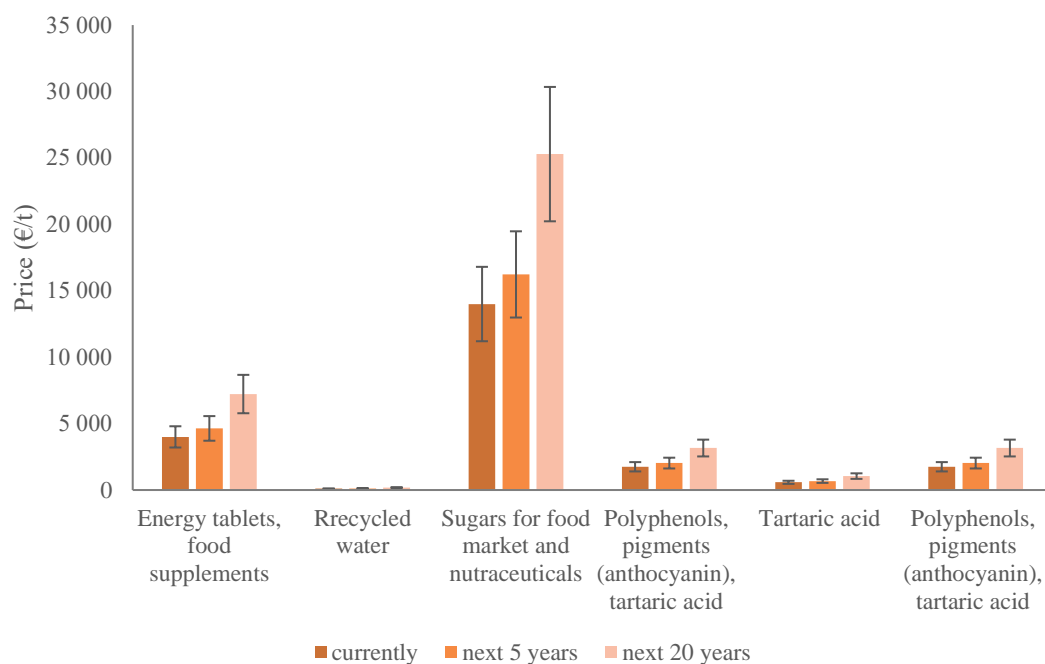


Figure 1. Price change over time in predicted market of new products in dairy and wine industry.

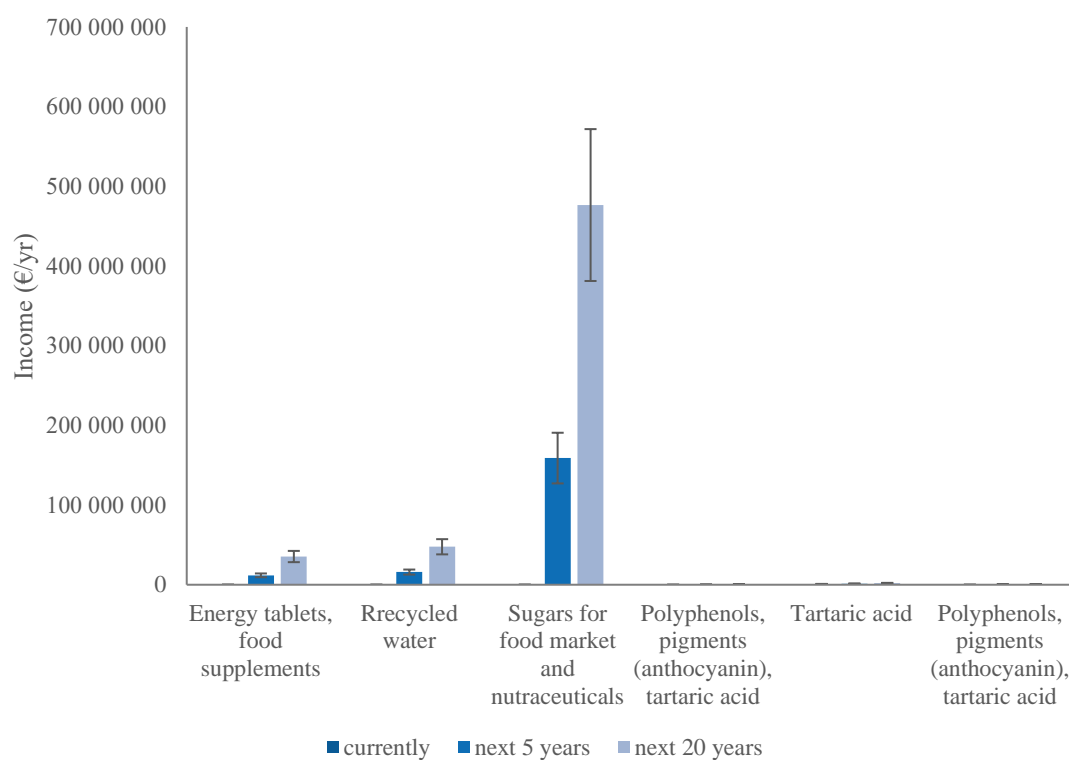


Figure 2. Predicted income of new products in dairy and wine industry.



2.2. High added value molecules from apple processing residues

As part of the regional value chain, FHI (PP-3) proposed using residues from the fruit and wine industry to produce high added value molecules (Table 3). There were 22 companies in the fruit industry that produced eight types of by-products and waste (B+W): apple juice, apple puree, apple cooked_IQF_frozen, fresh cut, apple seeds, apple pomace, apple skin. Of these B+W, the largest amounts were found for apple juice (120,588 t/year) and apple pomace (97,913 t/year). However, the smallest amount was found in the case of fresh cut (687 t/year). In turn it was found high price for apple puree, apple skin and apple juice: 480, 400 and 350 €/t, respectively. However, the price of the remaining B+W ranged from 100 to 150 €/t.

Table. 3. Selected elements of the value chain characterization in the field of high added value molecules from apple processing residues

Source and name of by-product and waste (B+W)	Number B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Number of companies in the region working in new value chain	Number of companies in the region working in new value chain in next 20 years
Fruit industry						
apple juice	22	120,588.20	350	not known	not known	-
apple puree	22	7,558.20	480	not known	not known	-
apple cooked_iqf_frozen	22	42,945.00	-	not known	1	-
fresh cut	22	687.04	-	not known	1	-
apple seeds	22	39,508.94	150	oils, paraffins	2 (not AA)	6
apple pomace	22	97,913.46	100	cellulose (for recycled paper), pectin, compost, fertilizer, hydrocarbons, xyloglucan	3	6
apple skin	22	34,355.608	400	phenols	0	1
Wine industry						
grape pomace	19	16,152.39	150	phytochemicals related to antioxidant, anti-inflammatory, antimicrobial, anticancer and antimicrobial, anticancer, antithrombotic effects, antidepressant activity, grape extract	7	12
wine lees	19	1,372.00	170	tartaric acids, yeast, phenolic compounds	3	4
seeds	19	2,692.06	60	oils, tannins, extract	0	1
stems	19	2,153.65	20		2	3



It was assumed that the products obtained from apple seeds would be oils and paraffins (Table 3). Currently, there are two companies operating in this field in the region, while it is expected that there will be six companies in the next 20 years. However, it is possible to produce new products from apple pomace like cellulose (for recycled paper), pectin, compost, fertilizer, hydrocarbons, xyloglucan. Currently, three companies operate in this field in the region, while it is expected that there could be six companies in the next 20 years. In turn, with apple skin it is possible to produce new products in the form of phenols. Currently there is no company operating in this field, but it is expected that in the next 20 years there could be one company. However, the current market prices of new products and their potential value in the future have not been identified.

There were 19 companies in the wine industry that produced four types of B+W: grape pomace, wine lees, seeds and stems (Table 3). Among these B+W, the highest amounts were found for grape pomace (16,152 t/year). However, smaller amounts were found in the case of other B+W (1,372-2,692 t/year). In turn, in relation to the current market price of B+W, it was found that price for wine lees and grape pomace was 170 and 150 €/t, respectively. The price of seeds and stem was 60 and 20 €/t, respectively. This chain assumes that a few products can be obtained from grape pomace, such as: phytochemicals related to antioxidant, anti-inflammatory, antimicrobial, anticancer and antimicrobial, anticancer, antithrombotic effects, antidepressant activity and grape extract. Currently, seven companies operate in this area in the region, and it is expected that in the next 20 years there could be 12 companies. However, with wine lees it is possible to obtain new products like tartaric acids, yeast and phenolic compounds. Currently, three companies operate in this field in the region, and it is expected that there could be four companies in the next 20 years. In turn, seeds could be used to obtain oils, tannins and extracts. There is no company operating in this field in the region, but it is expected that in the next 20 years there could be one company. However, the current market prices of new products and their potential value in the future have not been identified.

Many directions and trends in the use of B+W from the fruit and wine industry were indicated (Table 4). The analysed B+W were mainly used in the food market, animal feed, energy and fuels, environmental management, healthcare and pharmaceuticals, cosmetics and others. In addition, the main barriers/restrictions in B+W supply for new business and use were identified, including shelf life and preservation, packaging, storage, transportation, extraction, differences in quality terms, seasonal availability, storage, economic viability, regulation and compliance, processing, technological constraints and others. As a result of these analyses, it was found that only the availability of apple juice is high. The availability of apple cooked_iqf_frozen and grape pomace is medium. However, the availability of the remaining eight types of B+W was defined as low or not applicable (only waste).

Table. 4. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business in terms of high added value molecules from apple processing residues

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
apple juice	high	food market (beverage or food products)	shelf life and preservation, packaging, storage, transportation
apple puree	low	baby food, food market	shelf life and preservation, packaging, storage, transportation
apple cooked_iqf_frozen	medium	food market	shelf life and preservation, packaging, storage, transportation
fresh cut	low	food market	shelf life and preservation, packaging, storage, transportation



apple seeds	not applicable (only waste)	food market, cosmetics	extraction, differences in quality terms (supply chain management challenges), treatment (presence of cyanide)
apple pomace	not applicable (only waste)	food and beverage industry, agriculture and animal feed, energy and fuels, environmental management, healthcare and pharmaceuticals, cosmetics, manufacturing	desiccation, pretreatment, storage, transportation
apple skin	not applicable (only waste)	mixed phenols for different applications	supply consistency, extraction quality, shelf life and preservation
grape pomace	medium	bioenergy, animal feedstock, cosmetics, water treatment, food market, agricultural use, waste reduction	seasonal availability, storage, economic viability, regulatory and compliance, processing, technological constraints, quality
wine lees	low	pharmaceutical use, bioenergy, food market, animal feedstock, cosmetics	collection, storage, processing, extraction, regulatory and compliance, market demand, consumer perception, quality, consistency, logistics
seeds	low	food market (supplements/integrators)	collection, processing, regulatory and compliance, quality, consistency, logistics
stems	low	agriculture and horticulture, renewable energy and biofuels, manufacturing, chemical industry	collection, storage, regulatory and compliance issues, extraction, quality, consistency, processing

* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W

Tannins had the highest unit price of 70,000 €/t. The second group of products with a higher initial price were polyphenols (20,000 €/t) and pectin (19,000 €/t) (Figure 3). The highest revenues were estimated from their sales of pectins (Figure 4). Other products contributed marginally to the expected income of new products.

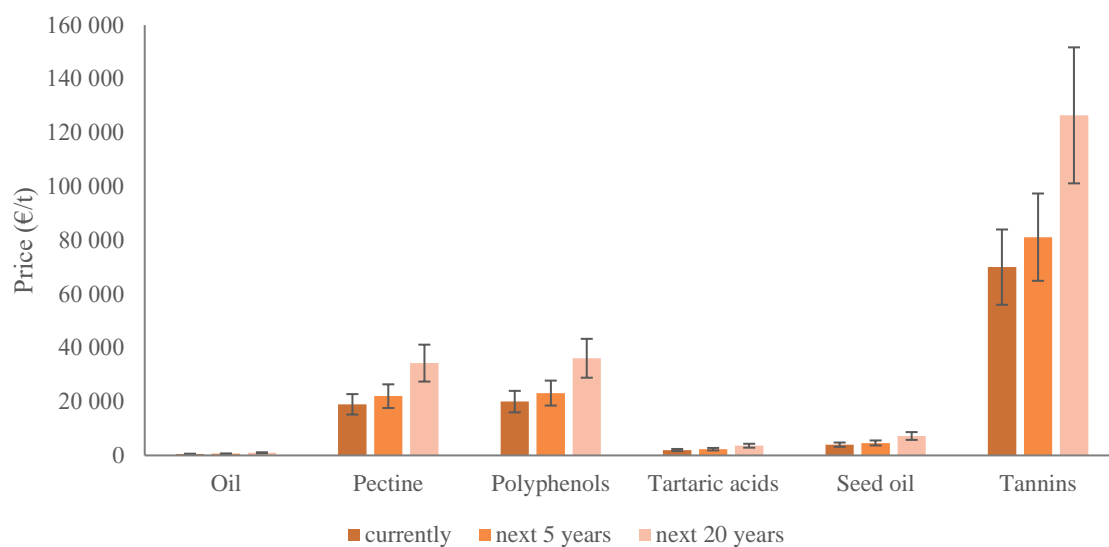


Figure 3. Price change over time in predicted market of new products obtained from high added value molecules from apple processing residues.

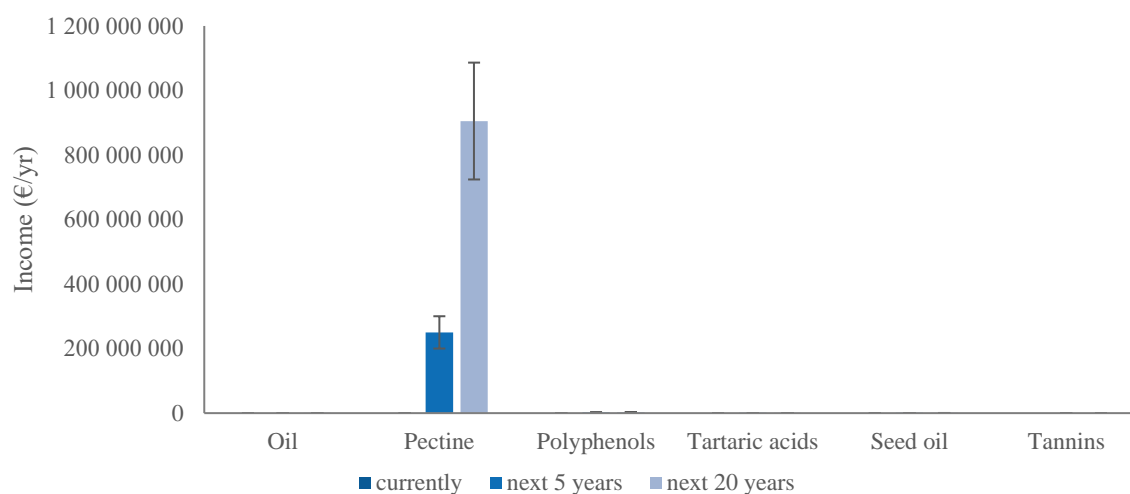


Figure 4. Predicted income of new products obtained from high added value molecules from apple processing residues.



3. Slovenija value chains

3.1. High added value molecules and products from wine, fruit, oil and timber processing residues

As part of the regional value chain, NIC (PP-2) proposed using residues from the wine and fruit industry to produce high added value molecules (Table 5). There were 18 companies within the wine industry in the region that produced B+W in the form of grape pomace and red grape pomace. Of these B+W, there was definitely more grape pomace (18,100 t/year), where red grape pomace represents around 1/3 of total grape pomace. This chain assumes that the products obtained from grape pomace and red grape pomace would be grape pectin and natural colours, respectively. In turn, within the fruit industry, there were 20 companies that produced B+W in the form of apple pomace in the amount of 1,336 t/year, and apple pectin could be made from them. There is no company operating in this value chain in the region, but it is expected that in the next 20 years there could be at list one company. It was found that the current market prices of red grape pomace, pumpkin seed cakes and bark were respectively: 300; 870 and 70 €/t (Table 5). However, it was estimated that the value of the new product obtained in the value chain in the form of apple pectin (for food application) would be approximately 50,000-70,000 €/t. However, in the case of pumpkin protein flour it would be 20,000, and for tannins (for wine application) 65,000 €/t.

Table. 5. Selected elements of the value chain characterisation in the field of high added value molecules and products from wine, fruit, oil and timber processing residues

Source and name of by-product and waste (B+W)	Number B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Number of companies in the region working in new value chain	Number of companies in the region working in new value chain in next 20 years
Wine industry						
grape pomace	18	18,100	200	grape pectin	not known	1
red grape pomace	5	6,265	300	natural colours	not known	1
Fruit industry - apple						
apple pomace	20	1,336	N/A	apple pectin	not known	1
Oil industry						
pumpkin seed cakes	6 (9)	232	870	pumpkin protein flour	1	2
olive pomace	3 (9)	955	N/A	olive pectin	not known	1
Timber industry						
bark	63 (103)	27,000	70	tannins	1	2

There were nine companies in the oil industry that produced B+W, six in the form of pumpkin seed cakes and three in the form of olive pomace, in amounts of 232 and 955 t/year, respectively (Table 5). This chain assumes that the products obtained from pumpkin seed cakes and olive pomace would be pumpkin protein flour and olive pectin. In turn, there were 103 companies within the timber industry that produced B+W in the form of bark in the amount of 27,000 t/year, which can be used to produce tannins. Single companies operated in these value chain in the region, and little development is possible in this area over the next 20 years.

Many directions and trends in the use of B+W from the wine, fruit, oil and timber industries were indicated (Table 6). The analysed B+W were mainly used in the food market, feed market, agriculture, renewable



energy production, production of biopolymers and polyphenols. In addition, the main barriers/restrictions in B+W supply for new business and use were identified, including competition from feed, food and energy market, seasonal production, stability of processed by-product, storage, transportation and others. As a result of these analyses, it was found that only bark availability is high. The availability of grape pomace was assessed as medium. However, the availability of the remaining four types of B+W was defined as low.

Table. 6. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business in terms of high added value molecules and products from wine, fruit, oil and timber processing residues

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
grape pomace	medium	Food market (pectin, polyphenols extracts), Feed market (animal feed), Agriculture (natural fertiliser), Renewable Energy production (biochar), Production of biopolymers and polyphenols	competition from feed market, seasonal production, instability of processed by-product, storage, transportation
red grape pomace	low	Food market (natural colours, polyphenols extracts), Feed market (animal feed), Agriculture (natural fertiliser), Renewable Energy production (biochar), Production of biopolymers and polyphenols	competition from feed market, seasonal production, instability of processed by-product, storage, transportation
apple pomace	low	Food market (vinegar production, apple flour), Feed market (animal feed), Agriculture (natural fertiliser)	competition from feed market, seasonal production, instability of processed by-product, storage, transportation
pumpkin seed cakes	low	Food market (seed flour), Feed market (animal feed)	competition from feed market, storage, transportation
olive pomace	low	Feed market (animal feed), Agriculture (natural fertiliser, biochar), Renewable Energy production (biochar), Production of biopolymers and polyphenols	competition from feed market, seasonal production, storage, transportation
bark	high	Food market (beverage), Feed market (animal feed), Energy, Production (biopolymers)	competition from energy market, collecting, transportation, storage

* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W

Prices of new products ranged from 100 €/kg for natural colors for food application, through 65-60 €/kg for grape pectin, apple pectin, olive pectin and tannins, all for food application, to 20 €/kg for pumpkin protein flour (Figure 5). The highest revenue values could be achieved when selling tannins for food applications (Figure 6).

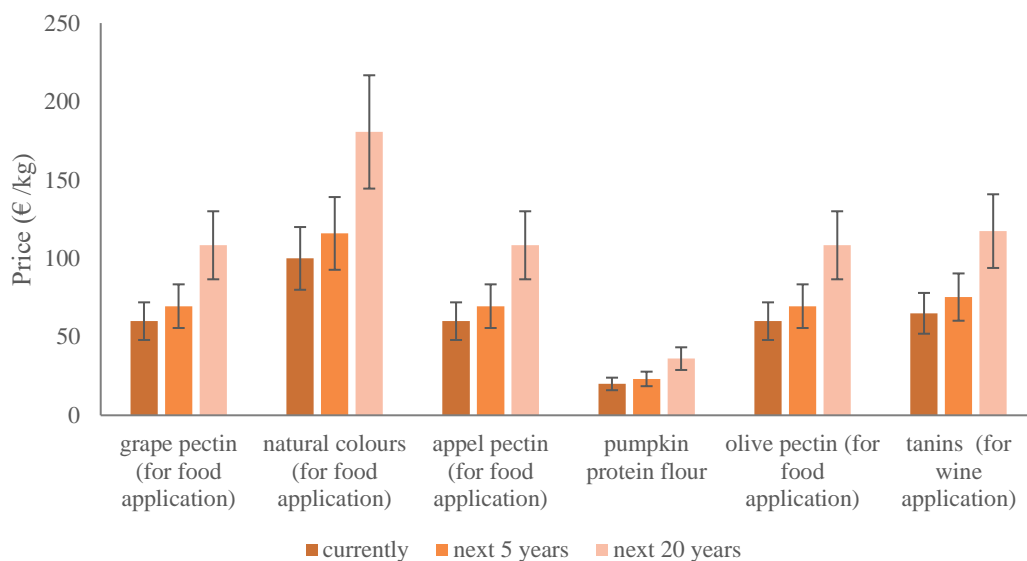


Figure 5. Price change over time in predicted market of new products obtained from high added value molecules and products from wine, fruit, oil and timber processing residues.

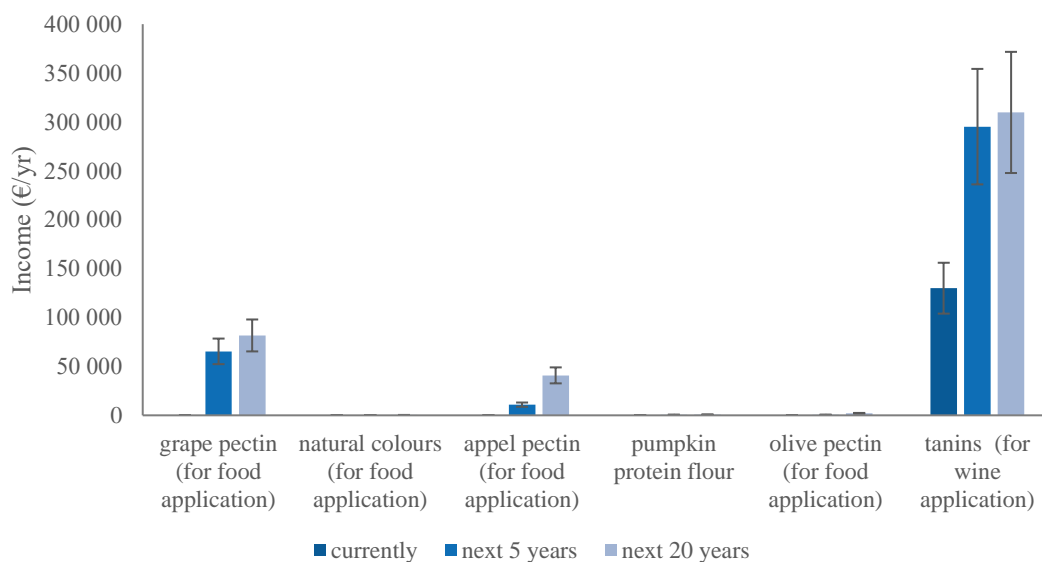


Figure 6. Predicted income of new products obtained from high added value molecules and products from wine, fruit, oil and timber processing residues.



4. Germany value chains

4.1. High added value products and molecules from hemp, wood and residues of alcoholic fermentation

As part of the regional value chain, CCB (PP-4) proposed the use of hemp, wood and residues of alcoholic fermentation to produce added value products and molecules (Table 7). There were 352 companies within the fibrous material industry that produced B+W in the form of hemp shives and hemp fibres. Of these B+W, there were more hemp shives (7,650 t/year) compared to hemp fibres (3,825 t/year). However, the current market price of these two B+W was 200 €/t on average. It is assumed that the new products obtained from hemp shives and hemp fibres could be hemp-biocomposites for application in construction and hemp-textiles, respectively. There was only one company operating in the hemp-textiles value chain, and it is expected that there could be four companies in the next 20 years.

In turn, there were as many as 25,000 companies within the forestry industry that produced B+W in the form of wood waste in amount of 5 million t/year, at price of 50 €/t (Table 7). A biogas could be produced from wood waste. There are five companies operating in this value chain in the region, and it is expected that there could be 20 companies in the next 20 years.

There were 836 companies in the fruit industry that produced B+W in the form of beer draff, in the amount of 600,000 t/year, at price of 56 €/t (Table 7). Products obtained from beer draff would be biobased packaging and biochar.

There are no companies operating in the biobased packaging value chain, but it is expected that there would be 10 companies in the next 20 years. In turn, in the biochar value chain, five companies operated in the region, and significant development in this area (100 companies) could be possible over the next 20 years.

Table. 7. Selected elements of the characterisation of value chains in the field of high added value products and molecules from hemp, wood and residues of alcoholic fermentation

Source and name of by-product and waste (B+W)	Number B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Number of companies in the region working in new value chain	Number of companies in the region working in new value chain in next 20 years
Fibrous Material						
hemp shives	352	7,650	200-450	hemp-biocomposites	0	4
hemp fibres	352	3,825	200	hemp-textiles	1	5
Forestry						
wood waste	25,000	5,000,000	50	biogas	5	20
Beverage industry						
beer draff	836	600,000	56	biobased packaging	0	10
beer draff	836	600,000	56	biochar	5	100

The main directions and trends in the use of hemp shives and wood waste include construction, energy production, stable bedding, lignin extraction for base chemicals, wood materials, fertilizer and insulation material (Table 8). In turn, in the case of hemp fibres, these were: textiles, construction, isolation and paper. The beer draff was mainly used in animal feed, energy production and food. In addition, main



barriers/restrictions in B+W supply for new business and use were identified. In the case of hemp shives, hemp fibres and wood waste, these were: transport, new machinery, unclear long-term legal restrictions, economic feasibility and technological development. In the case of beer draff, these were: lack of alternative use cases and valorisation, hygienic concerns, conservation/storage, broad distribution, as well as variable quality and properties. The assessment showed that the availability of beer draff and hemp shives is medium. However, the availability of hemp fibres and wood waste was defined as low.

Table. 8. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business in terms of high added value products and molecules from hemp, wood and residues of alcoholic fermentation

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
hemp shives	medium	construction, energy production	transport, new machinery, unclear long-term legal restrictions, regulation
hemp fibres	low	textiles, construction, isolation, paper	transport, new machinery, unclear long-term legal restrictions, regulation
wood waste	low	energy use, pellets, stable bedding, lignin extraction for base chemicals, wood materials, fertilizer, insulation material	economic feasibility and technologic development
beer draff	medium	animal feed, energy production, food	lack of alternative use cases and valorisation, hygienic concerns, conservation/storage, broad distribution, variable quality and properties
beer draff	medium	animal feed, energy production, food	lack of alternative use cases and valorisation, hygienic concerns, conservation/storage, broad distribution, variable quality and properties

* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W

The highest prices on the market were found for hemp-bioocomposites and hemp-textiles (Figure 7), but much higher revenues can be achieved from the sale of hemp-bioocomposites (Figure 8).

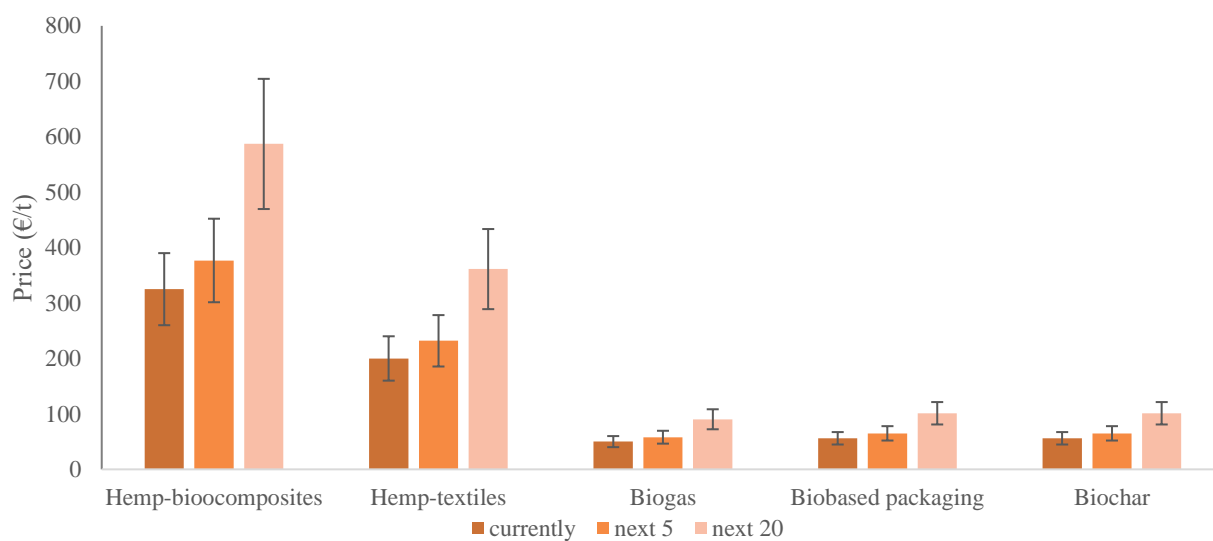


Figure 7. Price change over time in predicted market of new products obtained from high added value products and molecules from hemp, wood and residues of alcoholic fermentation.

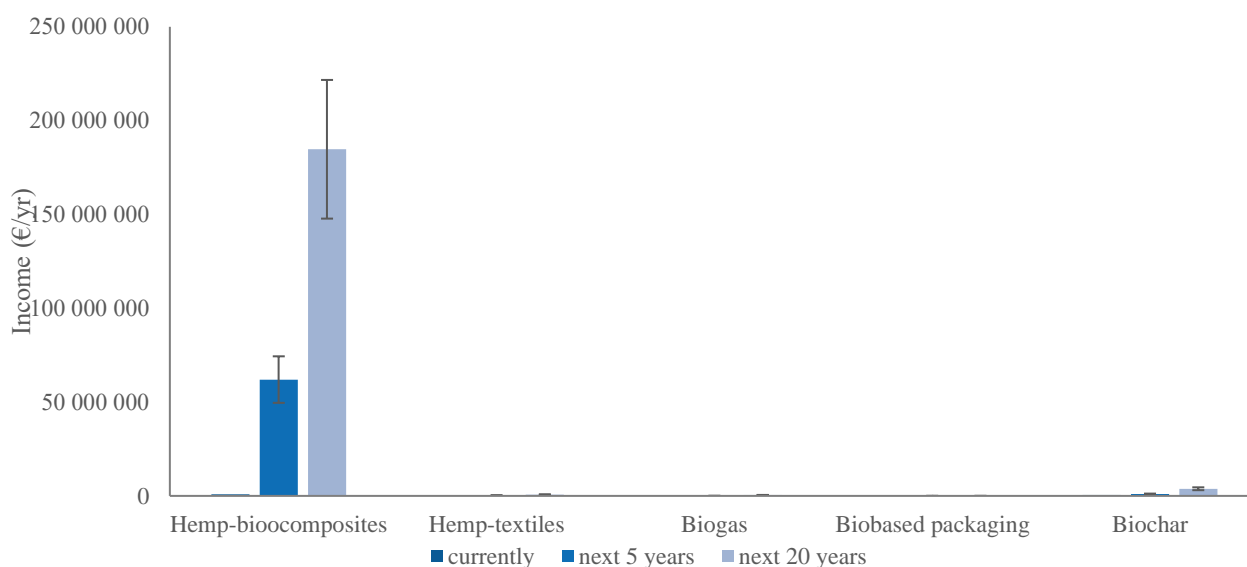


Figure 8. Predicted income of new products obtained from high added value products and molecules from hemp, wood and residues of alcoholic fermentation.



5. Polish value chains

5.1. Utilisation of vegetal residues from agriculture and food industry for insects rearing

As part of the regional value chain for the NUTS 1 area, UWM (PP-5) proposed the use of plant residues from agriculture and the agri-food industry for insect rearing (yellow mealworm) for food and feed. The main source of by-product and waste was grain and milling industry (Table 9). Particularly important raw materials that can be used to produce mealworm in the analysed area were wheat bran, produced in eight plants (approx. 120,000 t/year), at an average price of 162 €/t. It was assumed that the new obtained products would be yellow mealworm, dried insect (larvae) and insect frass for fertilizer. The current market price of these products was 2,000 and 270 €/t, respectively (Table 9). The current volume of these new products is small and has been estimated at 12 and 14 t/year for yellow mealworm dried insect and fertiliser, respectively. However, much higher amounts of these products are expected in five years, 4,300 and 5,000 t/year, and in 20 years, 27,000 and 32,000 t/year, respectively.

Table. 9. Selected elements of the characterization of the value chain in the field of utilization of vegetal residues from agriculture and food industry for insects rearing

Source and name of by-product and waste (B+W)	Number B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Current market price of the new product (€/t)	Actual amount of the new product (t/year)	Predicted amount of the new product in next 5 years (t/year)	Predicted amount of the new product in next 20 years (t/year)
Grain and milling industry								
wheat bran	8	120,000	162.0	Yellow mealworm dried insect (larvae)	2,000	12	4,300	27,000
				Fertiliser	270	14	5,000	32,000
rye bran	8	30,000	139.0	Insect pate	2,600	28	10,000	65,000
				Fertiliser	270	14	5,000	32,000
2nd grade seeds from seed cleaning	35	4,500	100.0	Defatted (insect) meal	2,500	0	3,100	20,000
				Yellow mealworm oil	1,400	0	1,100	7,000
				Fertiliser	270	0	5,000	32,000
Oil industry								
cakes and meals from oil extraction	3	360,000	300.0	Dried insect (larvae)	2,000	3	1,075	6,750
				Fertiliser	270	3.5	1,250	8,000



Another by-product and waste was rye bran, also produced in 8 plants but in smaller quantities, approximately 30,000 t/year. Its price is estimated as 139 €/t (Table 9). The obtained new products will be insect pate and fertiliser. The current market price of these products was 2,600 and 270 €/t, respectively. The current volume of these new products has been estimated at 28 and 14 t/year for insect pate and fertiliser, respectively. However, the estimated quantities of these products in five years could be 10,000 and 5,000 t/year, respectively, and in 20 years 65,000 and 32,000 t/year, respectively.

Second grade seeds from seed cleaning are another type B+W, which was produced in 35 plants in an amount of approximately 4,500 t/year. Its average price was 100 €/t (Table 9). It was assumed that the new products would be defatted (insect) meal, yellow mealworm oil and fertiliser. The current market price of these three products was 2,500, 1,400 and 270 €/t, respectively. Unfortunately, these products are currently not available on the market. However, the estimated quantities of these products in five years could be 3,100, 1,100 and 5,000 t/year. However, in 20 years it could be 20,000, 7,000 and 32,000 t/year.

These analyses also indicated that the oil industry is also an important source of by-product and waste. Particularly interesting are cakes and meals from oil extraction, which can also be used as feed for insect rearing. This by-product was produced in 3 large plants in an amount of approximately 360,000 t/year (price of 300 €/t) (Table 9). It was assumed that the obtained new products would be dried insects (larvae) and fertiliser. The current market price of these products was 2,000 and 270 €/t, respectively. The current amount of these new products is small and has been estimated at 3 and 3.5 t/year for dried insect and fertiliser, respectively. However, the quantity of these products in five years is estimated to be 1,075 and 1,250 t/year, respectively, and in 20 years 6,750 and 8,000 t/year, respectively.

Within these value chains, the main directions and trends in the use of B+W from grain and milling industries are food and feed market (Table 10). In turn, in the case of cakes and meals from oil extraction, it was the feed market because this B+W is used as protein feed material. Therefore, the main barriers/restrictions in B+W supply for new business and use include competition from feed market and unstable price. Despite these barriers, it was found that the availability of all four analysed B+W for new business in the region is at the medium level.

Table. 10. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business in terms of utilization of vegetal residues from agriculture and food industry for insects rearing

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
wheat bran	medium	food market (high quality bran), feed market (lower quality bran with impurities)	competition from feed market, unstable price
rye bran	medium	food market (high quality bran), feed market (lower quality bran with impurities)	competition from feed market, unstable price
2nd grade seeds from seed cleaning	medium	feed market, lower quality with impurities	competition from feed market
cakes and meals from oil extraction	medium	feed market (used as feed material for protein feeds)	competition from feed market

* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W



Most current prices for new insect products ranged from 2,000 €/t (dried insect larvae), yellow mealworm defatted meal), to 2,600 €/t for insect paste (Figure 9), but the highest revenues will be achieved in case of selling insect paste (Figure 10).

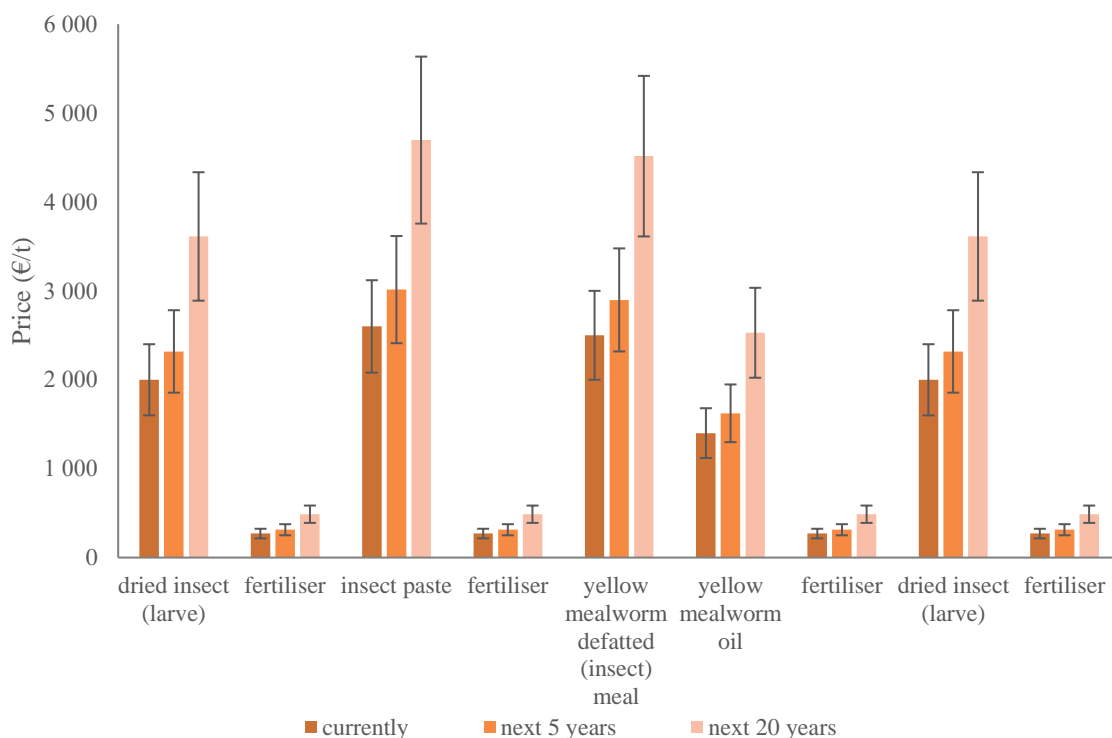


Figure 9. Price change over time in predicted market of new products obtained from utilisation of vegetal residues from agriculture and food industry for insects rearing.

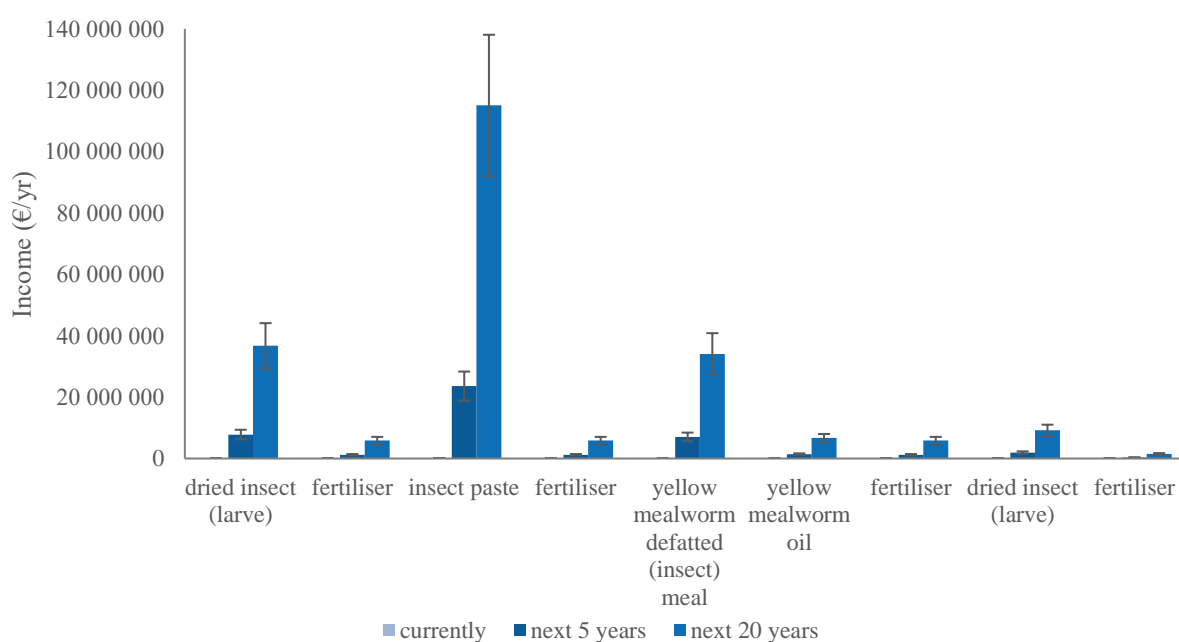


Figure 10. Predicted income of new products obtained from utilisation of vegetal residues from agriculture and food industry for insects rearing.



5.2. Agri-food waste bioconversion into animal feed, fuel or other products

Within this regional value chain, KPV (PP-6) proposed agri-food waste bioconversion into animal feed, fuel or other products. The main sources of by-product and waste for this value chain were the grain and milling industry as well as vegetable industry (Table 11). From the grain and milling industry sector, corn and wheat straws were indicated as important B+W, produced in 50 companies in an amount of approximately 1,128 t/year (average price 81 €/t). In this chain, it was assumed that the new products would be biogas, organic fertilizer and animal feed. The current market price of these products was 0.61 €/m³, 23 €/m³ and 642 €/t, respectively. The current amount of biogas was estimated at 32,546,090 m³/year, organic fertilizer at 180,000 m³/year, and animal feed at 23,908 t/year. However, the expected quantities of these products in five years would be higher.

Table. 11. Selected elements of the characteristics of the value chain in the field of agri-food waste bioconversion into animal feed, fuel or other products

Source and name of by-product and waste (B+W)	Number B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Current market price of the new product (€/t)	Actual amount of the new product (m³/year)	Predicted amount of the new product in next 5 years (m³/year)	Predicted amount of the new product in next 20 years (m³/year)
Grain and milling industry								
corn and wheat straws	50	1,128	81	biogas	0.61	32,546,090	65,092,180	162,730,450
				organic fertilizer	22.94	180,000	360,000	900,000
				animal feed	642 €/t	23,908 t/year	25,000 t/year	28,000.0 t/year
corn rachis	14	9,000-12,000	94	biogas	0.61	32,546,090	65,092,180	162,730,450
				organic fertilizer	22.94	180,000	360,000	900,000
Vegetable industry								
whole parts of wasted food (plants such as carrots , onion, pea etc.)	233	97,081	42	biogas	0.61	32,546,090	65,092,180	162,730,450
				organic fertilizer	22.94	180,000	360,000	900,000



Another B+W from the same sector was corn rachis, produced in 14 plants in the amount of 9,000-12,000 t/year, with an average price of 94 €/t (Table 11). It was assumed that the new products would be biogas and organic fertilizer. The current volumes of these new products were estimated at 32,546,090 and 180,000 m³/year for biogas and organic fertilizer, respectively. However, the estimated quantities of these products in five years could be 65,092,180 and 360,000 m³/year, respectively, and in 20 years 162,730,450 and 900,000 m³/year, respectively.

As part of these analyses, it was also indicated that the vegetable industry is also an important source of B+W (the whole parts of food waste: carrots, onion, pea, etc.). This type of B+W was produced in 233 plants in an amount of approximately 97,081 t/year, (market price 42 €/t) (Table 11). This chain assumed that the new products obtained and their quantities would be similar to those in the case of corn rachis.

Within these value chains, the main directions and trends in the use of B+W from grain and milling industries include their use in agriculture for feed purposes and for biogas production (Table 12). In turn, in the case of B+W from vegetable industry it was disposal because they are usually treated as waste within further upcycling. The main barriers/restrictions for grain and milling industry B+W in supply for new business and use include difficulties in obtaining permits to connect biogas installation to network, availability of cheap substrates and unstable price. More barriers were found in the case of whole parts of food waste. Despite these barriers, it was found that the availability of corn rachis for new businesses in the region is at an average level. However, the availability of the remaining two analysed B+Ws was defined as high.

Table. 12. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business in the field of agri-food waste bioconversion into animal feed, fuel or other products

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
corn and wheat straws	high	agricultural (feed, mulch, leaving the field to be ploughed) or commerce	difficulties in obtaining permits to connect biogas installation to network; availability of cheap substrates; unstable price
corn rachis	medium	agricultural (silage, feeding - CCM (corn cob mix)) or biogas	difficulties in obtaining permits to connect biogas installation to network; availability of cheap substrates; unstable price
whole parts of food waste	high	disposal (they are treated as waste, not managed)	many countries have strict regulations on food waste management, which can make it difficult for new companies to source raw materials from waste; there are safety and hygiene concerns about the reuse of food waste, which may affect its use in the production of new products; consumers' perceptions about products derived from food waste may limit their acceptance and demand; integration and coordination in the supply chain can be difficult to achieve, especially when processing waste from different sources; start-up costs for food waste processing can be high, which is a barrier to new businesses; lack of adequate financial models and support for innovative food waste projects can hinder their implementation

* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W



The highest prices of new products were found animal feed (642 €/t) (Figure 11), while the highest revenues will be related to the sale of biogas (Figure 12).

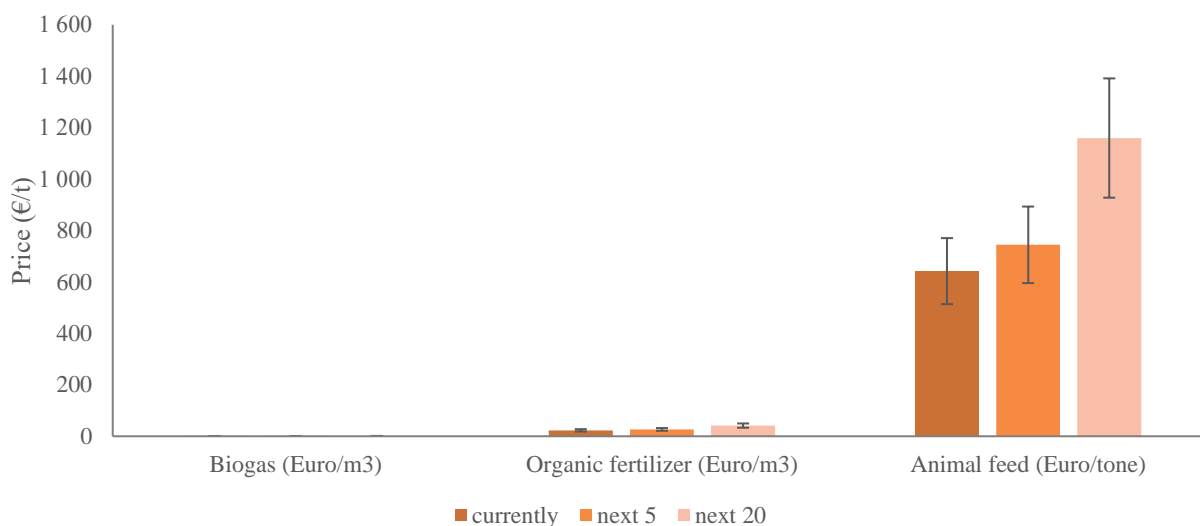


Figure 11. Price change over time in predicted market of new products obtained from agri-food waste bioconversion into animal feed, fuel or other products.

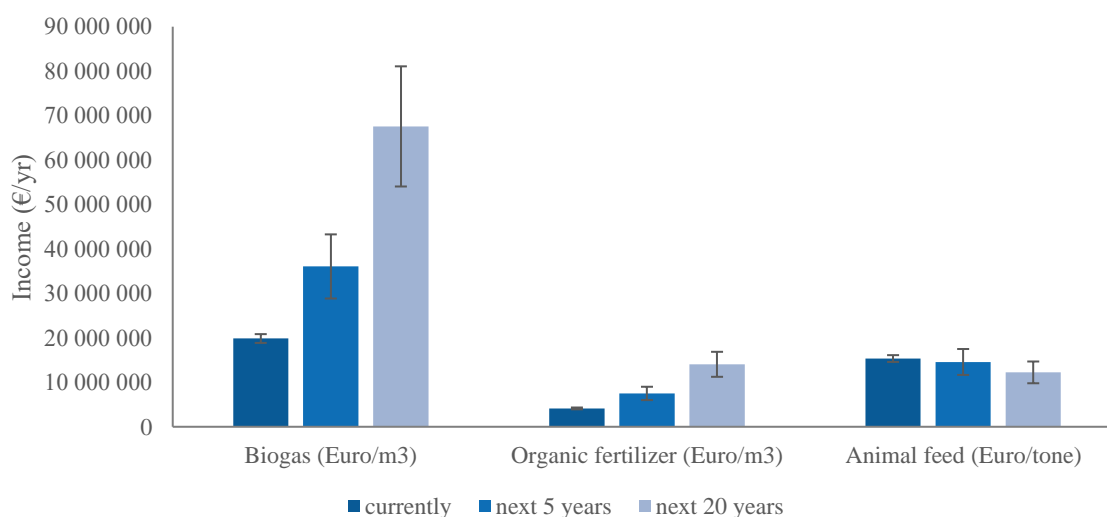


Figure 12. Predicted income of new products obtained from agri-food waste bioconversion into animal feed, fuel or other products.



6. Slovensko value chains

6.1. High added value products from hemp processing

As part of the regional value chain, SUA (PP-9) proposed the use of residues from the hemp industry to produce high added value products (Table 13). There were six companies within the hemp industry that produced B+W in the form of shives, fibre, S&F micro-parts. Of these B+W, shives were the most abundant (1,080 t/year), followed by fibre (630 t/year) and micro-parts S&F (90 t/year). The current market price of shives and fibre was 450 and 550 €/t, respectively.

It was assumed that the new products obtained from the hemp industry would be innovative art of furniture and design panels, new art of biocomposites and special paper and new type of filaments for 3D-printing (Table 13). There were 2 companies operating under shives, and it is expected that there could be 10 companies in the next 20 years. However, rates in this respect were demonstrated in the case of S&F fibre and micro-parts. However, the current market prices of new products and their potential value in the future have not been identified.

Table. 13. Selected elements of the value chain characteristics in the field of high added value products from hemp processing

Source and name of by-product and waste (B+W)	Number B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Number of companies in the region working in new value chain	Number of companies in the region working in new value chain in next 20 years
Hemp industry						
shives	6	1,080	450	innovative art of furniture and design panels	2	10
fibre	6	630	550	new art of biocomposites and special paper	1	3
micro-parts S&F	6	90	N/A	new type of filaments for 3D-printing	1	4

Within these value chains, the main directions and trends in the use of B+W from hemp industry include, among others: building, furniture, biocomposites, special paper and biocomposites for 3D-printing (Table 14). However, the main barriers/restrictions in B+W supply for new business and use include competition from conventional materials, seasonal production, storage, and transportation. Despite these barriers, it was found that the availability of all three B+Ws is medium.



Table. 14. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business in terms of high added value products from hemp processing

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
shives	medium	building, furniture, design, biocomposites	competition from conventional materials, seasonal production, storage, transportation
fibre	medium	special paper, biocomposites for shaping, lamination and panels	competition from conventional materials, seasonal production, storage
micro-parts S&F	medium	biocomposites for 3D-printing	competition from plastic materials, seasonal production, dev. technologies

* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W

The highest prices for new products from the hemp industry were assessed for new type of filaments for 3D-printing, 30,000 €/t. The prices of other products were approximately 10 times lower (Figure 13). However, the highest revenues were estimated from the sale of innovative art of furniture and design panels (Figure 14).

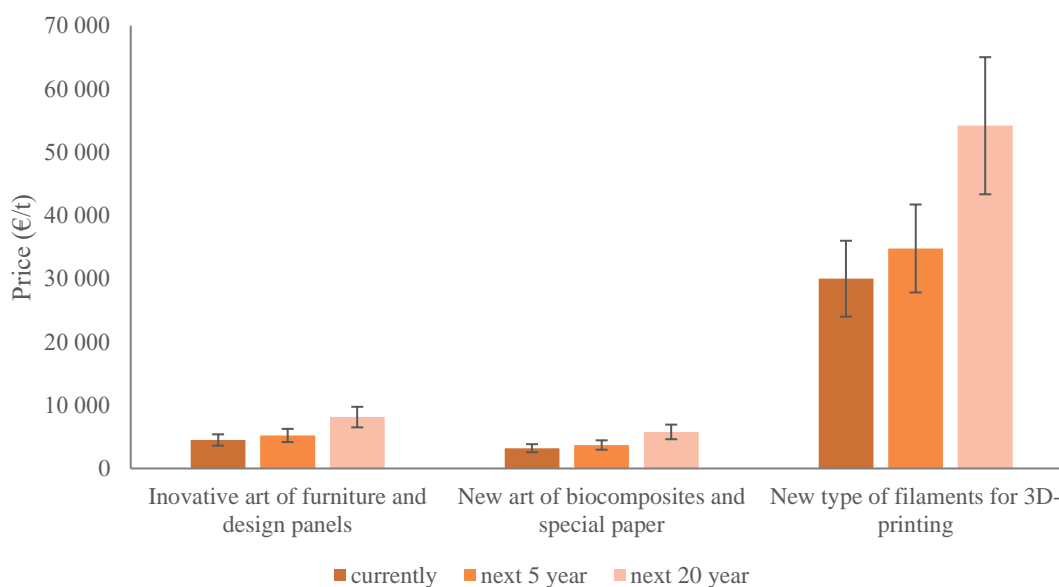


Figure 13. Price change over time in predicted market of new products obtained from high added value products from hemp processing.

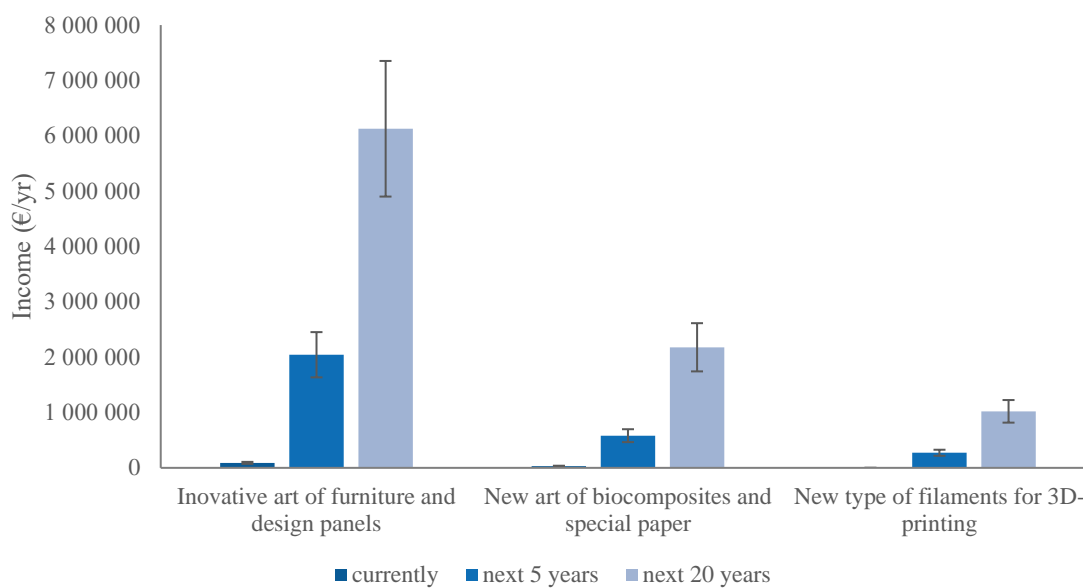


Figure 14. Predicted income of new products obtained from high added value products from hemp processing.



7. Österreich value chains

7.1. High added value products from oil industry

As part of the regional value chain, CAUS (PP-8) proposed using residues from the oil industry to produce high added value products (Table 15). There were 39 companies in this sector that produced B+W in the form of pumpkin seed cake in an amount of 3,100 t/year with current market price at 1,100 €/t. It is assumed that this type of B+W would be used to produce pumpkin seed meal/flour, pesto, pumpkin seed salt, noodles and breadcrumbs. It is estimated that there are approximately 14 companies operating in this area. However, the market prices of new products and their potential value in the future have not been identified.

Table. 15. Selected elements of the value chain characteristics in the field of high added value products from the oil industry

Source and name of by-product and waste (B+W)	Number of B+W production companies	Amount of generated B+W (t/year)	Current market price B+W (€/t)	Type/ name of product obtained from new B+W utilisation	Number of companies in the region working in new value chain	Number of companies in the region working in new value chain in next 20 years
Oil industry						
pumpkin seed cake	39	3,100	1,100	pumpkin seed meal/flour pesto pumpkin seed salt noodles breadcrumbs	14	not known

Four main directions and trends in the use of pumpkin seed cake were indicated (Table 16). Additionally, nine main barriers/restrictions in B+W supply for new business and use were identified, including both financial and technological aspects. The availability of this B+W for new business in the region was determined to be average.

Table. 16. Availability, main directions/trends in use of by-product and wastes and main barriers/restrictions in its supply for new business

By-product and waste (B+W)	Availability of B+W for new business in the region*	Main directions and trends in use of B+W	Main barriers/restrictions in B+W supply for new business and use
pumpkin seed cake	medium	- food market/industry (as gluten-free flour alternative, as protein and fibre booster, for its functional properties, in plant-based products) - nutraceutical and dietary supplement industry (as	- high initial investment (purchase of machinery and vehicles is relatively expensive) - competition (the market for (organic) pumpkin seed products is relatively competitive) - marketing and sales (building a new successful brand and developing markets is time-consuming and expensive)



		source of nutrients, for specific health benefits) - animal feed industry (as protein source, for its health-promoting properties, as alternative to soy flour) - cosmetics and personal care industry (for its exfoliating properties, as source of antioxidants)	- limited research and development (insufficient research and development efforts to optimize production processes) - weather dependency/climate change (pumpkin harvest is highly dependent on weather conditions) - susceptibility of the crop - specific requirements (cultivation and oil production requires specific knowledge and experience) - permits and licenses (required for the production and sale of pumpkin seed oil) - seasonal availability, storage
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* low = up to 20%; medium = 20-50%; high = above 50% of amount of generated B+W

The price of new high added value products from the oil industry, i.e. pumpkin seed meal/flour, pesto, pumpkin seed salt, noodles, breadcrumbs, was estimated at approximately 13,000 €/t (Figure 15), which in the context of a slight increase in the market size, despite assumed price increase (3% per year) and with the assumed decline in the value of money over time (5% per year), will generate revenues at a constant level from approximately 38,000,000 to 44,000,000 €/year (Figure 16).

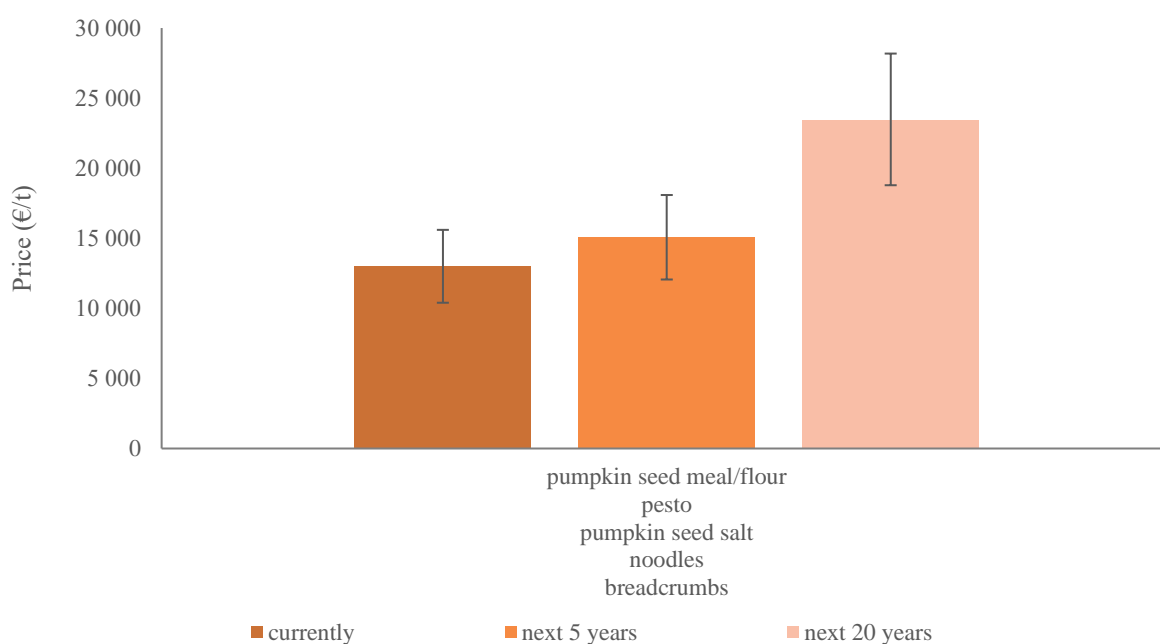


Figure 15. Price change over time in predicted market of new products obtained from high added value products from oil industry.

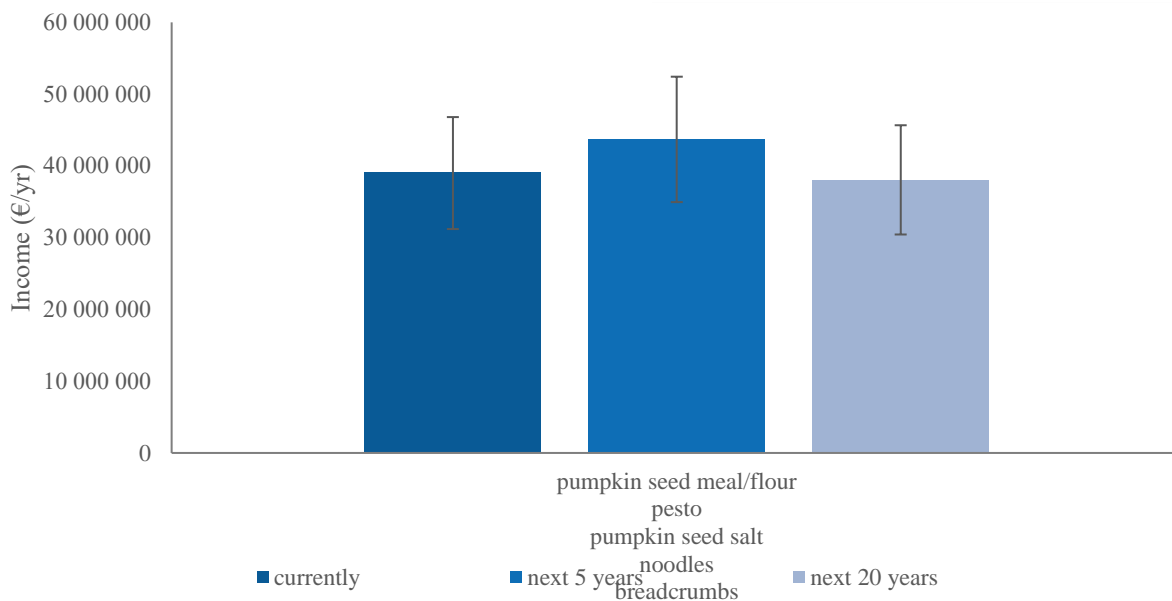


Figure 16. Predicted income of new products obtained from high added value products from oil industry.



8. PESTEL analysis

8.1. PESTEL (Political, Economic, Social, Technological, Environmental, Legal)

PESTEL analysis is a comprehensive analysis that allows for the assessment of the company's macroeconomic environment, while indicating the company's opportunities and threats. PESTEL involves the description of factors from the political, economic, social, technological, environmental and legal environment affecting the enterprise. The name of the analysis was created from the first letters of the names of the factors, i.e.: Political, Economic, Social, Technological, Environmental and Legal. The comprehensive nature of this analysis means that it can also be used to describe new and innovative areas of economic activity, e.g. new products and value chains.

Political factors indicate the impact of policies on the economy. This applies to both financial aspects such as, among others: education and infrastructure. The political factors include GATT (General Agreement on Tariffs and Trade), antitrust legislation, tax policy, labour law, environmental protection regulations.

Economic factors indicate the level of economic development and profitability of activities. Economic factors include changes in GDP, inflation, unemployment, interest rates, money supply, budget revenues. Economic factors can be analysed at two levels. Macroeconomic factors include, among others: the country's economic policy and changes in GDP. Microeconomic factors describing the level of consumer decisions include factors influencing demand and supply.

Social factors indicate the needs of society, their trends and preferences, as well as working attitudes and conditions. Social factors include income structure, social mobility, lifestyle changes, level of education, population demographics.

Technological factors indicate product manufacturing technologies as well as the need to change to new and innovative technologies and products and the costs associated with it. Technological factors include research costs, access to innovative technologies and products.

Environmental factors indicate the impact of the environment, including climate change, on the economic situation. On the one hand, the increase in the costs of raw materials and environmental fees, and on the other, consumer expectations of sustainable products produced from the best possible raw materials, in an appropriate and ethical way. Legal factors include the law regulating production processes at every stage and in every scope.

The analysed innovative chains and new products were defined in various European countries, which means that they may have an international character, therefore the LoNGPESTEL analysis (Local, National, Global, Political, Economic, Social, Technological, Environmental, Legal) was used, in which each factor was analysed in relation to the level at which it occurs, i.e. local, national and international.

The first stage of the analysis was to determine the factors (political, economic, social, technological, environmental, legal). The second stage included the synthesis of factors in individual groups and the assessment of the impact on the development of the analysed value chains. As part of the third stage, weights were established and the impact importance structure was established in terms of opportunities and barriers for value chain implementation at each level of LoNGPESTEL impact (Local, National, Global, Political, Economic, Social, Technological, Environmental, Legal).



8.2. Introduction

The oil industry was the most frequently chosen sector. Other sectors where new value chains can be created or existing value chains modified are the fruit industry, wine industry, grain and milling industry, wood industry, hemp industry and vegetable industry.

A total of four value chains were selected in the oil industry: High added value product from oil processing residues (PP-2); High added value products from residues of alcoholic fermentation (PP-4); Utilization of vegetable residues from agriculture and food industry for insects rearing (PP-5); High added value products from oil industry (PP-8).

Three value chains were selected in the fruit industry: High added value molecules from wine and fruit processing residues (PP-2); High added value molecules from apple processing residues (PP-3); High added value products from residues of alcoholic fermentation (PP-4).

Two value chains were selected within the wine industry: High added value molecules from wine and fruit processing residues (PP-2); High added value molecules from apple processing residues (PP-3).

Two value chains were selected within the grain and milling industry: Utilization of vegetal residues from agriculture and food industry for insects rearing (PP-5); Agri-food waste bioconversion into animal feed, fuel or other products (PP-6).

Two value chains were selected within the Hemp industry: High added value products from hemp (PP-4); High added value products from hemp processing (PP-9).

Two value chains were selected within the wood industry: High added value product from wood (PP-2); High added value molecules from wood (PP-4).

8.3. Oil industry

Oil industry value chain was proposed in 4 countries. Slovenija - NIC, (PP-2) suggested pumpkin seed cakes and olive pomace utilisation (Table 17). Among the PESTEL factors, economic factors had the strongest influence, both on the decreasing side and on the increasing chain development side.

Factors limiting the pumpkin seed cakes market include competition from feed market, storage, transportation. Factors limiting the olive pomace market include competition from feed market, seasonal production, storage, transportation.

However, the factors stimulating the development of the pumpkin seed cakes market include production of healthy products, reduction of agri/food residues. In turn, the factors that stimulate olive pomace utilisation include the use of renewable resources for the production of natural additives (pectin, polyphenols, antioxidants) and biopolymers.

Table. 17. Main barriers and stimulants supply for new business and use of pumpkin seed cakes and olive pomace in Slovenija

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Pumpkin seed cakes (PP2)	competition from feed market, storage, transportation	economic	national/ global	production healthy product, reduction of agri/food residue	economic	national/ global



Olive pomace (PP2)	competition from feed market, seasonal production, storage, transportation	economic	national/ global	use of renewable resources for the production of natural additives (pectin, polyphenols, antioxidants) and biopolymers;	economic	national/ global
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The second country that chose pumpkin seed cake was Österreich - CUAS (PP-8), (Table. 18), where similarly economic factors were the main barriers and stimulants for development. Both barriers and stimulants were of a market nature. On the one hand, the competitiveness of the raw material market and investment costs were pointed out, as well as the growing demand for new products, plant-based diets, gluten-free trend focused on premiumization.

Table. 18. Main barriers and stimulants supply for new business and use of pumpkin seed cakes in Österreich

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Pumpkin seed cake (PP8)	high initial investment (purchase of machinery and vehicles is relatively expensive)	economic	national/ global	growing demand (increased health awareness, rising popularity of plant-based diets, gluten-free trend)	social	national/ global
	competition (the market for (organic) pumpkin seed products is relatively competitive)	economic	national/ global	unique product characteristics (distinctive flavour and texture, versatility, local and regional appeal)	social	national/ global
	marketing and sales (building a new successful brand and developing markets is time-consuming and expensive)	economic	national/ global	emerging market trends (focus on sustainability, e-commerce and online marketplaces, direct marketing and subscription services, growing trend towards consuming organic products)	economic	national/ global
	limited research and development (insufficient research and development efforts to optimize production processes)	technological	national/ global	potential for innovation (new flavour combinations, product diversification, focus on premiumization)	technological	national/ global

Germany- CCB (PP-4) (Table 19) and Poland - UWM (PP-5) (Table 20) chose rapeseed and the use of cakes and meals from oil extraction. The development of these chains is related to both economic and legal factors, and most of them had an international range. Economic factors included competition from the feed



market again, while stimulants indicated, among others, were cost reduction, pesticide reduction, simultaneous fertilization and also demand for animal protein.

Table. 19. Main barriers and stimulants supply for new business and use of rapeseed in Germany

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Rapeseed (PP4)	lack of information/education, lack of alternative use cases, glucosinolate content in conflict with feed application, restructuring of processes from liquid insecticides to solid	legal	national/global	cost reduction, pesticide reduction, simultaneous fertilization, uncertainty of admission of common pesticides like glyphosate and neonicotinoides	legal	national/global

Table. 20. Main barriers and stimulants supply for new business and use of cakes and meals from oil extraction in Poland

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Cakes and meals from oil extraction (PP5)	competition from feed market	economic	national	demand for animal protein	economic	national/global

8.4. Fruit industry

Fruit industry value chain was selected by Slovenija - NIC (PP-2) (Table 21), Italy - FHI (PP-3) (Table 22). The greatest interest in both Slovenia and Italy was the apple industry, where eight value chains were indicated: apple pomace (in both countries), apple juice, apple puree, apple cooked_IQF_frozen, fresh cut, apple seeds, apple skin. Most barriers were of an economic nature, including shelf life and preservation, packaging, storage, transportation and international range. However, most of the stimulating factors were economic and technological, environmental awareness, regulatory incentives, market demand, corporate social responsibility, circular economy, cost reduction, resource management.

Table. 21. Main barriers and stimulants supply for apple pomace in Slovenija

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Apple pomace (PP2)	competition from feed market, seasonal production, instability of processed by-product, storage, transportation	economic	national / global	use of renewable resources for the production of natural food additives (pectin, polyphenols, antioxidants, colours) and biopolymers;	economic	national/global



Table. 22. Main barriers and stimulants supply for apple processing in Italy

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Apple Juice (PP3)	research costs, access to innovative technologies	technological	national/global	budget revenues	economic	national/global
Apple Puree (PP3)	research costs, access to innovative technologies	technological	national/global	budget revenues	economic	national/global
Apple Cooked_I QF_Frozen (PP3)	research costs, access to innovative technologies	technological	national/global	budget revenues budget revenues	economic	national/global
Fresh Cut (PP3)	research costs, access to innovative technologies	technological	national/global	budget revenues budget revenues	economic	national/global
Apple Seeds (PP3)		technological	national/global	budget revenues	economic	national/global
Apple Pomace (PP3)	research costs, access to innovative technologies	technological	national/global	budget revenues	economic	national/global
Apple Skin (PP3)	research costs, access to innovative technologies	technological	national/global	consumer expectations of sustainable products	environmental factors	national/global

8.5. Wine industry

Wine industry value chain was chosen in two countries: ITALY - FHI (PP-3) and AVISP (PP-1) (Table 23) and SLOVENIJA - NIC (PP-2) (Table 24). The raw materials for the new chains were grape pomace, wine lees, seeds and vinasses. Both the factors limiting and stimulating new chains were most often economic and international in nature. As in the chains mentioned above, competition from the feed market was the most frequently mentioned barrier. The stimulants were also economic in nature, but environmental factors were also indicated. The development of the described chains was conditioned by the high value market, but also by the reduction of agri/food residues and further by valuable compounds re-use, cost-effective raw material, and market differentiation.

Table. 23. Main barriers and stimulants supply for wine processing residues in Italy

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Lees (PP1)	technological implementation/knowledge/research cost (investment)	technological	national	high value market (nutraceutical, cosmetic, pharma)	economic	national
Vinasses (PP1)	technological implementation/knowledge/ research cost (investment)	technological	national	high value market (nutraceutical, cosmetic, pharma)	economic	national



Grape Pomace (PP3)	economic viability, changes in gdp	economic	national / global	waste reduction, sustainability, valuable compounds re-use, cost-effective raw material, market differentiation, alignment with consumer trends, support local economies	economic	national / global
Wine Lees (PP3)	market demand, consumer perception, quality, consistency, logistics, changes in gdp	economic	national / transnational	waste valorisation and environmental sustainability, re-use of valuable compounds, cost savings, health and nutritional benefits	economic	national / global
Seeds (PP3)	collection, processing, changes in gdp	economic	national / global	value addition to by-products, health and nutritional benefits, trends towards organic products, consumer awareness and demand, global health trends, potential for premium pricing, environmental sustainability	economic	national / global
Stems (PP3)	collection, storage, regulatory and changes in gdp	economic	national / global	value addition to by-products, market demand, regulatory frameworks and incentives, environmental concerns, innovation, resource availability	economic	national / global

Table. 24. Main barriers and stimulants supply for grape pomace in Slovenia

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Grape pomace (PP2)	competition from feed market, seasonal production, instability of processed by-product, storage, transportation	economic	national / global	production of high value natural additives (pectin, polyphenols, antioxidants); global healthy food production trends; reduction of agro/food residue; innovations; use of renewable sources	economic technological	national / global
Red grape pomace (PP2)	competition from feed market, seasonal production, instability of processed by-product, storage, transportation	economic	national / global	production of high added value natural dyes; health and nutritional benefits, new technical applications; use of renewable sources	economic technological	national / global



8.6. Grain and milling industry

Grain and milling industry value chain was selected by Poland - UWM (PP-5), KPV (PP-6) (Table 25). In this respect, five new value chains were described, the raw materials of which were: wheat bran, rye bran, 2nd grade seeds from seed cleaning, corn and wheat straws, corn rachis. Once again, economic factors had the greatest impact on the development of chains. The limiting factors mentioned once again include competition from feed market. However, in the group of stimulating factors, the influence of legal factors was indicated, e.g. legal demands for environmentally friendly products.

Table. 25. Main barriers and stimulants supply for grain processing residues in Poland

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Wheat bran (PP5)	competition from feed market	economic	national	demand for animal protein	economic	national/global
	unstable price of wheat bran	economic	national	legal demands for environmentally friendly products	legal	national/global
Rye bran (PP5)	competition from feed market	economic	national	demand for animal protein	economic	national/global
	unstable price and amount of rye bran	economic	national	legal demands for environmentally friendly products	legal	national/global
2nd grade seeds from seed cleaning (PP5)	competition from feed market	economic	national	demand for animal protein	environmental	national/global
Corn and wheat straws (PP6)	regulatory and legal issues: difficulties in obtaining permits to connect biogas installation to network	legal	national / global	cheap energy and biofertilizer production	economic	national/global
	economic issues: availability of cheap substates	economic	national / global	obtaining grants from EU and regional funds	economic	national/global
	economic issues: unstable price	economic	national / global	new and more favourable legal regulations	legal	national/global
Corn rachis (PP6)	regulatory and legal issues: difficulties in obtaining permits to connect biogas installation to network	legal	national / global	cheap energy and biofertilizer production	economic	national/global
	economic issues: availability of cheap substates	economic	national / global	obtaining grants from EU and regional funds	economic	national/global
	economic issues: unstable price	economic	national / global	new and more favourable legal regulations	legal	national/global



8.7. Hemp industry

Hemp industry value chain was selected by GERMANY - CCB (PP-4) (Table 26) and SLOVAKA - SUA (PP-9) (Table 27) where hemp shives, hemp fibres and micro-parts S&F were selected as raw materials. Among the economic factors limiting the development of chains, competition from conventional materials was indicated, and additionally, transport, new machinery, unclear long-term legal restrictions, and regulation were also indicated. However, among the factors stimulating development, political factors were indicated, including public funding, clear legal framework, technology development, market pull for sustainability, EU-legislation on green transition and biocircularity, waste reduction, sustainability, valuable re-use, cost-effective raw material, market differentiation, support local economies, health benefits.

Table. 26. Main barriers and stimulants supply for fibre processing residues in Germany

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Hemp shives (PP4)	transport, new machinery	economic	global	public funding, clear legal framework, technology development, market pull for sustainability, EU-legislation on green transition	political	global
Hemp fibres (PP4)	long term legal restrictions and legislation	legal	national and international			

Table. 27. Main barriers and stimulants supply for fibre processing residues in Slovakia

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Shives (PP9)	competition from conventional materials, seasonal production, storage, transportation	economic	national / global	biocircularity, waste reduction, sustainability, valuable re-use, cost-effective raw material, market differentiation, support local economies, health benefits	economic	national / global
Fibre (PP9)	competition from conventional materials, seasonal production, storage	economic	national / global	biocircularity, waste reduction, sustainability, valuable re-use, cost-effective raw material, market differentiation, support local economies, health benefits	economic	national / global
Micro-parts S&F (PP9)	competition from plastic materials, seasonal dev. technologies	economic	national / global	biocircularity, waste reduction, sustainability, valuable re-use, cost-effective raw material, market differentiation, support local economies, health benefits	economic	national / global



8.8. Wood industry

Wood industry was selected by SLOVENIJA - NIC (PP-2) (Table 28) and GERMANY - CCB (PP-4) (Table 29). The two selected value chains included: bark and wood waste. The analysis showed that among the economic factors limiting the development of the chain, competition from the market was also advisable, only this time competition from the energy market. In addition, economic feasibility and technological development were also identified as limiting factors. The factors stimulating the development of chains included environmental and technological factors. Bark was an excellent source for the production of natural additives, while wood waste can be used as an alternative to fossil energy, regional supply chains for energy.

Table. 28. Main barriers and stimulants supply for bark in Slovenija

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Bark (PP2)	competition from energy market, collecting, transportation, storage	economic	national/global	use of renewable resources for the production of natural additives (tannins and polyphenols) and components for production biopolymers	technological	national/global

Table. 29. Main barriers and stimulants supply for wood waste in Germany

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Wood waste (PP4)	economic feasibility and technological development	economic	national	need for biogas as an alternative to fossil energy, regional supply chains for energy	environmental	national/global

8.9. Vegetable industry

Vegetable industry value chain was chosen by POLAND - KPV (PP-6) (Table 30). The proposed chain included the use of whole parts of waste food (plants such as carrots, onion, pea, etc.). The development of this chain was conditioned by all groups of factors. Social factors that rarely appeared in this case included limitations resulting from consumer acceptance issues: consumers' perceptions about products derived from food waste may limit their acceptance and demand. Social drivers included corporate social responsibility: growing consumer awareness and demand for sustainable practices may encourage companies to find innovative uses for food waste.



Table. 30. Main barriers and stimulants supply for vegetable processing residues in Poland

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Whole parts of wasted food (plants such as carrots, onion, pea etc.) (PP6)	regulatory and legal issues: many countries have strict regulations on food waste management, which can make it difficult for new companies to source raw materials from waste	legal	national / global	economic profits: tax breaks, subsidies or other financial benefits for companies that use food waste	economic	national / global
	food safety issues: there are safety and hygiene concerns about the reuse of food waste, which may affect its use in the production of new products	legal	national / global	technological advances: improvements in technology can make it easier and more cost-effective to process and use food waste.	technological	national / global
	consumer acceptance issues: consumers' perceptions about products derived from food waste may limit their acceptance and demand	social	national / global	corporate social responsibility: growing consumer awareness and demand for sustainable practices may encourage companies to find innovative uses for food waste.	social	national / global
	supply chain challenges: integration and coordination in the supply chain can be difficult to achieve, especially when processing waste from different sources	political	national / global	collaborations and partnerships: collaborations between food producers, waste processors and users can facilitate the efficient collection and use of food waste.	social	national / global
	economic issues: start-up costs for food waste processing can be high, which is a barrier to new businesses	economic	national / global			
	financial constraints: lack of adequate financial models and support for innovative food waste projects can hinder their implementation	economic	national / global			



8.10. Dairy industry

Dairy industry value chain was selected by ITALY - AVISP, (PP-1; LP) (Table 31). where three chains were described: whey to proteins, whey to osmotised water and whey to sugars. The limiting factors were of an economic nature, nothing in particular, development of dedicated consortium and plants. The stimulating factors were of a social nature - dissemination.

Table. 31. Main barriers and stimulants supply for whey processing in Italy

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Whey to proteins (PP1)	nothing in particular, development of dedicated consortium and plants	economic	national/global	dissemination	social	national
Whey to osmotised water (PP1)	nothing in particular, development of dedicated consortium and plants	economic	national	dissemination	social	national
Whey to sugars (PP1)	nothing in particular, development of dedicated consortium and plants	economic	national/global	dissemination	social	national

8.11. Beverage industry

Beverage industry was selected by Germany - CCB (PP4) (Table 32), where draff beer was described. Political factors were most stimulating whether economic, legal and technical were limiting factors.

Table. 32. Main barriers and stimulants supply for beer draff in Germany

Source and name	Main barriers in B+W supply for new business and use			Main stimulants in B+W supply for new business and use		
	Factor description	Type	Range	Factor description	Type	Range
Beer draff (PP4)	lack of alternative use cases and valorisation, hygienic concerns, conservation/storage, broad distribution, variable quality and properties	economic	national	facilitation of sustainable alternatives to fossil-based materials (legal/administrative), business support tools (networks, clusters, incubators), trends for new foods	political	national/global
	hygienic concerns, conservation/storage, variable quality and properties	technological	national			



9. Conclusions

Analysis of market readiness for new products from by-products and wastes (B+W) in the primary production and agri-food processing sectors showed great opportunities and pointed out several market needs of new products. A readiness of market at transnational level report included the analysis of new value chains in Italy, Slovenia, Germany, Poland, Slovakia and Österreich. In Italy 16 value chains from 4 sectors were found. The highest amount of B+W was found for apple juice, the highest price for new product was predicted for tannins but the highest income in next 20 years was predicted for pectine.

In Slovenia 6 value chains from 4 sectors were found. The highest amount of B+W was found for bark, the highest price for new product was predicted for natural colours for food application, but the highest income in next 20 years was predicted for tanins for wine application.

In Germany 5 value chains from 3 sectors were found. The highest amount of B+W was found for wood waste, the highest price for new product was predicted for hemp-biocomposites and the highest income in next 20 years was also predicted for hemp-biocomposites.

In Poland 7 value chains from 4 sectors were found. The highest amount of B+W was found for cakes and meals from oil extraction, the highest price for new product was predicted for insect paste, and the highest income in next 20 years was predicted also for insect paste.

In Slovakia 3 value chains from 1 sector were found. The highest amount of B+W was found for shives, the highest price for new product was predicted for new type of filaments for 3D-printing, but the highest income in next 20 years was predicted for innovative art of furniture and design panels.

In Österreich one, the most interesting value chain was found in one sector. The highest amount of B+W was found for pumpkin seed cake, the highest price for new product was predicted for next 20 years, but the highest income was predicted in next 5 years.

The oil industry was the most frequently chosen sector. Other sectors where new value chains can be created or existing value chains modified are the fruit industry, wine industry, grain and milling industry, wood industry, hemp industry and vegetable industry. A total of four value chains were selected in the oil industry: High added value product from oil processing residues (PP-2); High added value products from residues of alcoholic fermentation (PP-4); Utilization of vegetable residues from agriculture and food industry for insects rearing (PP-5); High added value products from oil industry (PP-8).

Three value chains were selected in the fruit industry: High added value molecules from wine and fruit processing residues (PP-2); High added value molecules from apple processing residues (PP-3); High added value products from residues of alcoholic fermentation (PP-4).

Two value chains were selected within the wine industry: High added value molecules from wine and fruit processing residues (PP-2); High added value molecules from apple processing residues (PP-3).

Two value chains were selected within the grain and milling industry: Utilization of vegetal residues from agriculture and food industry for insects rearing (PP-5); Agri-food waste bioconversion into animal feed, fuel or other products (PP-6).

Two value chains were selected within the hemp industry: High added value products from hemp (PP-4); High added value products from hemp processing (PP-9). Two value chains were selected within the wood industry: High added value product from wood (PP-2); High added value molecules from wood (PP-4).

The most frequent main barriers in B+W supply for new business and use and main stimulants in B+W supply for new business and use were economic factors on national/global scale. The second main barriers in B+W supply for new business and use were technological factors and the second main stimulants in B+W supply for new business and use were social factors.