Latvia University of Life Sciences and Technologies

REPORT ON THE COMPOSITION AND QUANTITY OF PLASTIC PACKAGING IN LATVIA

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SUMMARY

As the momentum toward sustainability gains traction, the issue of packaging circulation and recycling becomes increasingly crucial. Conducting an inventory and analysis of packaging is vital to understanding the situation in retail trade and establishing a dataset that illustrates the diversity of polymer packaging.

Analyzing the flow of paper and polymer waste reveals that the majority of recycled paper and polymer packaging, accounting for 67% of paper, cardboard, and polymer packaging, is recycled in another EU country and only a relatively small portion (14%) is recycled locally in Latvia. Conversely, when considering only the recycling of polymer waste, 41.5% of recycled plastic packaging is handled locally in Latvia, while 55% is processed in other EU member states, and 3.4% outside the EU. This waste processing structure indicates that the EU offers viable options for managing this type of waste. However, it would be beneficial to assess the development of Latvia's waste processing capacity within these waste processing categories. This would enable the waste generated in Latvia to be managed locally without the need for transportation to other countries.

Considering plastic waste recycling capabilities in Latvia, Estonia, Lithuania, and Poland, it becomes apparent that Latvia and Poland have more advanced recycling systems for polyethylene terephthalate (PET) and polypropylene (PP). Meanwhile, in Lithuania and Estonia, polyethylene (PE) is also recycled to a greater extent, with Lithuania additionally recycling combined multi-layer cardboard packaging. Consequently, it can be deduced that while certain materials can be recycled locally in Latvia, there is currently no infrastructure in place to locally recycle other types of waste that are widely used in production.

The study aims to analyze the diversity of polymer materials to provide an overview of the current situation in retail trade, both overall and categorized by groups of packaged products. In Latvia, a wide array of packaging types are utilized in retail, with the largest group comprising polypropylene (PP) packaging, accounting for 25.31% of the total. However, it's important to note that there are various subtypes of PP packaging within this group. The second largest group consists of packages where the type of packaging is not indicated, representing 21.88%. Another substantial group, comprising 12.59%, consists of packaging materials marked with the numerical code 7, indicating they are often challenging to recycle due to multiple layers. Following this is the PET packaging group, constituting 11.65%, primarily comprising bottle packaging, which is relatively well recyclable in the Latvian context. Finally, there's the polyethylene group, accounting for 13.53%, comprising 7.25% LDPE and 6.28% HDPE.

To enhance the recyclability of packaging, it's crucial to consider not only the recycling of packaging waste but also the early stages of the packaging life cycle. This includes the initial use of the packaging, including its compatibility with potential packaging equipment, product/goods shelf life, printing quantity, label type selection, and packaging form design. These factors collectively determine the packaging materials and solutions manufacturers choose for their products/goods. Consequently, over 3000 packaging units were analyzed in the study.

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INTRODUCTION

Considering current concerns regarding the use of natural resources and waste reduction, it is essential to inventory and analyze packaging to identify solutions for the optimization of the packaging.

The aim of the study:

To identify and analyze the variety of polymer packaging types in Latvia's retail sector, encompassing the full range of supermarket products, including both food and non-food items.

Research methods:

- Data collection through physical photofixation of packages.
- Analysis of the collected data.
- Interviews with food manufacturers and packaging manufacturers/distributors.

Scope of the research:

- Analyzed 3295 packaging units.
- Conducted discussions with food manufacturers and packaging manufacturers/distributors.
- Performed preliminary calculations for transitioning from non-recyclable to recyclable packaging.
- Identified and analyzed potential factors influencing packaging changes.

The collected data indicate that a wide variety of packaging types are used in Latvia's retail trade. The largest group, making up 25.31% of the total, consists of polypropylene (PP) packaging. It is important to note that there are different types of PP packaging within this group. The second largest group, accounting for 21.88%, includes packages where the type of packaging is not indicated. A relatively large group, comprising 12.59%, consists of packaging materials marked with the numerical code 7, indicating they are difficult to recycle due to their multi-layer composition. The PET packaging group follows at 11.65%, primarily consisting of bottle packaging, which is relatively well recyclable in Latvia. The polyethylene group accounts for 13.53%, split between 7.25% LDPE and 6.28% HDPE.

When implementing potential packaging changes, significant attention should be paid to the compatibility of the packaging with the packaging equipment. This is crucial because there is a risk that the equipment may not be able to seal the new packaging with the required quality.

DESIGNATION AND NUMERIC CODE OF PACKAGING MATERIALS

The packaging designations and codes analyzed in the study are in accordance with the Regulation No. 140 Cabinet of Ministers of the Republic of Latvia, adopted on 2002 "Packaging Classification and Marking Regulations"[1]

Abbreviation (abbreviated designation)	Numeric code	Full name of the packaging material
PET	1	polyethylene terephthalate
HDPE	2	high density polyethylene
PVC	3	polyvinyl chloride
LDPE	4	low density polyethylene
PP	5	polypropylene
PS	6	polystyrene
OTHER	7	other polymers
PAP	20	corrugated cardboard
PAP	21	cardboard
PAP	22	paper
FE	40	iron/iron tin
ALU	41	aluminum
C/80	80	paper and cardboard/mixed metals
C/81	81	paper and cardboard/plastic
C/82	82	paper and caron/aluminum
C/83	83	paper and cardboard/iron tin
C/84	84	paper and cardboard/plastic/aluminium
C/85	85	paper and cardboard/plastic/aluminium/iron tin
C/90	90	plastic/aluminum
C/91	91	plastic/iron tin
C/92	92	plastic/mixed metals
C/95	95	glass/plastic

[1] Regulation No. 140 Cabinet of Ministers of the Republic of Latvia, adopted on 2002 ''Packaging Classification and Marking Regulations'': [online] [Accessed 18.12.2023.]. Available: https://likumi.lv/ta/id/60915-iepakojuma-klasifikacijas-un-markesanas-noteikumi

COMPLIANCE WITH CN CLASSIFIER CODES

According to the Combined Nomenclature[2]

Product group in this study	CN code	CN code name
Packaging of meat products (semi-finished products) and sausages	1601 00	Sausages and similar products made from meat, meat offal, blood or insects; food products based on these products
	1602 20	from the liver of any animal
Chilled packages of fresh meat and eggs	0201	Fresh or chilled beef
	0203	Fresh, chilled or frozen pork
	0207	Meat and offal of poultry of heading 0105, fresh, chilled or frozen
	0208	Other fresh, chilled or frozen meat and meat offal
	0407	Birds' eggs in shell, fresh, preserved or cooked
Frozen food	1902	Dough (pasta) products, whether or not cooked or filled (meat or other products) or otherwise prepared, such as spaghetti, macaroni, noodles, chips, dumplings, dumplings, stuffed pasta; couscous, prepared or unprepared
	2105 00	Ice cream, with or without cocoa
	0406	Cheese and cottage cheese
	0304	Fresh, chilled or frozen fish fillets and other fish meat (whether or not minced)
	0306	Crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; smoked crustaceans, whether or not in shell, whether or not cooked before or during the smoking process; crustaceans in shell, cooked by steaming or boiling in water, whether or not chilled, frozen, dried, salted or in brine
	0307	Molluscs, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; smoked molluscs, whether or not in shell, whether or not cooked before or during the smoking process
	0202	Frozen beef
	0203	Fresh, chilled or frozen pork
	0207	Meat and offal of poultry of heading 0105, fresh, chilled or frozen
	0208	Other fresh, chilled or frozen meat and meat offal
	0811	Frozen fruit and nuts, uncooked or cooked by steaming or boiling in water, whether or not containing added sugar or other sweetening matter
	0710	Frozen vegetables (uncooked or processed by steaming or boiling in water)
	1006	Rice
Bread and flour products	1905	Bread, pastries, cakes, biscuits and other bread and pastry products with or without added cocoa; divine rolls, pharmaceutical wafers, stamp wafers, rice paper and similar products

[2] Kombinētā nomenklatūra 2023 [online] [Accessed 08.01.2024.]. Available: https://e.csb.gov.lv/helpdesk/lv/SubCategory/309

	1001	Wheat and a mixture of wheat and rye
	1002	Rye
Beverages	2201	Water, including natural or artificial mineral waters and carbonated waters, without added sugar or other sweetening matter, unflavoured, ice and snow
	2202	Water, including mineral waters and aerated waters, containing added sugar or other sweetening matter or flavored, and other non-alcoholic beverages, excluding fruit or vegetable juices of heading 2009
	2009	Fruit juices (including grape must) and vegetable juices, unfermented and not containing added spirit, whether or not containing added sugar or other sweetening matter
	21069030	Flavored or colored isoglucose syrups
	0901	Coffee, whether or not roasted, caffeinated or decaffeinated; coffee bean shells and casings; coffee substitutes containing coffee in any proportion
Packaging of milk and milk products	0401	Milk and cream, not condensed and without added sugar or other sweetening matter
	0402	Milk and cream, condensed or with added sugar or other sweeteners
	0403	Yogurt; buttermilk, sour milk and cream, kefir and other fermented or sour milk products, whether or not thickened or containing added sugar or other sweetening matter, or flavored or containing fruit, nuts or cocoa
	0404	Whey, whether or not thickened and containing added sugar or other sweetening matter; products containing natural milk ingredients, whether or not containing added sugar or other sweetening matter, not elsewhere specified or included
	0406	Cheese and cottage cheese
	1704	Sugar confectionery (including white chocolate) without added cocoa
	070960	Vegetables of the Capsicum genus or Pimenta genus (vegetable peppers or paprika, allspice, etc.)
	0709 92	Olives
Packages of dry bulk products	1902	Dough (pasta) products, whether or not cooked or filled (meat or other products) or otherwise prepared, such as spaghetti, macaroni, noodles, chips, dumplings, dumplings, stuffed pasta; couscous, prepared or unprepared
	1904	Prepared foods obtained by puffing or roasting cereal products (eg cornflakes); Cereal products (except maize) in the form of grains or flakes or in other processed grains (except flour, semolina and meal), previously cooked or otherwise prepared, not elsewhere specified or included
	110100	Wheat or mixed grain flour
	1103	Cereal groats, groats and pellets
	1104	Cereal grains otherwise worked (for example, hulled, flattened, flaked, hulled, split or crushed), other than rice of heading 1006; cereal germ, whole, flattened, flaked or ground
	1105	Potato flour, powder, flakes, granules and peas
	1108	Starches; inulin
	1702	Other sugars, including chemically pure lactose, maltose, glucose and fructose, in solid form; sugar syrups without

		flavoring or coloring additives; artificial honey, also mixed with natural honey; roasted sugar
	0713	Dried shelled leguminous vegetables, whether or not peeled or split
	190420	prepared foods obtained from unroasted cereal flakes or from mixtures of unroasted cereal flakes and roasted cereal flakes or from puffed cereals
	0801	Coconuts, Brazil nuts and cashew nuts, fresh or dried, whether or not shelled or shelled
	0802	Other nuts, fresh or dried, whether or not shelled or shelled
	1006	Rice
	1008	Buckwheat, sorghum and barley; otherwise
	1701	Cane or beet sugar and chemically pure sucrose in solid form
	250100	Salt (including table salt and denatured salt) and pure sodium chloride, whether or not in aqueous solution or with added anti-caking agents and carriers; sea water
	200410	Potatoes
	2103	Ready-made sauces and products for their preparation; spice mixes and spicy spice mixes; mustard powder and ready mustard
	29251100	Saccharin and its salts
Spices	0904	Peppers of the genus Piper; dried, crushed or ground vegetables of the genus Capsicum and Pimenta (vegetable peppers, allspice, etc.)
	0905	Vanilla
	0906	Cinnamon and cinnamon tree flowers
	0907	Cloves (whole fruit, flowers and stems)
	0909	Common anise, star anise, fennel, coriander, cumin or caraway seeds; juniper berries
	1902	Dough (pasta) products, whether or not cooked or filled (meat or other products) or otherwise prepared, such as spaghetti, macaroni, noodles, chips, dumplings, dumplings, stuffed pasta; couscous, prepared or unprepared
	200410	Potatoes
	2102	Yeasts (active or inactive); other inactive unicellular organisms (excluding vaccines of heading 3002); ready baking powders
	2104	Prepared soups and broths, preparations for their preparation; homogenized mixed food products
	2103	Ready-made sauces and products for their preparation; spice mixes and spicy spice mixes; mustard powder and ready mustard
	0910 99 50	Bay leaves
	0910 91	mixtures referred to in Note 1 (b) of this chapter
	0801	Coconuts, Brazil nuts and cashew nuts, fresh or dried, whether or not shelled or shelled
	1701	Cane or beet sugar and chemically pure sucrose in solid form
	0712	Dried vegetables, whole, cut or sliced, ground or powdered, but not further prepared
	0910	Ginger, saffron, turmeric, marcil, bay leaves, curry and other spices

	1207	Seeds and fruits of other oleaginous plants, whether or not crushed (including sesame and poppy)
	1704	Sugar confectionery (including white chocolate) without added cocoa
	2918 14 00	Citric acid
	3503 00	Gelatin (including gelatin in rectangular, even square, sheets, whether or not surface treated, colored or uncoloured) and gelatin derivatives; fish glue; other glues of animal origin, excluding casein glues of heading 3501
	1904	Prepared foods obtained by puffing or roasting cereal products (eg cornflakes); Cereal products (except maize) in the form of grains or flakes or in other processed grains (except flour, semolina and meal), previously cooked or otherwise prepared, not elsewhere specified or included
	1905	Bread, pastries, cakes, biscuits and other bread and pastry products with or without added cocoa; divine rolls, pharmaceutical wafers, stamp wafers, rice paper and similar products
	1860	Chocolate and other food products with added cocoa
Packaging of sweets and fast snacks	190420	prepared foods obtained from unroasted cereal flakes or from mixtures of unroasted cereal flakes and roasted cereal flakes or from puffed cereals
	1005	Corn
	1904	Prepared foods obtained by puffing or roasting cereal products (eg cornflakes); Cereal products (except maize) in the form of grains or flakes or in other processed grains (except flour, semolina and meal), previously cooked or otherwise prepared, not elsewhere specified or included
	200410	Potatoes
Animal fee	2309 10	dog or cat food, put up for retail sale
	9619 00	Sanitary napkins (packages) and tampons, baby diapers and diaper liners and similar articles, of any material
	6815	Articles of stone or other minerals (including carbon fiber and articles thereof and articles of peat), not elsewhere specified or included
	1904	Prepared foods obtained by puffing or roasting cereal products (eg cornflakes); Cereal products (except maize) in the form of grains or flakes or in other processed grains (except flour, semolina and meal), previously cooked or otherwise prepared, not elsewhere specified or included
	1214	Fodder stalks, fodder beets, fodder roots, hay, alfalfa, clover, sedges, fodder cabbage, lupine, vetch and similar fodder products, whether or not in the form of pellets
Packaging of children's goods	9503 00	tricycles, scooters, pedal cars and similar wheeled toys; doll carriage; dolls; other toys; scale models and similar models for entertainment purposes, movable or immovable; all kinds of puzzles
	9619 00	Sanitary napkins (packages) and tampons, baby diapers and diaper liners and similar articles, of any material
Packaging of hygiene and cosmetic products	9603 10 00	toothbrushes, shaving brushes, hair brushes, nail brushes, eyelash brushes, other brushes for body care, including brushes that are part of appliances
	9619 00	Sanitary napkins (packages) and tampons, baby diapers and diaper liners and similar articles, of any material

	3304	Cosmetic or make-up products and skin care products (except medicinal products), including anti-tan and tanning products; manicure or pedicure products
	3305	Hair care product
	3306	Oral or dental hygiene products, including denture fixing pastes and powders; dental floss (waxed floss for cleaning between teeth), in individual retail packaging
	3307	Pre-shave, post-shave or shaving products, body deodorants, bath products, depilatories and other perfumery, cosmetic or body care products not mentioned or included elsewhere; room deodorants, whether or not flavored or with disinfectant properties
	8212	Beard knives and blades (including blade blanks)
	3401	Soap; organic surfactants and preparations used as soap, in bars, pieces or figures, whether or not containing soap; organic surfactants and body washes, liquid or creamy, put up for retail sale, whether or not containing soap; paper, wadding, felt and non-woven fabrics, impregnated, coated or sprayed with soap or detergents
	4014 10 00	Condoms
	1704	Sugar confectionery (including white chocolate) without added cocoa
	2936	Natural and synthesized provitamins and vitamins (including natural concentrates), their derivatives, used primarily as vitamins, and mixtures of these compounds, whether or not in solvent
Packaging of household chemicals	4818	Toilet and similar paper, cellulose wadding or cellulose fiber paper, of a kind used for household or sanitary and hygienic purposes, in rolls of a width not exceeding 36 cm or cut to size or shape; handkerchiefs, cosmetic tissues, towels, tablecloths, table napkins, bed sheets and similar household, sanitary or hospital articles, garments and clothing accessories of paper pulp, paper, cellulose wadding or cellulose fiber fabrics
	3405	Polishes and creams for shoes, furniture, floors, transport equipment, glass or metals, cleaning pastes and powders and similar preparations (including in the form of paper, cotton wool, felt, non-woven fabrics, porous plastics or porous rubber, impregnated, coated or sprayed with these preparations), excluding waxes mentioned in heading
	3402	Organic surfactants (except soap); surfactants, detergents (including washing aids) and cleaning preparations, whether or not containing soap, other than those of heading 3401
	3401	Soap; organic surfactants and preparations used as soap, in bars, pieces or figures, whether or not containing soap; organic surfactants and body washes, liquid or creamy, put up for retail sale, whether or not containing soap; paper, wadding, felt and non-woven fabrics, impregnated, coated or sprayed with soap or detergents
Packaging of garden products	3101 00 00	Fertilizers of animal or vegetable origin, whether or not mixed together or chemically treated; fertilizers obtained by mixing or chemically treating plant and animal products
	3120	Mineral or chemical nitrogen fertilizers
	3103	Mineral or chemical phosphorus fertilizers
	3104	Mineral or chemical potassium fertilizers

	3105	Mineral or chemical fertilizers containing two or three nutrients: nitrogen, phosphorus and potassium; other fertilizers; the products referred to in this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg
	120750	Mustard seeds
	0601 10	Onions, gum, corms, corms, crowns and rhizomes, unsprouted
	3808	Insecticides, rodenticides, fungicides, herbicides, anti-sprouting agents and growth regulators, disinfectants and similar products, put up or put up for retail sale or in the form of preparations and articles (for example, sulfur-treated tapes, wicks, candles and fly paper)
	282590	calcium oxide, hydroxide and peroxide
	36069090	Metaldehyde, hexamethylenetetramine and substances prepared in similar forms (tablets, sticks, etc.) for use as fuel; alcohol-based fuel and similar ready-made solid or semi-solid fuel; resin torches, burners, etc. products
	38190000	Brake fluids and other prepared fluids for hydraulic transmissions, not containing or containing less than 70 % by weight of petroleum oil or oil obtained from bituminous minerals
	3402	Organic surfactants (except soap); surfactants, detergents (including washing aids) and cleaning preparations, whether or not containing soap, other than those of heading 3401
	3401	Soap; organic surfactants and preparations used as soap, in bars, pieces or figures, whether or not containing soap; organic surfactants and body washes, liquid or creamy, put up for retail sale, whether or not containing soap; paper, wadding, felt and non-woven fabrics, impregnated, coated or sprayed with soap or detergents
	3405	Shoe, furniture, floor, transport equipment, glass or metal polishes and creams, cleaning pastes and powders and similar preparations (including in the form of paper, cotton wool, felt, non-woven cloth, porous plastic or porous rubber, impregnated, coated or sprayed with these preparations
	2201	Water, including natural or artificial mineral waters and carbonated waters, without added sugar or other sweetening matter, unflavoured, ice and snow
	3820 00 00	Ready-made antifreeze and antifreeze fluids
	3506	Ready-made adhesives and other ready-made adhesives, not elsewhere specified or included; products intended for use as glues or adhesives, put up for retail sale as glues or adhesives, of a net weight not exceeding 1 kg
	8201	The following hand tools: shovels and ladles, hoes, picks, hoes, forks and rakes; axes, garden knives and similar cutting tools; any type of garden shears and loppers; scythes, sickles, pitchforks, hedge shears, wedges for splitting wood and other tools used in agriculture, horticulture or forestry
	8203	Files, needle files, scraper files, pliers (including cutting pliers), pliers, tweezers, pincers, metal screws, pipe cutters, screw cutters, hole punches and similar hand tools
	9017 80 10	Measuring tapes, measuring tapes and rulers

	3307	Pre-shave, post-shave or shaving products, body deodorants, bath products, depilatories and other perfumery, cosmetic or body care products not mentioned or included elsewhere; room deodorants, whether or not flavored or with disinfectant properties
	8539	Electric incandescent lamps and gas-discharge lamps, including directed light hermetic lamps, as well as ultraviolet and infrared lamps; arc lamps, light emitting diodes (LED) light sources
	32141010	Glazing putty, pot wax, resin cements, sealing compounds and other mastics
Candies, chocolate and cookies	1704	Sugar confectionery (including white chocolate) without added cocoa
	1860	Chocolate and other food products with added cocoa
	1905	Bread, pastries, cakes, biscuits and other bread and pastry products with or without added cocoa; divine rolls, pharmaceutical wafers, stamp wafers, rice paper and similar products

1. ASSESSMENT OF THE SITUATION OF LATVIA AND EU COUNTRIES IN THE FIELD OF PLASTIC WASTE RECYCLING

The regulations of the Cabinet of Ministers do not require entrepreneurs to report separately on the types of plastic used, but it is determined that it is necessary to report the type and weight of packaging material and disposable tableware and accessories, which include - polystyrene, bags and bioplastics. In Latvia, manufacturers and traders report data according to a certain material classification[3].

The specified classification of the material types of packaging and disposable tableware and utensils, according to which manufacturers and traders report.

- ✓ Packaging of goods and products:
  - glass;
  - plastic (except polystyrene, bioplastic and plastic shopping bags);
  - polystyrene;
  - bioplastics;
  - light plastic bags;
  - plastic bags with material thickness ≥ 50 microns;
  - black metal;
  - aluminum;
  - paper and cardboard or other natural fibers;
  - wood.
- ✓ Disposable tableware and accessories:
  - plastic (except polystyrene and bioplastic);
  - polystyrene;
  - bioplastics;
  - metal foil;
  - paper and cardboard or other natural fibers;
  - wood.

In the countries of the European Union, a similar distribution for the types of used packaging is used for data collection: glass, plastic, paper and cardboard, wood, metal.

1.1. Assessment of the situation in the European Union countries

On average, in the countries of the European Union (EU), one resident sold 117.9 kg of used packaging in 2020, which is 0.3 kg more than in 2019 and 6.6 kg more than in 2018 (see Fig. 1.1). The largest generated amount of used packaging in 2020 was found in Germany (225.8 kg per inhabitant) and the least generated amount of used packaging was found in Croatia (66.0 kg per inhabitant).

[3] Ministru kabineta 2007. gada 19. jūnija noteikumi Nr. 404 "Kārtība, kādā aprēķina un maksā dabas resursu nodokli, izsniedz dabas resursu lietošanas atļauju un auditē apsaimniekošanas sistēmas" [online] [Accessed 08.06.2023]. Available: https://likumi.lv/ta/id/159270

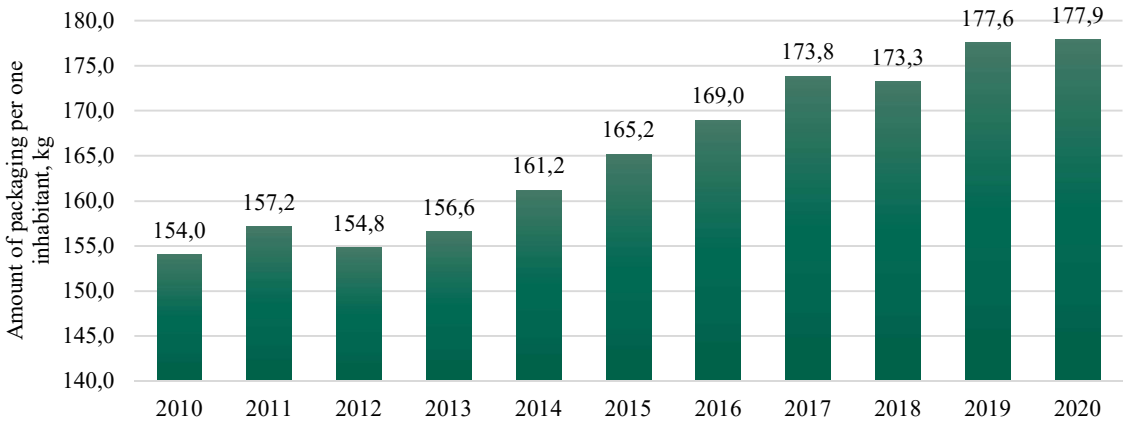


Fig. 1.1. The generated quantity of used packaging per inhabitant in the European Union countries [4,5]

The Baltic states are in the middle of the rest of Europe, Estonia is in 15th place out of 37 European countries, where 154.74 kg of used packaging material is sold per inhabitant. Latvia is in 17th place and 142.81 kg of used packaging is sold per inhabitant, while Lithuania occupies 19th place and sells 136.7 kg of used packaging in 2020.

The most common packaging materials in 2020 are paper and cardboard, which make up 41.1% of the total amount of packaging waste generated in 2020, followed by plastic (19.4%), glass (19.1%), wood (15.2%) and metal (5.0%) and other materials (0.2%). The total generated amount of used packaging reached 79.6 million tons, which is 0.3% more than in 2019. The increase was mainly made up of paper and cardboard packaging (1.3% increase), as well as an increase in the volume of plastic packaging. Metal packaging remained relatively stable, with a 0.2% increase compared to 2019. On the other hand, the volume of wooden packaging decreased by 2.7%, and glass packaging - by 0.2%. Plastic was the second most sold used packaging material in 2020, accounting for 15.5 million, which is 26.7% more than in 2009. The largest volume of paper packaging in 2020 was generated in Germany (99.1 kg per capita), the volume of glass packaging per capita was the largest in Liechtenstein (61.91 kg per capita), the volume of wooden packaging in Finland (43.02 kg per capita) and the volume of metal packaging also in Ireland (13.48 kg per inhabitant). The largest generated amount of used plastic per capita in 2020 was found in Ireland (61.52 kg per capita), Hungary (47.45 kg per capita), Norway (46.12 kg per capita), Portugal (40.34 kg per capita), Estonia (40.32 kg per inhabitant). In terms of used plastic, Croatia also maintains the smallest generated amount of plastic at 16.17 kg per inhabitant, followed by Cyprus (20.28 kg per inhabitant), Liechtenstein (23.49 kg per inhabitant), Slovakia (23.49 kg per inhabitant) and Slovenia (23.68 kg per inhabitant).

Evaluating the recycling volumes of types of used packaging material in 2020, paper and cardboard packaging were recycled the most (59.6 kg per inhabitant). For glass packages 25.7 kg per inhabitant were recycled and of the 34.6 kg used plastic packaging, 13 kg were recycled per inhabitant (see Fig. 1.2).

[4] Eurostat, *Generation of packaging waste per capita [CEI_PC040]* [online] [Accessed 08.06.2023.]. Available:https://ec.europa.eu/eurostat/databrowser/view/CEI_PC040/default/table?lang=en&category=cei.cei_pc

[5] Eurostat, Packaging waste statistics [online] [Accessed 08.06.2023.]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Packaging_waste_statistics#Generation_and_recycling_per_inhabitant

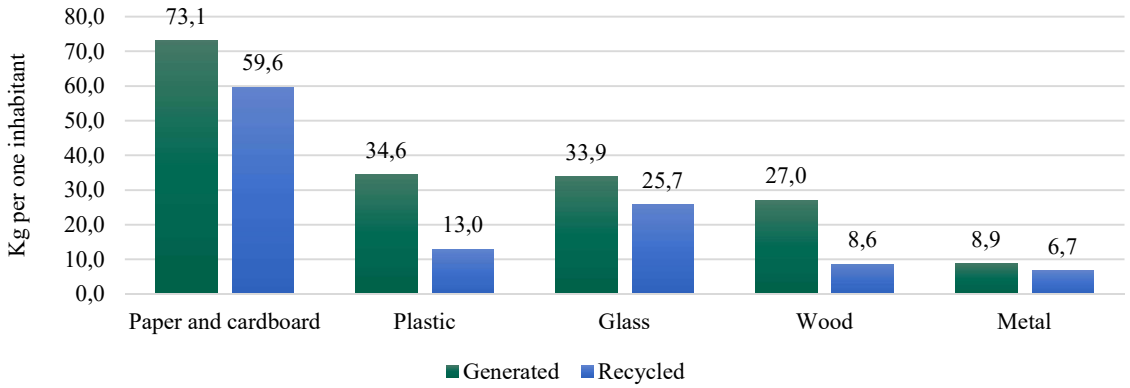


Fig. 1.2. The generated and recycled amount of used packaging per capita in the countries of the European Union in 2020 [6]

The generated volume of used plastic packaging per inhabitant in Europe has steadily increased from 2011 to 2020 by 23% or 6.5 kg (see Fig. 1.3). On the other hand, the volumes of processing increased dynamically until 2019 (14.0 kg per inhabitant) and in 2020, 13.0 kg per inhabitant were processed out of the generated 34.6 kg.

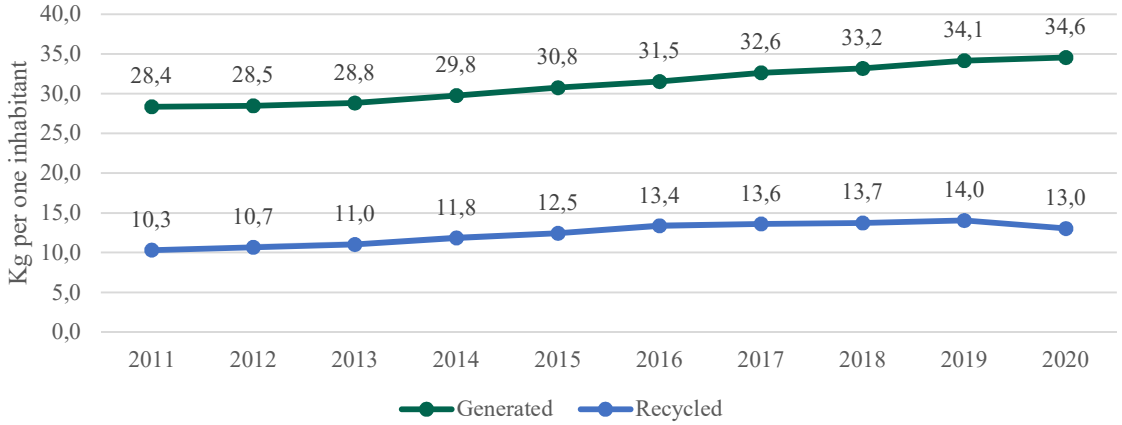


Fig. 1.3. The generated and recycled quantity of used plastic packaging per inhabitant in the countries of the European Union[7]

Analyzing the volume of recycled used plastic packaging from the generated volume, it can be concluded that the most successful examples in Europe are given by Slovakia (56.3% recycled from the generated plastic packaging volume), Lithuania (56.1% recycled from the generated plastic packaging volume), Spain (51.4% recycled from generated plastic of packaging) and Italy (51.2% recycled from the generated plastic packaging volume). These countries are able to recycle more than half of the sold plastic packaging (see Fig. 1.4). In Latvia in 2020, 35.9% of the sold plastic packaging was recycled, which is slightly less than the average figure in European

[6] Eurostat, *Packaging waste by waste management operations* [online] [Accessed 08.06.2023]. Available: https://ec.europa.eu/eurostat/databrowser/view/ENV_WASPAC__custom_6511001/default/table

[7] Eurostat, *Generation of plastic packaging waste per capita* [CEI_PC050] [online] [Accessed 08.06.2023]. Available: https://ec.europa.eu/eurostat/databrowser/view/CEI_PC050/default/table?lang=en&category=cei.cei_pc

countries (37.6%). On the other hand, Ireland, Norway, Hungary, Denmark, France and Malta were able to recycle less than one third of the sold plastic packaging in 2020.

In 2019, Lithuania also retained the 1st place in the recycling of used plastic packaging (69.6 %). Lithuania's plastic packaging recycling rating can be justified by an organized deposit system from 2016, which was already successful at the end of 2017 (92% of the sold plastic bottles were returned to recycling using deposit system machines)[8]. Lithuania has also created an electronic monitoring system that makes it easier for state authorities to track information submitted by companies on the sale, recycling and recovery of used packaging [9]. The example of Slovakia in 2020 can be explained by the government's plans to introduce an additional fee for plastic packaging [10].

[8] The Economist, Why Lithuanians cash in on their trash [online] [Accessed 08.06.2023]. Available: https://www.economist.com/europe/2020/01/11/why-lithuanians-cash-in-on-their-trash

[9] GPAIS electronic system, [online] [Accessed 08.06.2023]. Available: https://www.gpais.eu/en/web/guest

[10] *CMS Expert Guide to plastics and packaging laws* https://cms.law/en/int/expert-guides/plastics-and-packaging-laws/slovakia [online] [Accessed 08.06.2023]. Available: https://cms.law/en/int/expert-guides/plastics-and-packaging-laws/slovakia

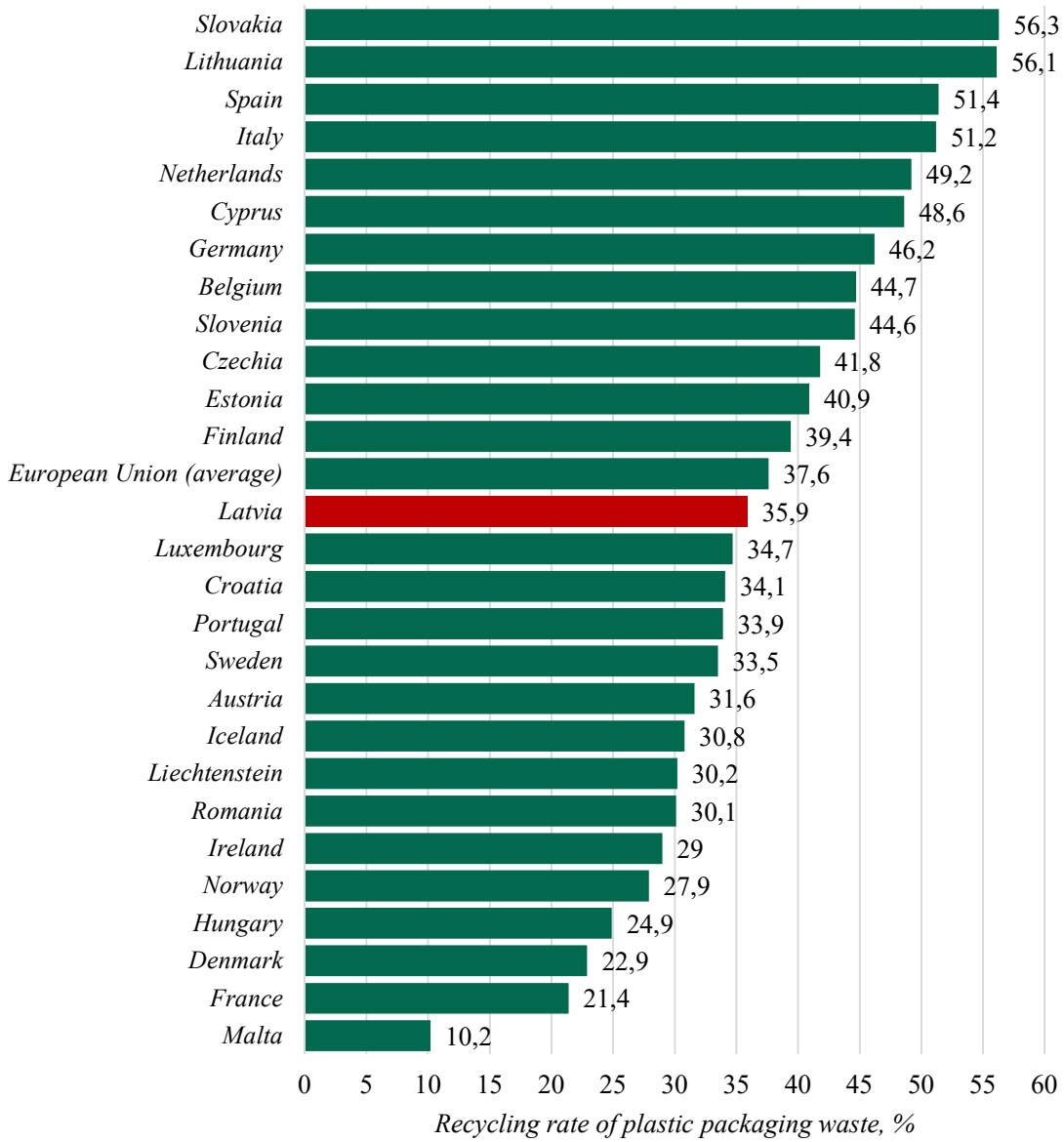


Fig. 1.4. Amount of recycled plastic packaging, % [11]

From 2022, a deposit system began to operate in Slovakia, the results of which could be observed only at the end of 2023[12]. Possible improvements in the future in Slovakia can be provided by the electronic program RecycleMe, activated at the beginning of 2023, which allows packaging manufacturers and distributors to obtain free information about the possibilities of recycling their packaging[13].

[11] Eurostat, *Recycling rate of packaging waste by type of packaging* [CEI_PC050] [online] [Accessed 08.06.2023]. Available: https://ec.europa.eu/eurostat/databrowser/view/CEI_WM020/default/table

[12] Recycling magazine, *Slovakia has launched its Deposit Return System* [online] [Accessed 08.06.2023]. Available: https://www.recycling-magazine.com/2022/05/09/slovakia-has-launched-its-deposit-return-system/

[13] RecycleMe, RecycleMe launches free Recyclability-Tool in Slovakia [Accessed 08.06.2023]. Available: https://recycleme.eco/de/en/blog/recycleme-launches-free-recyclability-tool-in-slovakia/

1.2. Assessment of the situation in Latvia

According to the data of the State Environmental Service, the amount of used packaging material has increased significantly over the last four years. The amount of packaging sold on the territory of Latvia in 2019 was 260.3 thousand tons, which increased in 2020 by 7.3 thousand tons and in 2021 by 26.2 thousand tons (see Fig. 1.5).

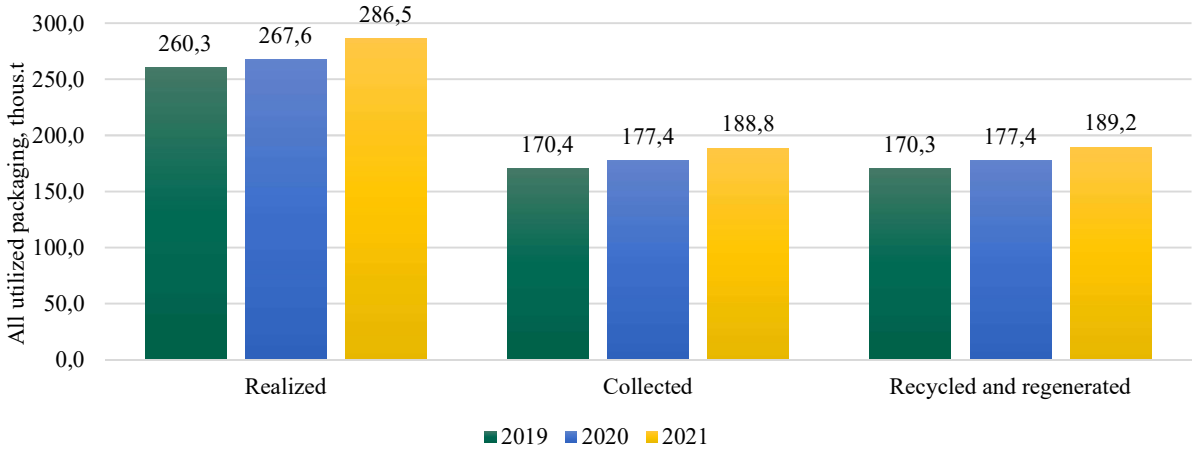


Fig. 1.5. Information provided by producer responsibility systems on the volumes of used packaging in 2019, 2020 and 2021 [14;15;16]

For all types of packaging, a positive generated quantity can be observed both from 2019 to 2020 and from 2020 to 2021. From 2019 to 2020, the generated volume of plastic packaging increased by 2.4 thousand tons (see Fig. 1.6), the volume of paper packaging by 1.2 thousand tons, the volume of wooden packaging by 3.6 thousand tons. On the other hand, from 2020 to 2021, the amount of plastic packaging generated increased by 2.7 thousand tons (see Fig. 1.2), the amount of paper packaging by 5.7 thousand tons, and the amount of wooden packaging by 7.0 thousand tons.

There is also a positive increase in the volumes of collected and recycled, regenerated packaging. The collected amount of used packaging increased by 7.1 thousand tons from 2019 to 2020 and by 11.4 thousand tons from 2020 to 2021.

From 2019 to 2020, the amount of plastic packaging collected increased by 2.5 thousand tons (see Fig. 1.2), the amount of paper packaging by 2.0 thousand tons, the amount of wooden packaging by 0.01 thousand tons. On the other hand, from 2020 to 2021, the amount of plastic packaging collected increased by only 1.4 thousand tons, the amount of paper packaging by 6.0 thousand tons, and the amount of wooden packaging by 2.9 thousand tons. The significant increase in the amount of used packaging in recent years could have been influenced by the situation of the

[14] Valsts vides dienests, Ražotāju atbildības sistēmu sniegtā informācija par atkritumu apsaimniekošanu 2019.gadā [online] [Accessed 08.06.2023]. Available: https://www.vvd.gov.lv/lv/media/1185/download
[15] Valsts vides dienests, Ražotāju atbildības sistēmu sniegtā informācija par atkritumu apsaimniekošanu 2020.gadā [online] [Accessed 08.06.2023]. Available: https://www.vvd.gov.lv/lv/media/8140/download
[16] Valsts vides dienests, Ražotāju atbildības sistēmu sniegtā informācija par atkritumu apsaimniekošanu 2021.gadā [online] [Accessed 08.06.2023]. Available: https://www.vvd.gov.lv/lv/media/9981/download

COVID-19 pandemic in the country, when goods were delivered at home or for takeaway in service areas, where disposable takeaway containers, bags and other types of packaging are mainly used.[17]

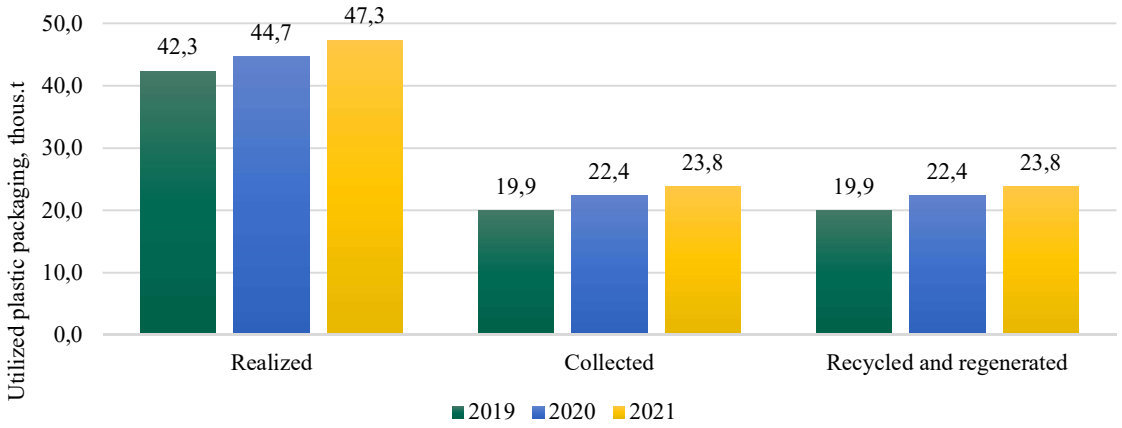


Fig. 1.6. Information provided by producer responsibility systems on the volumes of used plastic packaging in 2019, 2020 and 2021[12;13;14]

The European Commission's proposal for a Regulation of the European Parliament and of the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904 and repealing Directive 94/62/EC[18], includes specific targets for waste reduction, re-use and minimum recycling content in plastic packaging. The set goals require that all European member states take the necessary measures to be able to collect at least 65% of all types of packaging sold in their territory by 2025 and 70% by 2030. The set goals are also expressed for specific packaging materials, for example, plastic would be able to collect at least 50% of the generated volume by 2025 and 55% by 2030 (see Fig. 1.7).

[17] Valsts vides dienests, Valsts vides dienests vērtē ražotāju atbildības sistēmu darbu un dabas resursu nodokļu atbrīvojumu pamatotību 247 miljonu eiro apmērā [online] [Accessed 08.06.2023]. Available https://www.vvd.gov.lv/lv/jaunums/valsts-vides-dienests-verte-razotaju-atbildibas-sistemu-darbu-un-dabas-resursu-nodoklu-atbrivojumu-pamatotibu-247-miljonu-eiro-apmera

[18] Priekšlikums Eiropas Parlamenta un Padomes Regula par iepakojumu un iepakojuma atkritumiem, ar kuru groza Regulu (ES) 2019/1020 un Direktīvu (ES) 2019/904 un atceļ Direktīvu 94/62/EK [online] [Accessed 08.06.2023]. Available:https://eur-lex.europa.eu/resource.html?uri=cellar:de4f236d-7164-11ed-9887-01aa75ed71a1.0024.02/DOC_1&format=PDF

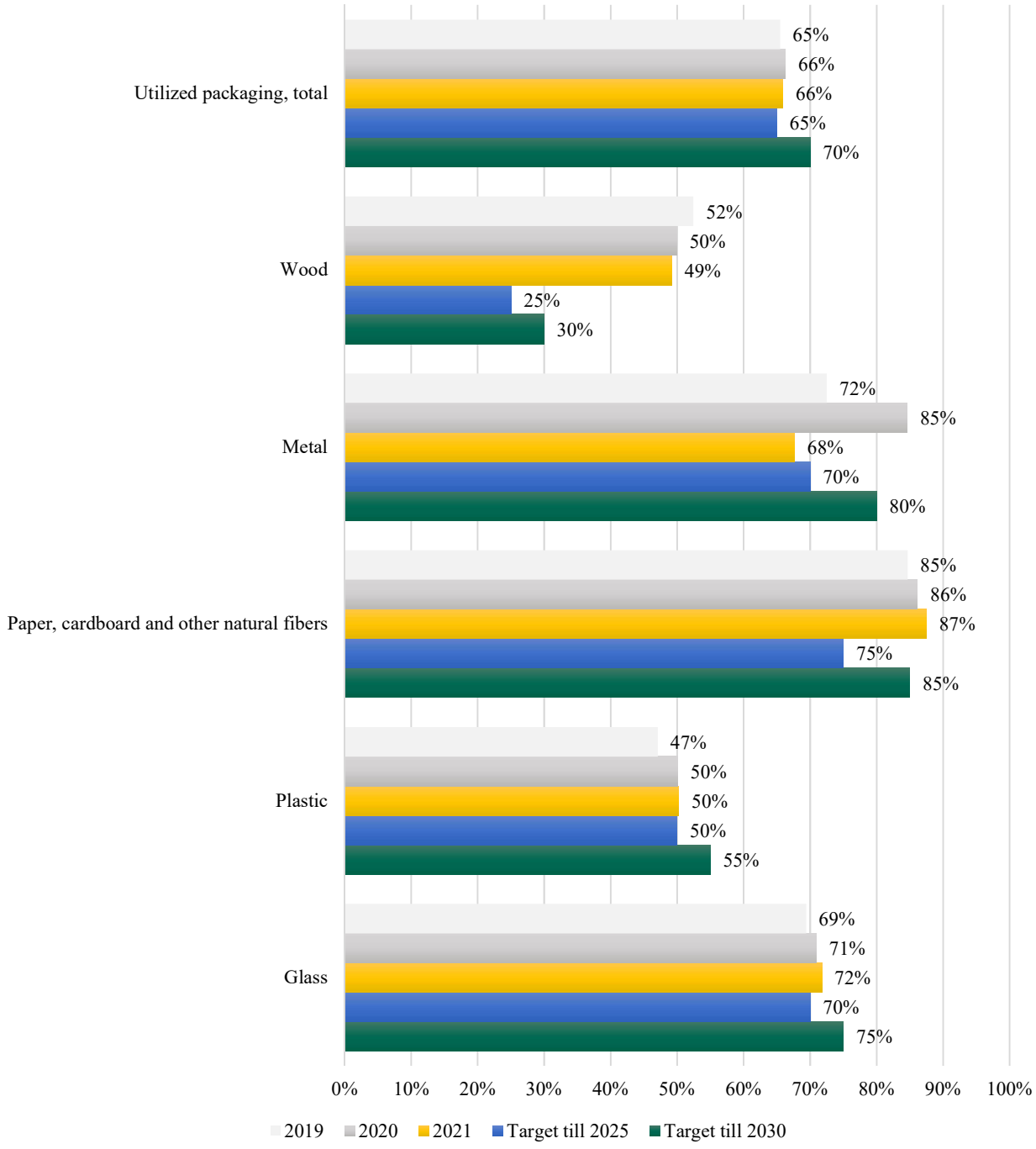


Fig. 1.7. Packaging for recycling and reuse [12;13;14;16]

Comparing the set goals with the real situation of the last years, it can be observed that the ratio of generated and collected packaging volume for all packaging goals is positive and already achievable. According to the essential new waste management goals set by the European Union directives for the period up to 2035, the additionally set goals for plastic are "by 2025, to ensure the collection of separated used single-use plastic beverage packaging for at least 77% of the volume of the relevant packaging of beverages placed on the market in the relevant year by mass".

1.3 Characteristics of packaging volume and flows in Latvia

European Parliament and Council Directive no. 2018/852 it is noted that in the territory of the EU countries, until December 31, 2025, it is necessary to ensure the recycling of 65% of the total amount of used packaging, and also to recycle 50% of the used plastic packaging. Accordingly, on December 31, 2030, it must be ensured that 70% of the total amount of used packaging is recyclable, and 55% must be recyclable from used plastic packaging (EP Directive No. 2018/852, 2018). In 2021, of all plastic produced, 90.2% was from fossil non-renewable resources, 8.3% from recycled plastic, and 1.5% contained bio-based materials. In Europe, these indicators accounted for 87.6%, respectively; 10.1% and 2.3% (Skoczinski et al. 2023). In contrast, the volume of recycled plastic packaging in 2020 in the world accounted for 38% (EUROSTAT, 2022). According to statistical data, the volume of used packaging generated in Latvia in the period from 2009 to 2020 has gradually increased, see Fig. 1.8.

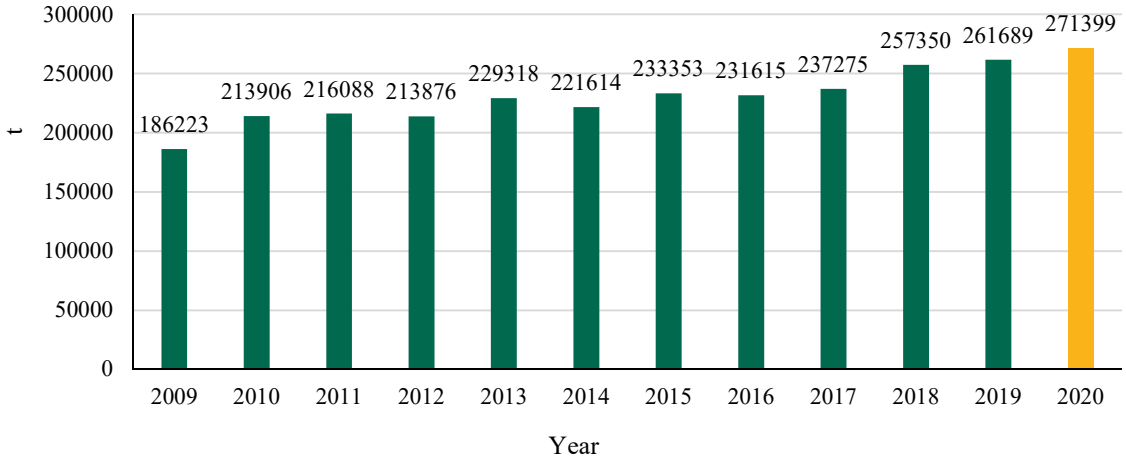


Fig. 1.8. Dynamics of the amount of used packaging generated in Latvia 2009-2020. per year (t) (VARAM, 2022).

The data of the conducted studies show that consumers' awareness of the volume of used packaging material waste is increasing, however, it is indicated that the available information on the possibilities of disposal of used food packaging is not sufficiently accessible and understandable for consumers. Consumer awareness of package labels is insufficient, as the available information is unclear and inconsistent. Also, consumers do not have an in-depth understanding of the need to rinse/wash used food packages before placing them in recyclable waste containers. It is indicated that in order to ensure the sustainable circulation of food packaging in Europe, it is necessary to continue to inform and educate consumers in a high quality (Norton, 2023).

It should be emphasized that the development of sustainability requires the involvement of all those involved in the food production chain, both producers of raw materials and products, as well as consumers, as well as those involved in the processing and management of production by-products and waste (United Nations, 2023).

Analyzing the data available in the Eurostat database on waste flows in Latvia, it can be seen (Fig. 1.9) that the majority of packaging consists of wooden packaging (81 814 t), followed

by paper and cardboard packaging (78 098 t) and glass packaging (65 500 t). In 2021, the total volume of waste in Latvia was 290 025 t, of which 176 876 t or 61% were recycled, incl. 77% paper and cardboard packaging; 41.6% plastic packaging; 48.3% wooden packaging; 66.6% metal and aluminum packaging and 77.3% glass packaging.[19]

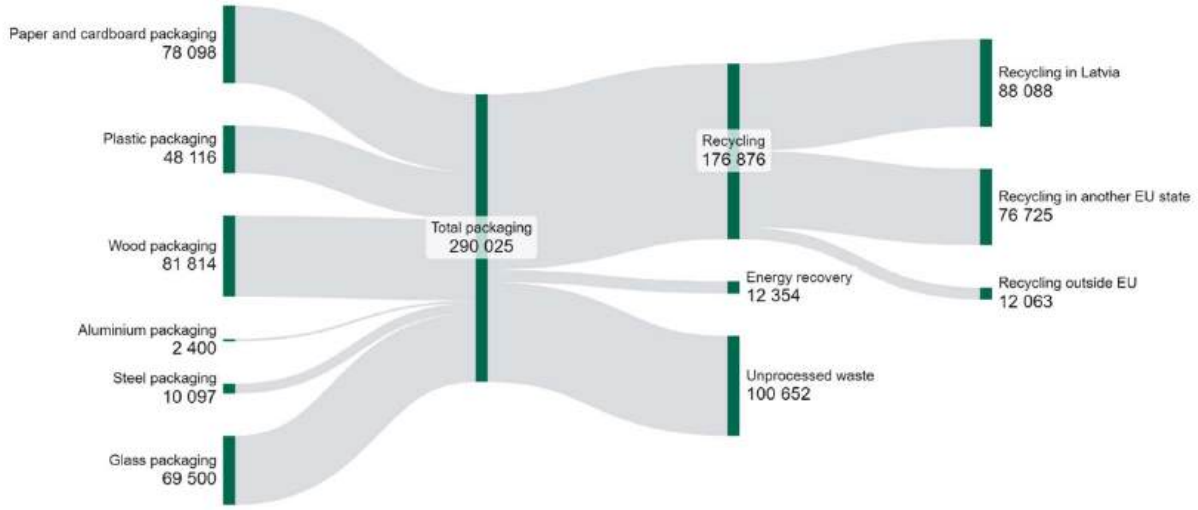


Fig. 1.9. Packaging waste flow in 2021 in Latvia, t[20]

Of the total amount of packaging that is recycled, less than half, or 88 088 t, is recycled locally in Latvia, while 76 725 t is recycled in another EU country and 12 063 t in another country outside the EU. Of all waste, 34.7% or 100 652 are currently not recycled.

Analyzing the flow of paper and plastic waste in more detail (Fig. 1.10), it can be seen that the majority or 56 216 t (67%) of paper, cardboard and plastic packaging is recycled in another EU country and only a relatively small part - 14% - is recycled in places in Latvia. A similar amount of waste, or 14.3%, is recycled outside the EU.

[19] Recycling rates of packaging waste for monitoring compliance with policy targets, by type of packaging: https://ec.europa.eu/eurostat/databrowser/view/env_waspacr__custom_8444333/default/table?lang=en

[20] Packaging waste by waste management operations, EUROSTAT, Eurostat env_waspac__custom_844469, [online] [Accessed 08.01.2024]. Available: https://ec.europa.eu/eurostat/databrowser/view/ENV_WASPAC__custom_3013758/default/table?lang=en

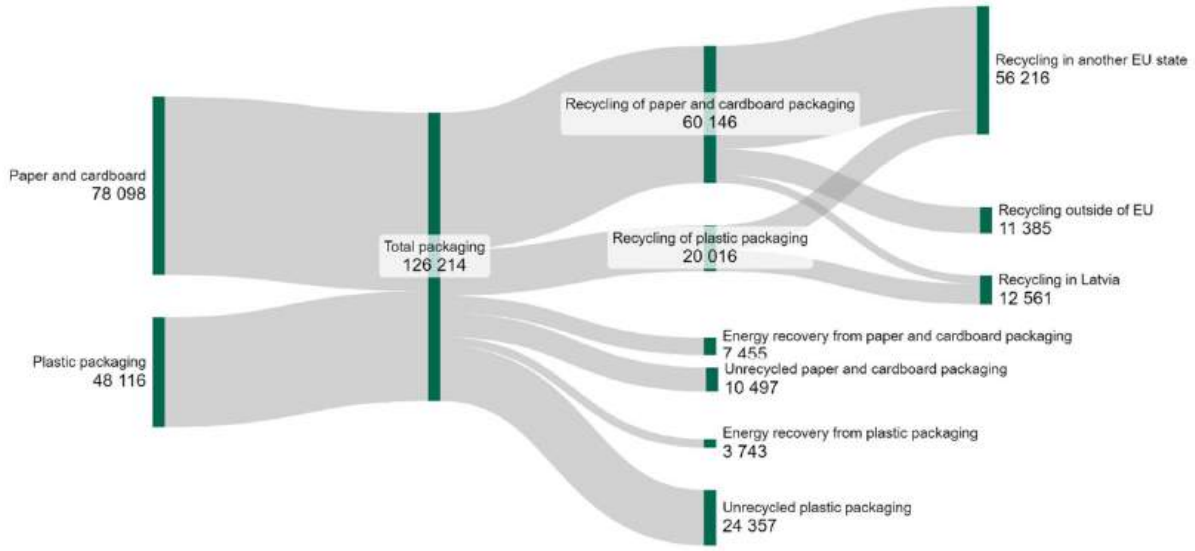


Fig. 1.10. Waste flow of paper, cardboard and plastic packaging in 2021 in Latvia, t[20]

This structure of paper, cardboard and plastic waste processing indicates that the EU has available options for processing this type of waste, but it would be useful to evaluate the development of Latvia's waste processing capacity in these waste groups.

Evaluating the possibilities of recycling plastic waste in Latvia and the neighboring countries, namely in Estonia, Lithuania and Poland (Fig. 1.11, full list in Annex 1), it can be concluded that PET and PP recycling is developed in Latvia and Poland, while in Lithuania and Estonia recycling is also PE and in Lithuania – combined multi-layer cardboard packaging. Therefore, it can be concluded that certain types of materials can be processed locally in Latvia. 8 304 t or 41.5% of plastic packaging is recycled in Latvia, 55% is recycled in other EU member states and 3.4% outside the EU.

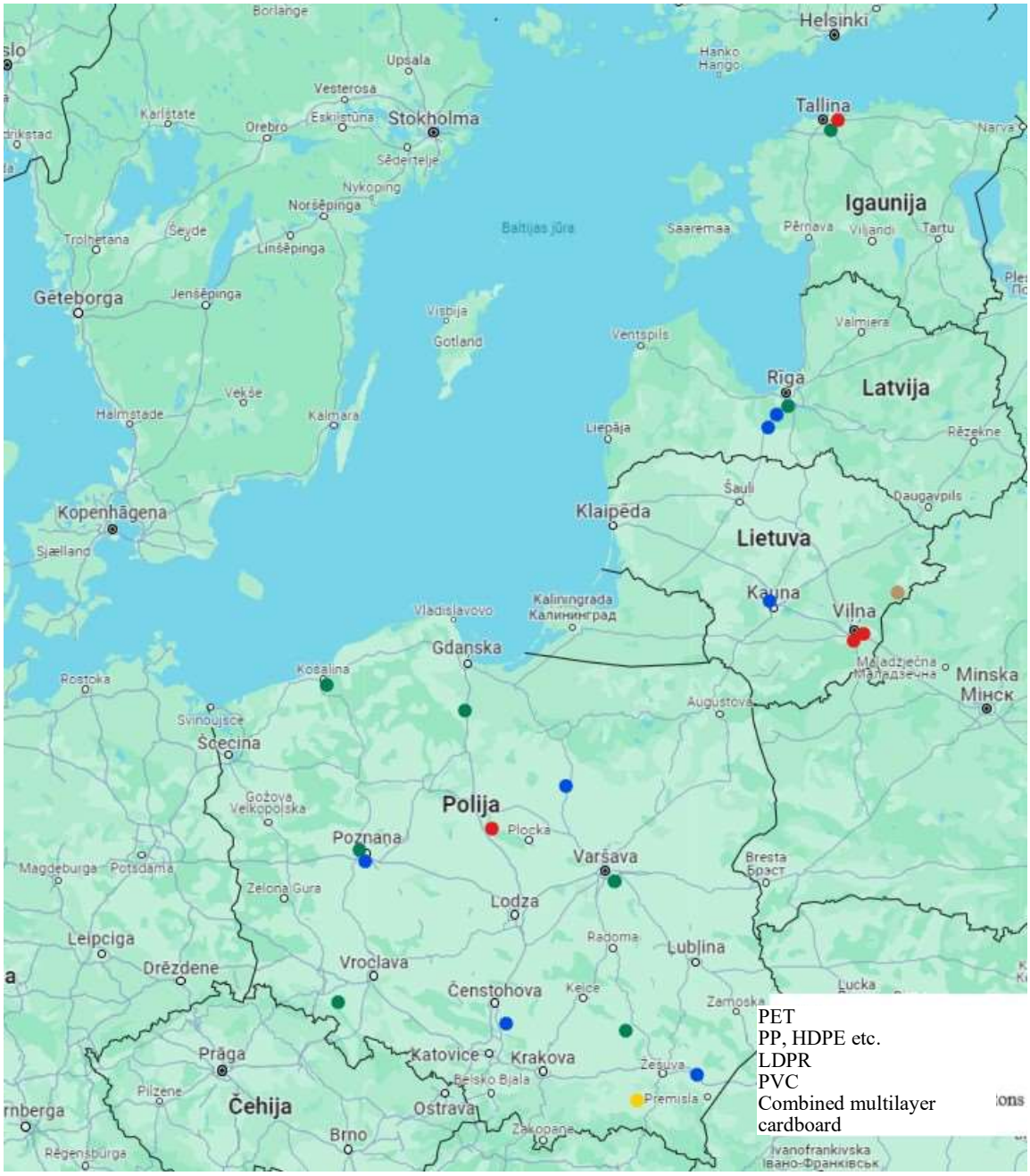


Fig. 1.11. Waste processing options in the Baltic States and Poland

1.4. Characteristics of packaging materials and packaging technologies

According to the regulations of the Cabinet of Ministers No. 140/2002, packaging materials are divided according to their type and marked with certain numbers, however, until now there is no mandatory requirement in the legislation that the packaging material must be indicated on the packaging. Providing information about the type of packaging is the choice and responsibility of entrepreneurs. In Latvia, packaging materials are classified into groups (Regulations No. 140, 2002):

- Natural fibers (cork, wood, paper, cardboard, corrugated cardboard, textiles), metal (aluminum, iron, iron tin, etc.);
- Glass (colored and colorless);
- Composite materials and plastic.

Plastic packaging is divided into seven types:

1) Polyethylene terephthalate (PET);
2) High density polyethylene (HDPE);
3) Polyvinyl chloride (PVC);
4) Low density polyethylene (LDPE);
5) Polypropylene (PP);
6) Polystyrene (PS);
7) Other polymers.

1.5. Packaging technologies in modified gas environment

Food packaging makes up a large part of the packaging, which has specific conditions, therefore it is essential to pay increased attention to it. Food products must be stored in packaging so that they are not exposed to microbiological, chemical or physical contamination. When choosing the type of food packaging accordingly, it is necessary to ensure that the food product is not only not contaminated, but also that the food product maintains its quality. Depending on the type of food product produced, it is necessary to choose appropriate packages to ensure the safety of the food product for the consumer, as well as the longest possible shelf life of the product (Swetha, 2023). The packaging process and technology solutions chosen by food product manufacturers significantly affect the shelf life of food products (Ganeson, 2023).

Scientists emphasize that it is also necessary to seriously evaluate the prevention of food waste, stating that reducing the weight of packages is necessary and more urgent than improving the recycling of packages (Pauer, et.al., 2020). It is necessary to note that by making changes in packaging and reducing its volume, it is possible to expose food products to the risk of premature spoilage, increasing the volume of food products that would then have to be disposed of in waste. When making any packaging changes, it is necessary to critically evaluate all stages of production and logistics (Klemeš et.al., 2020). In the world, the amount of food that ends up in food waste from each stage of food production and distribution reached 17% in 2022 (EUROSTAT, 2022).

In order to package products in an altered gas environment (vacuum or shielding gas environment), the packaging must have barrier properties, often this can only be ensured by using multilayer materials or composite materials. Vacuum packaging technology is one of the most commonly used food packaging technologies, which extends the shelf life of products compared

to packaging in air. In vacuum packaging technology, the oxygen in the package is reduced or even eliminated. Research on vacuum packaging of cheese indicates that the technology is suitable and stands out among other technologies because the cheese retains a longer shelf life as well as good sensory properties. As a result of the use of this technology, the growth of bacteria, as well as molds and yeasts is limited, which accordingly ensures microbiological safety (Todaro, et.al., 2018, Domínguez, et.al., 2021, Nogueira, et.al., 2021).

A shielding gas environment is a packaging technology in which the composition of the gas mixture, or their ratio, is changed or modified as necessary in a hermetically sealed food package. It is varied by three gases: oxygen (O_2), carbon dioxide (CO_2) and nitrogen (N_2). The packaging provides an optimal atmosphere to ensure high quality of food products, as well as to extend the shelf life of food products. In most cases, the technology envisages packaging the food product in a package containing a polymer film with high barrier properties. Depending on the type of film and storage temperature, gas permeability changes, which affects the composition of the atmosphere inside the package (Robertson, 2019).

1.6. Packaging and eco-design strategy

When using packaging, packaging waste is inevitably generated. In order to assess the possibilities of waste management and to prevent that waste processing does not adversely affect the surrounding environment, a waste management hierarchy pyramid consisting of five sections has been created (see Fig. 1.12):

1) The possibility of preventing/reducing the amount of waste generation, i.e. by reducing the thickness, volume, total weight of the material used and the part of the packaging that is non-functional as much as possible.
2) Production and use of reusable packaging for product packaging.
3) As far as possible, choose recyclable packaging for product packaging. This is to choose packages with several layers of material, if possible choose single-layer material packaging instead of multi-layer material packaging.
4) Creating a useful material or solution as a result of its processing.
5) Disposal of generated waste, which is the last step in the food packaging waste cycle, which the manufacturer, as well as the waste processor, needs to avoid by being included in one of the four sections listed above (EP Directive No. 2018/852, 2018).

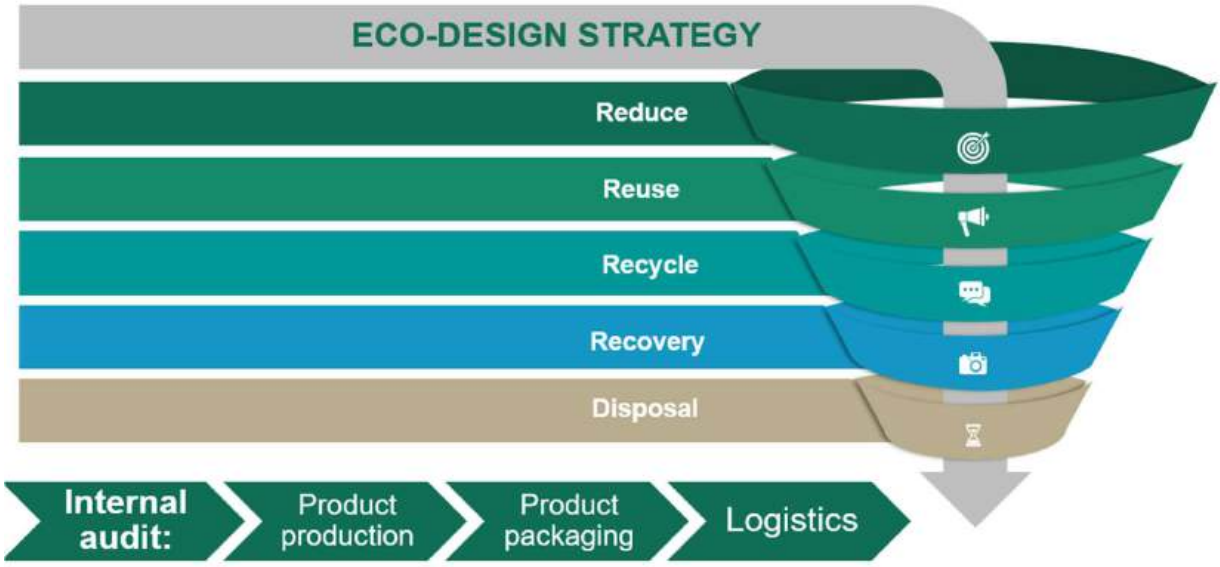


Fig. 1.12. Eco-design strategy

Plastic packaging can be recycled using mechanical, physical, chemical methods, as well as by utilizing it for energy production. Mechanical recycling includes processing steps such as collection, sorting, crushing, washing and extrusion of secondary plastic pellets. In most cases, the materials obtained after mechanical processing cannot be used in the production of food packaging. Chemical methods include depolymerization, pyrolysis and gasification, used to break down plastic waste into hydrocarbon components. The methods of energy production are the burning of plastic packaging, gasification and pyrolysis. Scientists point out that the possibility of technical recyclability of the packaging does not mean that it is possible to recycle the packaging in practical, real conditions. When choosing recyclable packaging in the production process, the entrepreneur must find out the possibilities of recycling in real conditions. There are circumstances in which it is not possible to recycle the material in question together with other, similar materials, i.e., when a situation arises in which it is necessary to accumulate the packages of the respective manufacturer in the amount of a year, so that the recycling does not cause losses (Pauer, et.al., 2020). Scientific studies show that packaging recyclers are the weakest link in the packaging cycle, as this service is provided by private companies. This type of business is not developing rapidly because the processing of individual polymers in Europe is not economically profitable. There is no support for entrepreneurs. There is a risk that plastic waste collected for recycling, regardless of its original purpose, will be sent for disposal or exported to developing countries (Bassi, et.al., 2020).

Fig. 1.13. The packaging cycle in the sense of the circular economy

Perishable products are a group of products that have a short shelf life, as well as products that require certain storage conditions to maintain their quality. Dairy and meat products belong to this group.

The production of such products requires packaging that prevents the release of moisture from the product, as well as the access of oxygen from the outside. If inappropriate conditions are chosen, as well as if they are not controlled, then as a result the products are not fit for distribution and the producer has economic losses (Düsterhöft et.al., 2017, McSweeney, 2021). The barrier properties of the packaging are also important to the manufacturer for economic reasons, as moisture losi has a direct relationship with the weight loss of the food product (Iqbal, et.al, 2021, Jafarzadeh, et.al., 2021).

To ensure the sustainability of conventional packaging, as research from other countries shows, it is preferable to use monomaterials, for example, polyethylene terephthalate (PET), polypropylene (PP), polyethylene (PE) plastic packaging, which are widely used in food packaging. The necessity of using transparent materials, as well as **reducing the amount of printing on the packaging**, is emphasized. Previous studies emphasize that the manufacturer should primarily think about the safety of the food product, i.e. ensuring hygiene requirements, microbiological safety and preserving the product's properties, rather than the recyclability of the product's packaging, because a large number of packaged products create more pollution during the production process than the packaging, so it is important to maintain the product's safety, rather than promoting its disposal (Pauer, et.al., 2020). In the context of the circular economy, it is important to look at the mutual balance between the amount of packaging and potentially spoiled food from both aspects (Figure 1.14). During the last 10 years, the total amount of used packaging in Europe and Latvia has increased by more than 20%. The data show that the volume of used plastic packaging has also increased during the relevant time period. It is concluded that if

preventive actions are not taken in the EU to reduce the amount of used waste, then the amount of this waste may increase by 19% by 2030 (EUROSTAT, 2023).

Fig.1.14. Interaction between food and packaging life cycles in the circular economy

To prevent the occurrence of food waste, as well as waste management, is a challenge not only for entrepreneurs, but also for consumers, society and the environment. For entrepreneurs, unsold food increases production, delivery and inventory costs. Accordingly, energy and resources are wasted, which is a threat to the environment and the economy. Unconsumed food that ends up in landfills has a negative impact on the environment, polluting the land and groundwater, as well as emitting greenhouse gases. Various solutions are being developed to attract the attention of consumers to purchase goods whose expiration date is approaching the end, for quick realization. It has been emphasized that it is necessary to increase consumer education on product expiration dates, encouraging the purchase of food products whose expiration date is approaching (Choi, et.al., 2022).

Over the past few years, in the markets of Latvia and other European countries, merchants have introduced the practice of reducing product prices if the products are nearing their expiration date. Accordingly, when marketers reduce the price of products, consumers' willingness to purchase a product with a short remaining shelf life increases. Such a system is a successful solution for producers, as producers and traders are provided with a higher cash flow for the product than if the product is sent for disposal. The data collected in 2020 on the amount of food waste produced indicate that 53% of the total amount of food waste was generated in households, 20% during food production, 11% during the cultivation and extraction of raw materials, 9% in the restaurant and cafe sector, and 7% in the distribution of food products and at the marketing stage (EUROSTAT, 2023b).

Research shows that significant attention should be paid to the implementation of scientific research in production. Scientists often focus on developing experimental packaging, but manufacturers need to develop solutions that will develop as an immediate result (Spreafico, Russo, 2021).

2. ANALYSIS OF THE PLASTIC PACKAGING AVAILABLE IN THE LATVIAN MARKET

2.1. Overview of the packaging available in Latvian retail outlets

In total, the study examined and evaluated 3295 different packaging units (detailed list of products in the excel annexes) from different product groups. The results do not reflect the total amount of packaging, but the diversity. Including packaged products available in retail outlets. This study analyses polymer packaging, as in the case of packaging that combines polymers with another packaging material. The interpretation of the data is seen initially in the overall view, in the illustration of the multiplicity of packaging shapes, and in the context of labels and printing. The analysis of the diversity of packaging formats also allows conclusions to be drawn on the potential packaging equipment and packaging technologies to be used. Looking at the overall situation, the following product/good groups are presented in more detail below:

- packages of meat products (semi-finished products) and sausages;
- packages of chilled fresh meat and eggs;
- packages of frozen foodstuffs;
- bread and flour packages;
- packages for beverages;
- packages of dairy products;
- packages of dry bulk products;
- packages of spices;
- packages of sweets and snacks;
- packages of sweets, chocolates and biscuits;
- animal feed packages;
- packages of children's products;
- packages for hygiene and cosmetic products;
- packages for household chemicals;
- packages for garden products.

The overall results are shown in Figure 2.1. The packaging material designations (numeric codes or corresponding abbreviations) shown on the packaging are broken down as follows: 25.31% – 5(PP); 12.59% – 7(OTHER); 11.65% – 1(PET); 7.25% – 4(LDPE); 6.28% – 2(HDPE); 4.04% – 84(C/PAP); 3.10% – 21(PAP); 2.25% – 81(C/PAP); 1.70% – 6(PS); 1.40% – 90(C/LDPE); 2.28% specified other material (22(PAP); 41(ALU); 3 (PVC); 90 (C/PP); 40 (FE); 80 (Paper); 93(C/LDPE); 20(PAP); 70 (GL); 95(glass/plastic)); 21.88% – the designation is not indicated (see Figure 2.1). As can be seen, polypropylene (PP) packaging accounts for the largest group at 25.31%, or one quarter of packaging. However, it should be noted that there are different types of PP packaging in the PP group. The second largest group is packaging with no indication of the type of packaging, i.e. 21.88%. A relatively large group, 12.59%, are packaging materials with the numeric code 7, which means that they are mostly shredded for recycling because they consist of several layers. This is followed by PET packaging, which accounts for 11.65% – as observed, mainly bottle packaging, which is relatively well recyclable in the Latvian situation. Polyethylene follows with 13.53% (consisting of 7.25% LDPE and 6.28% HDPE).

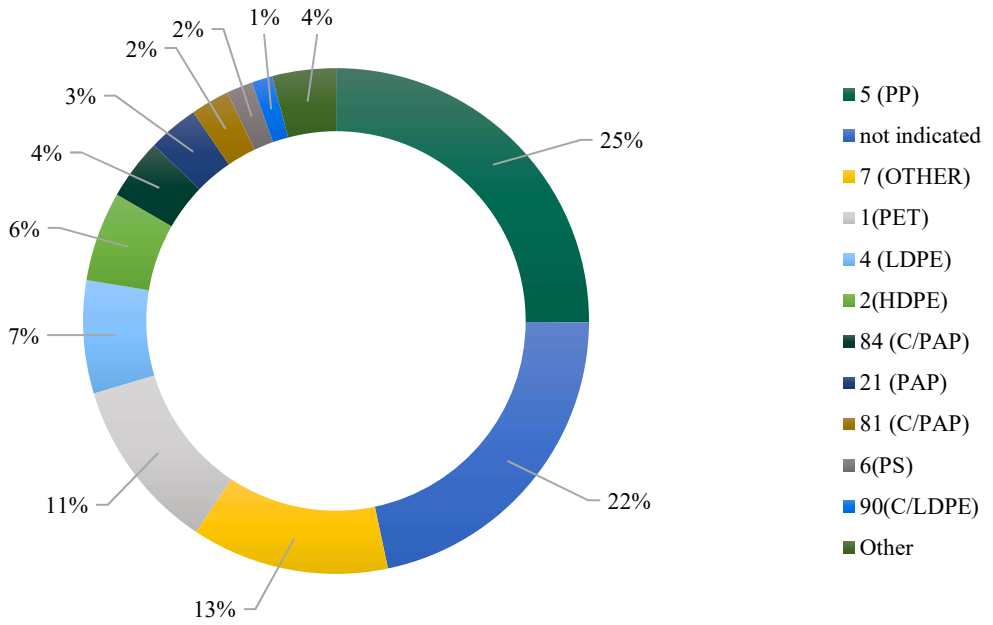
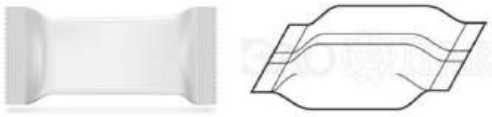


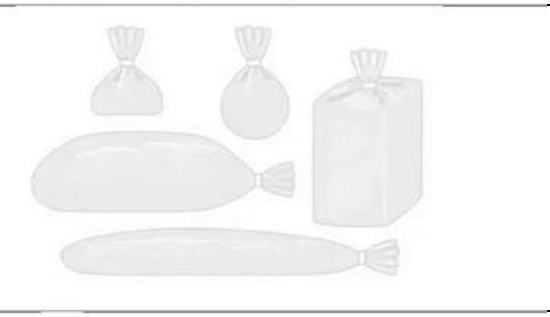
Fig. 2.1. Indication on the packaging of the decoding of the packaging material

The shape of the packaging also plays an important role in the analysis of packaging reduction and recycling opportunities, as the extent to which the packaging can be completely free of product residues is an important factor in the recyclability of packaging. As we know, packaging that could be recyclable, if not sufficiently disposed of, can become unrecyclable or make recycling more difficult. The process of preparing the packaging form is also often directly linked to the final stage of product production and the packaging waste generated during packaging, as well as the choice of packaging equipment in product manufacturing companies. Table 2.1. shows the packaging shapes analysed in the study.

Table 2.1.

Illustration of packaging shapes for further study (illustrative)

Type of packing	Forms of packaging (illustrative)
Rigid container	
Flowpack	
Glass	

Cardboard box and thermoform	
Box	
Laminated cardboard package (tetrapack)	
Bag/film	
Bottle	

Shrink film	
Pillow pack	
Doypack	
Thermoformed packaging	
Dish (container)	
Container with lid	

Thermoformed packaging with carton sheet	
Tube	
Cone	
Wrap	
Bucket	
Cylinder	

bag (shopping bag)	

Assessing product packaging shapes, 28.01% were in flowpack; 19.06% in bottle; 8.86% in pillow pack; 6.49% in thermoformed pack; 6.16% in container, 5.49% in laminated carton; 5.22% in stand-up or doypack; 4.55% in bag/film; 4.25% in cup; 2.43% in shrink film; 2.31% in rigid container; 1.52% in carton and thermoform; 1.52% in a container with a lid; 2.25% in a box and 1.88% in other packaging (tube, cone, wrap, bucket, bag, cylinder) (see Figure 2.2).

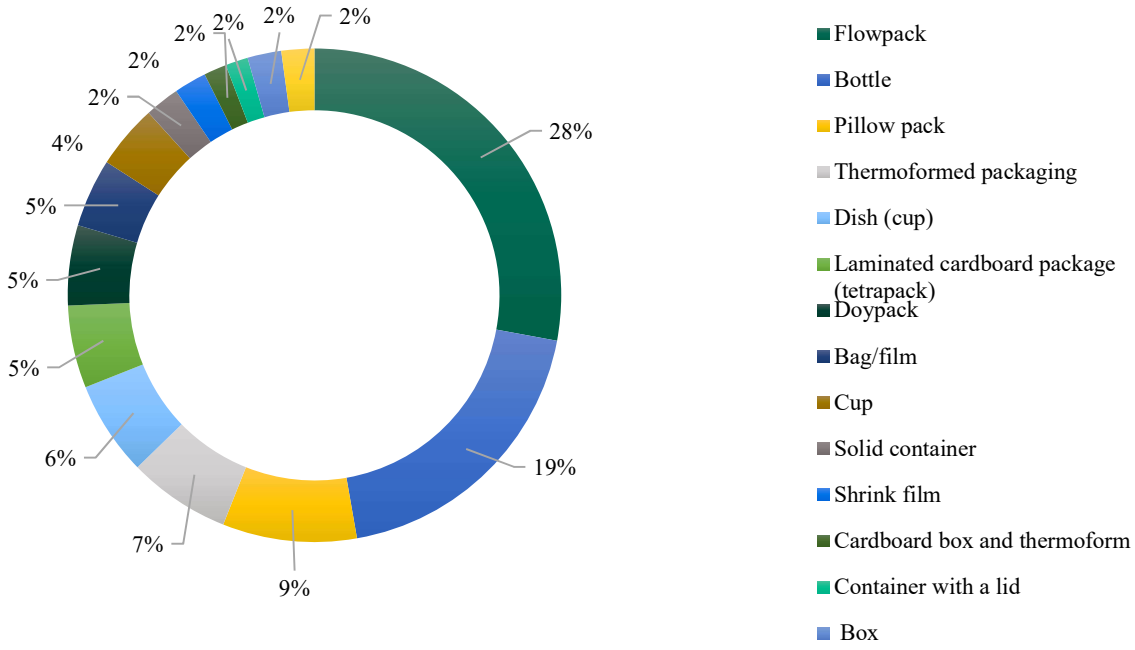


Fig. 2.2. Representation of packaging forms

As is well known, information about a product is important when purchasing it, both from the point of view of the regulatory requirements (Cabinet Regulation No 115) and from the point of view of the consumer. However, the choice of which type of label is used to provide the information is at the discretion of the product manufacturer. It is therefore important to find out what the situation is in Latvia and what opportunities there are for optimisation, as the recyclability of packaging is often facilitated or hindered by the label material, the type and quantity of print, varnish and inks on the packaging.

Summarising the label information on the packaging (see Fig. 2.3), it was found that for the majority of packages – 54.36% of the required information is printed on the packaging (D), so it is important to assess the amount of printing. On the 19.45% of the information was printed on

the polymer label without a label material designation (PLB), which is one-fifth, but due to the lack of a designation it is not possible to tell what type of polymer it is and its recyclability. 7.31% of cases have printing on the packaging and on the polymer label without indication of the label material (D_PLB); 7.65% printing on packaging and on paper label without indication (D_PB); 5.61% printing on paper without indication (PB); 2.25% printing on paper with indication (PA); 2.15% on paper without indication and on polymer without indication (PB_PLB), while the remaining 1.21% of samples had another option (other).

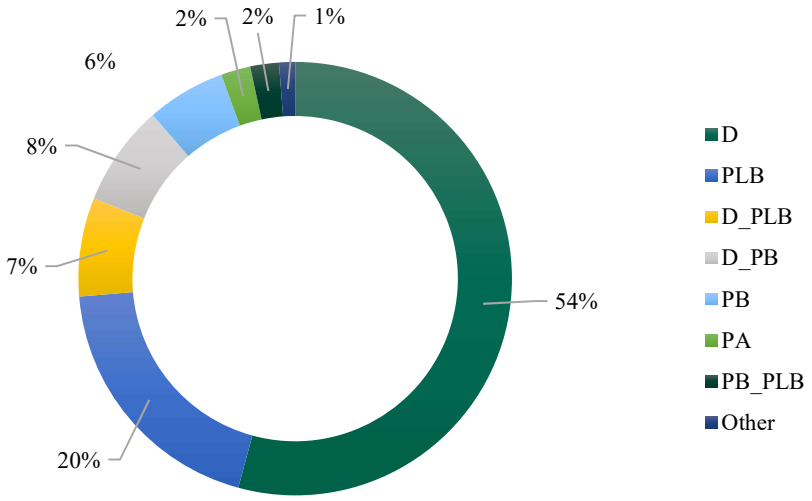


Fig. 2.3. The label, its type and indication of the material of the label, where:

- D – information printed on the packaging;
- PLB – polymer label without an indication of the label material;
- D_PLB – printing on the packaging and on the polymer label without an indication of the label material;
- D_PB – printing on the packaging and on the paper label without indication;
- PB – paper label without printed indication of label material;
- PA – a paper label with an indication of the label material printed on it;
- PB_PLB – paper label without printed label material and polymer label without label material;
- other option.

An analysis of the amount of printed area on the packs shows that 43.95% of the samples are fully printed on the main packaging (the packaging containing the product); 29.77% – no print, 16.57% – partly print; 8.53% – lots of print and 1.18% – other (see Fig. 2.4). This shows that it is possible to reduce the amount of colour area printing in more than 50% of the packages and thus increase the recyclability of some of the packages.

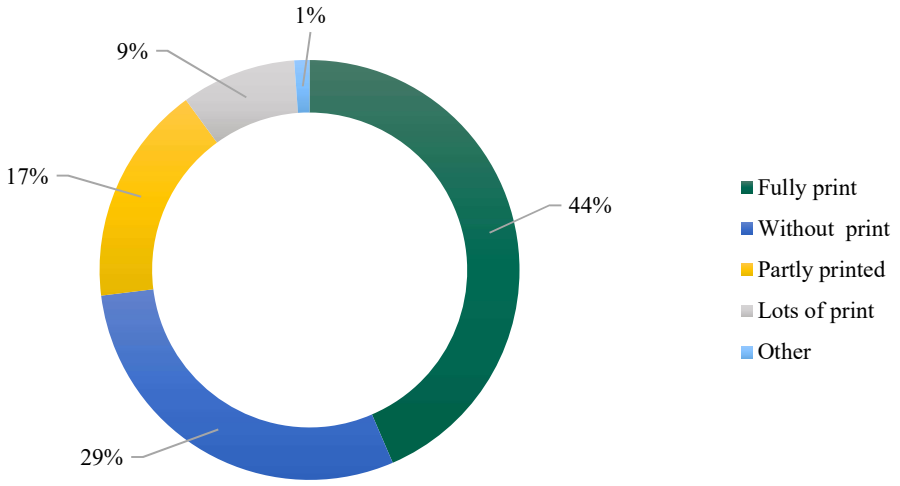


Fig. 2.4. Print volume of packaging

The key to the study is to find out how many packs are too big, and whether the use of one pack in a second pack does not affect product quality retention, as summarised in Table 2.2. As can be seen, about 11% of the packages are too large and 11% of the products/goods are double packed, where the quality of the products would not be compromised during storage if double packing was avoided.

Table. 2.2.

Conformity of pack size (%)

Food groups	The packaging is of an appropriate size	Packaging is too large
Meat products and sausages	72.73	27.27
Fresh (chilled) meat and eggs	89.06	10.94
Frozen foodstuffs	97.36	2.64
Bread and flour (farinaceous) products	48.10	51.90
Beverages	100.00	0.00
Milk and dairy products	100.00	0.00
Milk and fermented (drinkable) milk products	97.06	2.94
Yogurts	99.41	0.59
Cheese	84.48	15.52
Cream cheese, cottage cheese, sweet curd cheese, fresh cheese, cheese snacks, cream	95.43	4.57
Dry products	100.00	0.00
Spices	100.00	0.00
Sweets and snacks	73.21	26.79
Candies and biscuits	66.79	33.21
Feed for animals	91.67	8.33
Products for children's	66.34	33.66
Hygiene products and cosmetics	98.95	1.05

Household chemical products	84.12	15.88
Household products	70.00	30.00
Products for garden	88.00	12.00
FOR ALL STUDIED PRODUCT GROUPS TOGETHER	**88.76**	**11.24**

Table. 2.3.

Double packaging not affecting shelf-life (%)

Food groups	Yes	No
Meat products and sausages	100.00	0.00
Fresh (chilled) meat and eggs	15.63	84.38
Frozen foodstuffs	92.95	7.05
Bread and flour (farinaceous) products	98.73	1.27
Beverages	100.00	0.00
Milk and dairy products	86.49	13.51
Milk and fermented (drinkable) milk products	85.29	14.71
Yogurts	38.24	61.76
Cheese	83.62	16.38
Cream cheese, cottage cheese, sweet curd cheese, fresh cheese, cheese snacks, cream	58.86	41.14
Dry products	97.70	2.30
Spices	100.00	0.00
Sweets and snacks	100.00	0.00
Candies and biscuits	83.40	16.60
Feed for animals	100.00	0.00
Products for children's	100.00	0.00
Hygiene products and cosmetics	93.70	6.30
Household chemical products	98.24	1.76
Household products	100.00	0.00
Products for garden	98.00	2.00
FOR ALL STUDIED PRODUCT GROUPS TOGETHER	**88.97**	**11.03**

2.2. Packaging of meat products (semi-finished products) and sausages

In the category of packaged meat products and sausages, 143 different packaging units were analysed. This group covers various sausages (cooked, smoked, cured), various semi-finished products, culinary products, spindles, etc. The analysed packaged products available at retail outlets, both cut and uncut, are packaged in different packaging forms and in different packaging environments. The data are presented in Figures 2.5 to 2.8.

Summarising the designations (numerical codes and/or corresponding abbreviations) (see Figure 2.5) on the packaging material, 66.43% of the samples did not have the designation of the

material used on the packaging. The rest of the packaging is also labelled with the matereials used, as follows: 30.8% – 7(OTHER); 1.4% – 1(PET); 0.7% – 5(PP) and 0.7% – 93(C/LDPE).

A detailed investigation shows that the packages for which no packaging material is indicated are predominantly packaged in modified gas environments (vacuum (VP) or protective modified atmosphere packaging (MAP) or SKIN packaging), suggesting that the packaging materials used are multilayer materials with barrier properties. Consequently, more than 97% of packaging in this product group is multilayer packaging, and it is therefore a product group for which packaging materials are, to date, largely non-recyclable.

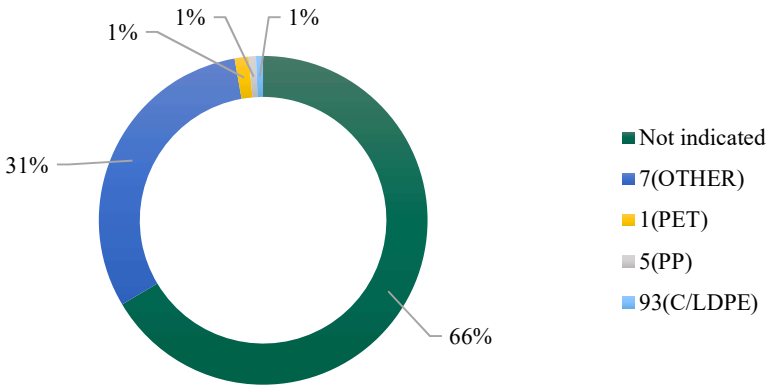


Fig. 2.5. Indication on the packaging of the decoding of the packaging material

When analyzing the packaging formats of meat products and sausages, it was found that thermoformed products are the most widely available on the market - 44.76% (see Fig 2.6). Flowpack packaging – 34.97%. Shrink film was used – 11.89%, including 11.76% in combination with a paper/cardboard sheet or box, and a polymer container was used - 4.90% of which 71.43% with a lid. Other packaging types: stand-up pouch (doypack) – 2.80% and pillow pack 0.70%.

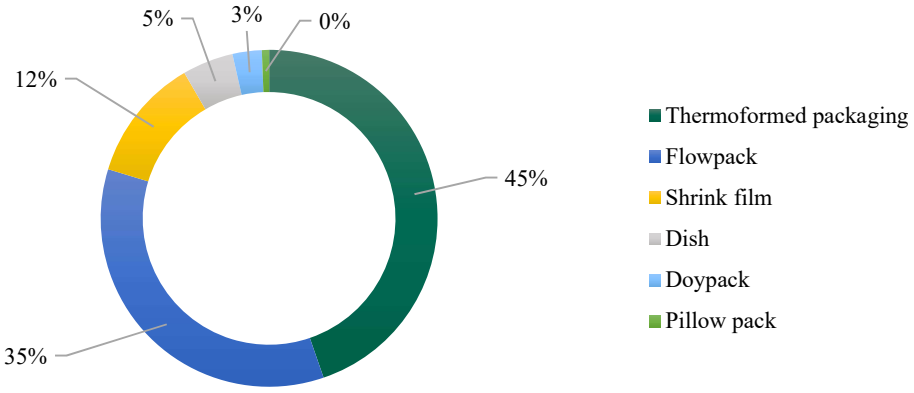


Fig. 2.6. Representation of packaging shapes

Summarising the information on the type of label material on the packaging, 56.64% of information was printed on a polymer label with no indication of the label material (PLB). 20.98%

of cases printed packaging and printing on a polymer label with no indication of the label material (D_PLB), and a paper label with no indication (PB) – 3.50%. On the other hand, 1.39% of the packages were printed with an unmarked paper label and an unmarked polymer label (D_PB_PLB). Printed packaging only (D) accounted for 14.69%, printed packaging with paper label without indication (D_PB) 2.10% and 0.70% were printed on paper label without indication and polymer label without indication (PB_PLB) (see Figure 2.7). As can be seen the three largest groups account for more than 90%.

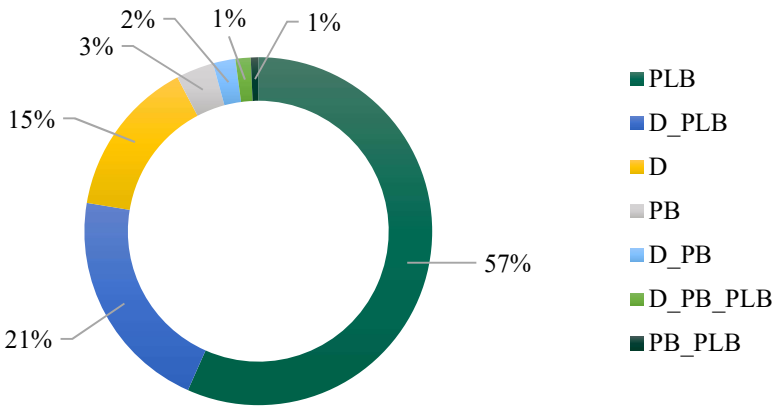


Fig. 2.7. The label, its type and an indication of the label material, where:

- D – information printed on the packaging;
- PLB – polymer label without an indication of the label material;
- D_PLB – printing on the packaging and on the polymer label without an indication of the label material;
- D_PB – printing on the packaging and on the paper label without indication;
- PB – paper label without printed indication of label material;
- PB_PLB – paper label without printed label material and polymer label without label material
- D_PB_PLB – printed on the packaging and on the paper label without an indication and on the polymer label without an indication of the material.

When analyzing the printing of packaging for this product group, 37.06% of the packaging is partially printed, 36.36% without printing, 19.58% with a lot of printing and 6.99% – fully printed (see Fig. 2.8). In this group, too, it is possible to reduce the amount of printing on packaging, as more than 25%, which is one quarter of the packaging types, can be reduced.

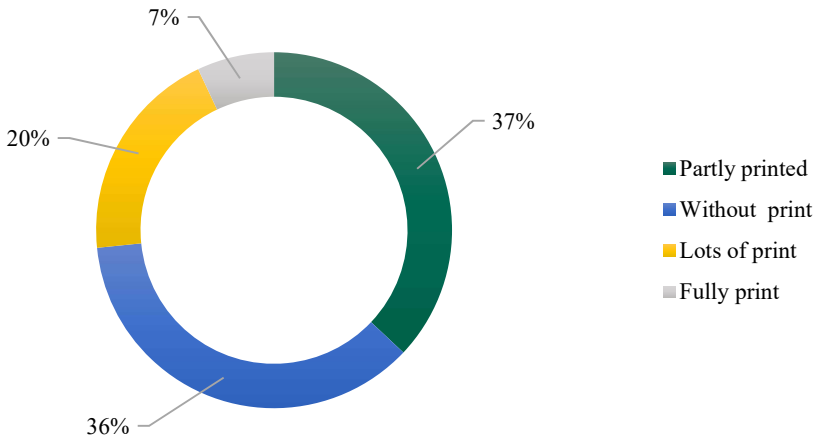


Fig. 2.8. Print volume of packaging

The analysis of the samples in this group showed that 72.73% of all samples had an adequate pack size, while the remaining 27.27% were too large. Also, none of the samples had double packaging, which does not affect the shelf life.

2.3. Packaging of chilled fresh meat and eggs

This category analyses 64 packaging units covering products such as fresh meat packaged in different ways, meat marinated in different marinades, prepared for roasting and/or grilling, packaged in different packaging technologies. The group also reflects the situation in the packaging of eggs. The data are presented in Figures 2.9 to 2.12.

A summary of the designations (numerical codes and/or corresponding abbreviations) (see Fig. 2.9) on the packaging material shows that 50.00% of the products do not indicate on the packaging what material the packaging is made of. However, given that meat products are perishable, it is evident that the products are packed in an altered gas environment (i.e. vacuum (VP) and modified atmosphere packaging (MAP)), suggesting that they are multilayer packages with barrier properties and therefore quite difficult to recycle or non-recyclable. It should also be noted that often after the products have been removed from their packaging, leftover marinades remain in the packaging. 21.88% of the packages indicate 1(PET), of which 14.29% indicate 1(PET) and 7(OTHER); 14.29% indicated 1(PET) and 7(OTHER) and 21(PAP). A relatively large group of products are packaged in polypropylene – 8.75% of the packaging is labelled 5(PP) and 6.25% 7(OTHER) of these 25.00% are labelled 7(OTHER) and 21(PAP) and 50.00% 7(OTHER); 23(PAP). Of the remaining samples, 3.13% were labelled 2(HDPE) and 21(PAP).

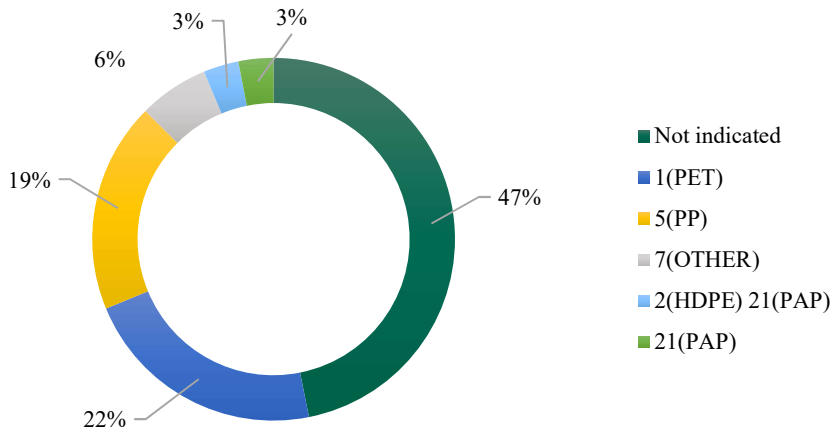


Fig. 2.9. Indication on the packaging of the decoding of the packaging material

The analysis of the types of packaging material found that more than half of the samples were packed in a container - 56.25%, of which 8.33% in a container with a cardboard sleeve (see Fig.2.10). 15.63% were packed in thermoformed packaging, of which 20% were packed in thermoformed packaging and cartons. 14.06% of the samples were packed in shrink film, of which 55.56% in shrink film and carton and 11.11% in shrink film and metal clamp. The remaining samples were packaged in 4.69% stand-up packs (doypack), 3.13% flowpack, 3.13% pillow packs and 3.13% cardboard sleeves with shrink film.

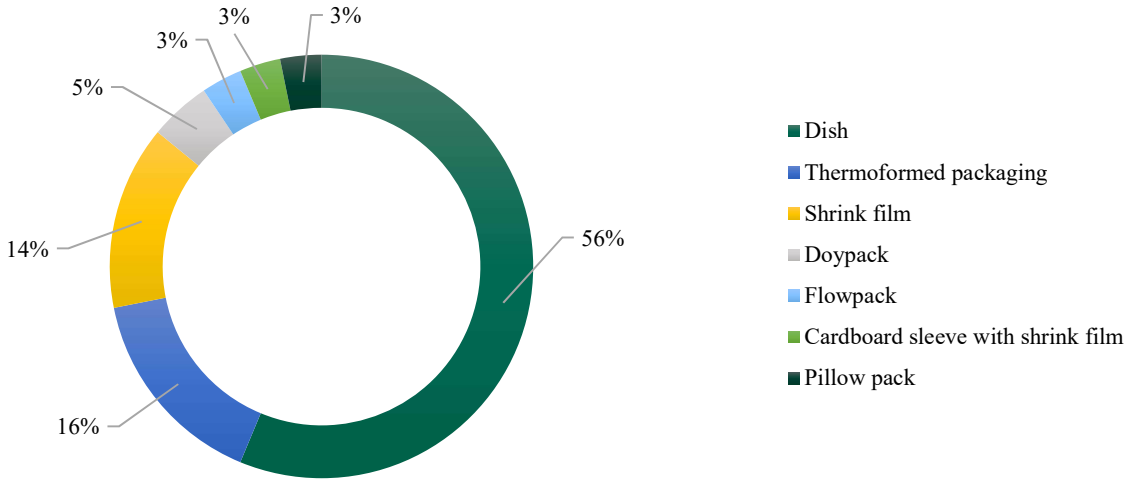


Fig. 2.10. Representation of packaging shapes

The analysis of the information on the label material on the packaging showed that the majority of the samples, 46.88%, had a paper label with no indication of the label material (PB). It should be noted here, however, that attention should also be paid to the amount of printing and post-processing of the printing, which can significantly impair the recyclability of the labels, as the proportion is relatively high (see Fig. 2.11). Of the remaining samples, 17.19% were printed on the packaging and on paper without indication (D_PB), 14.06% were printed on the packaging (D), 9.38% were printed on the polymer label without indication (PLB), 6.25% were printed on

the packaging and on the polymer label without indication (D_PLB) and 6.25% were printed on the polymer label with indication.

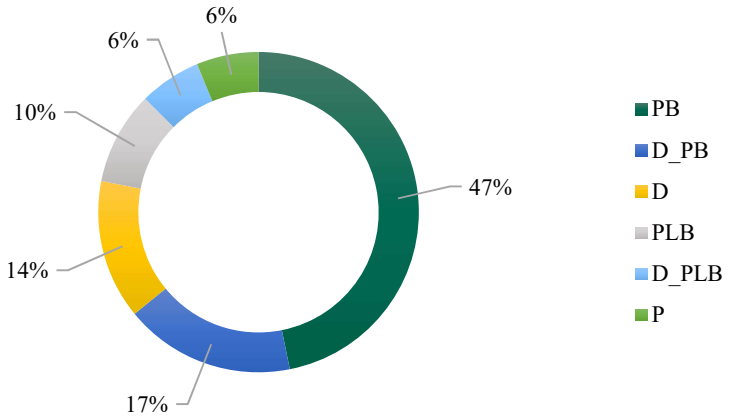


Fig. 2.11. The label, its type and an indication of the label material, where:

- D – information printed on the packaging;
- PLB – polymer label without an indication of the label material;
- D_PLB – printing on the packaging and on the polymer label without an indication of the label material;
- D_PB – printing on the packaging and on the paper label without indication;
- PB – paper label without printed indication of label material;
- P - Polymer label with indication of label material.

When analyzing the printing of the base material for this group, it was found that the majority, 71.88% of the packaging was unprinted (see Fig. 2.12). On the other hand, 18.75% were partially printed, 4.69% had a lot of printing and 4.69% were fully printed.

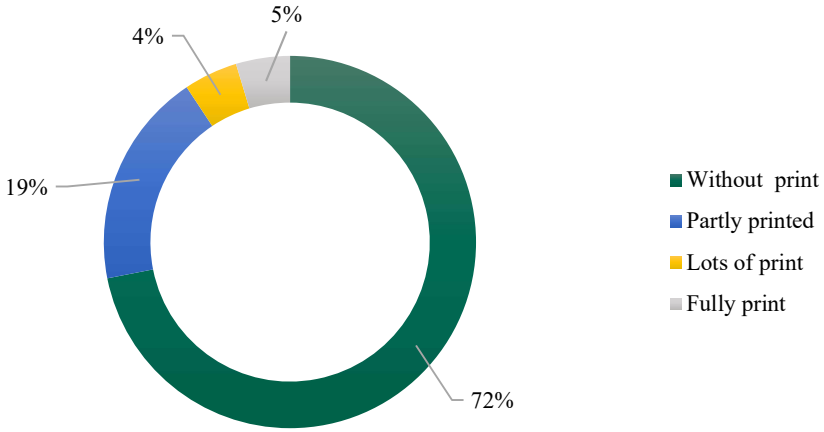


Fig. 2.12. Print volume of packaging

The analysis of the samples in this group showed that 89.06% of all samples had an adequate pack size, while the remaining 10.94% were too large. Also 84.38% of the samples were double packed, which does not affect the shelf life.

2.4. Packaging of frozen food

In this category, 227 packaging units are analysed, which include frozen products: dumplings, dough, pizza, vegetables and berries, potato wedges and fries, fish, fish products, seafood and ice cream. The obtained data can be seen in 2.13. until 2.16. figures.

Out of all the samples, 36.56% of the used packaging material is not indicated on the packaging (see Fig. 2.13). On the other hand, 22.47% of packages will be indicated by 5(PP), of which 2% is indicated by PAP PET. 19.82% of packages are indicated by 7(OTHERS) of them: 2.2% will indicate LDPE and OTHER, 4.4% are indicated, but the cardboard in the package is not mentioned, but only OTHER is indicated. Of all frozen food samples, 10.57% were packed in 4(LPDE) packaging. The fifth largest group in terms of used packaging for frozen products is 81(C/PAP), which accounts for 7.93% of packaging, of which 5.6% is indicated as being together with 90(C/LDPE). The other samples or 2.64% are packed in 84(C/PAP) packaging.

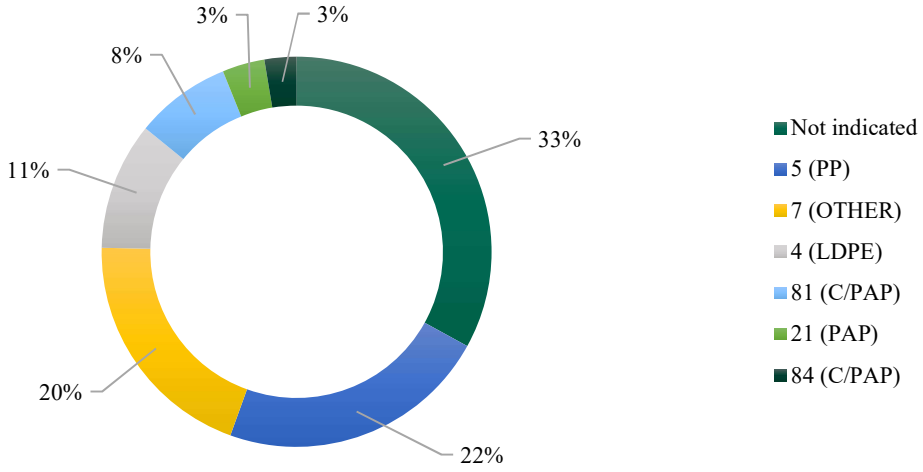


Fig. 2.13. Indication on the packaging of the decoding of the packaging material

Analyzing the shapes of product packaging materials (see Fig. 2.14). it was concluded that 54.6% of the samples were packed in flowpack, of which 1.6% were packed in a flowpack and then placed in a cardboard box and 0.8% in a flowpack with a clamp. 12.3% were packed in a pillow-shaped package, of which 10.7% were with a paper strip. On the other hand, 10.6% of all samples were packed in shrink film, of which 66.67% were packed in shrink film and a cardboard box. 9.7% of samples are packed in a container, of which 13.6% are in a container with a lid; 9.0% in container with lid and paper sleeve; 9.0% in a container with a lid and covered with shrink wrap; 4.5% in a container and with a lid; 4.5% (1pc) in container and box. On the other hand, 5.7% of the samples are packed in a box, of which: 23.0% in a box covered with shrink wrap; 7.7% in a box and container with a lid. The aged samples were respectively packed in a cardboard box - 3.52%, in a cone - 1.8%, wrapped in food film - 1.3% and placed in a bag-like package - 0.4%.

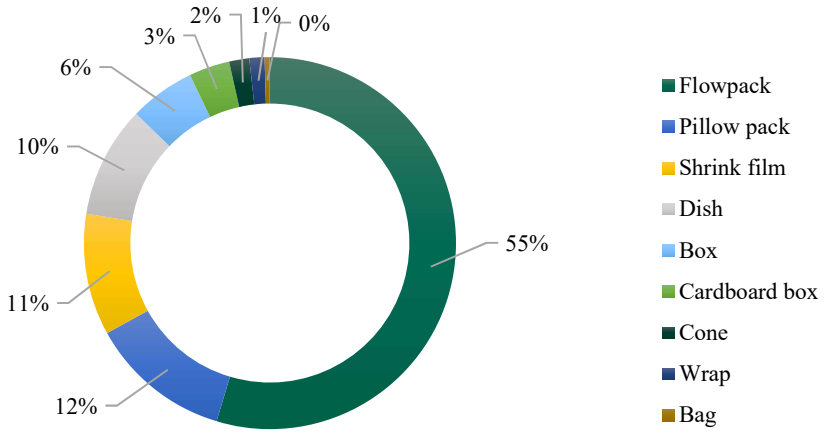


Fig. 2.14. Reflection of packaging shapes

Summarizing the information on the label on the package (see Fig. 2.15), it was concluded that the label was printed on the package itself (D) for the majority of samples, or 79%, which could largely be explained by the specifics of frozen products. 7.93% printed package and no polymer label indication (D_PLB), 7.93% polymer label without label material indication (PLB) and 4.84% printed package and paper label without material indication (D_PB).

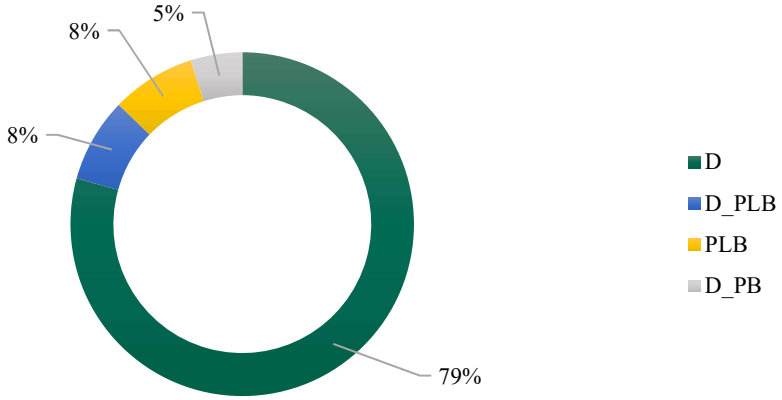


Fig. 2.15. The label, its type and an indication of the label material, where:

- D – information printed on the packaging;
- PLB – polymer label without an indication of the label material;
- D_PLB – printing on the packaging and on the polymer label without an indication of the label material;
- D_PB – printing on the packaging and on the paper label without indication.

of the packaging (see Fig. 2.16), it was concluded that 43.17% of the packaging is fully printed, 18.06% of the packaging is partially printed, 14.10% of the packaging has a lot of printing and 7.49% of the packaging is without printing. In this group, 17.18% of the samples had other variants - 69.23% of them have a printed laminate box with a product inside without other packaging; 25.65% the box is printed, but inside the box there is still polymer packaging without printing;

2.56% of the carton is printed in full, but the inner primary packaging is not printed and 2.56% of the box is printed, but the inner packaging of the product is partially printed.

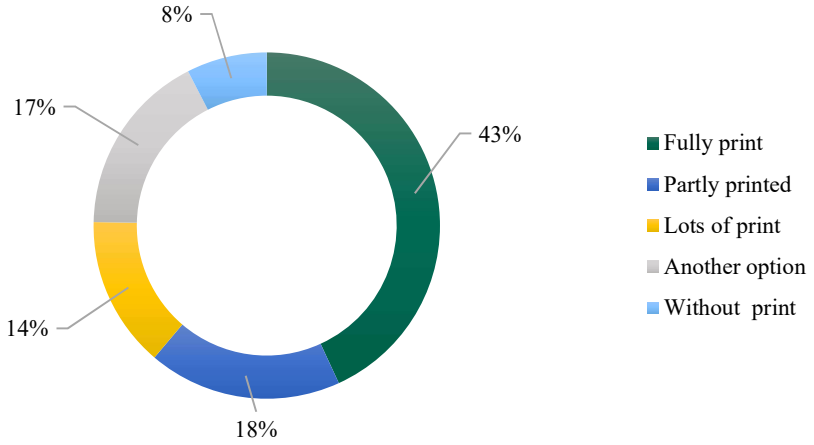


Fig. 2.16. Print volume of packaging

Analyzing the samples of this group, it was concluded that in 97.36% of all samples, the packages were of the appropriate size, but for the remaining 2.64%, it was too large. It was also concluded that 7.05% of the samples had double packaging, which does not affect the expiration date.

2.5. Packaging of bread and flour products

In this category, 158 packaging units were analysed, which cover different types of bread, lavash and cupcake packages. The obtained data can be seen in 2.17. until 2.20 Figure. Summarizing the markings indicated on the package (see Fig. 2.17) regarding the packaging material, it was concluded that 44.30% indicated 4(LDPE), 31.65% indicated 5(PP) and 5.70% indicated 7(OTHER). Out of all the samples of this group, 17.72% did not indicate what material was used for packaging, but 0.63% of the samples stated that the material is biodegradable. There are three main groups of polymer packaging materials for this product group: LDPE, PP and a third one, which is not specified - most likely materials with barrier properties.

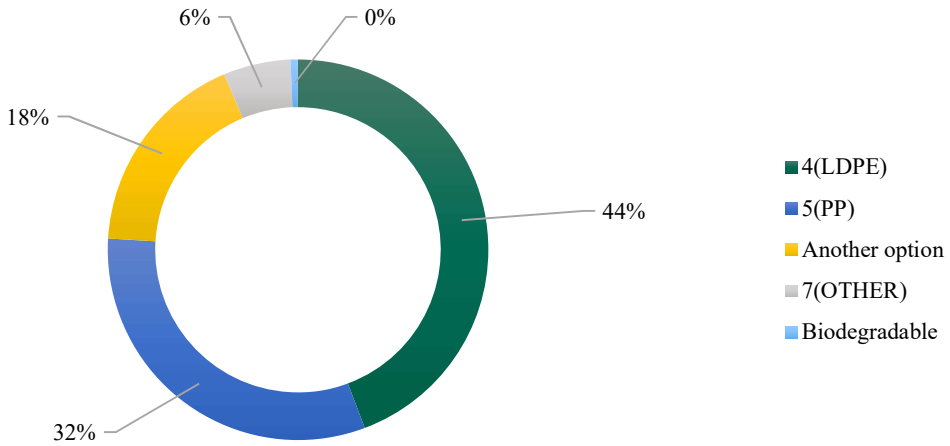


Fig. 2.17. Indication on the packaging of the decoding of the packaging material

When evaluating the packaging of this group, it was found that the majority, or 85.44%, are packed in a bag (see Fig. 2.18). And the rest 10.13% in flowpack packaging, 3.80% in shrink film and 0.63% in cushion packaging.

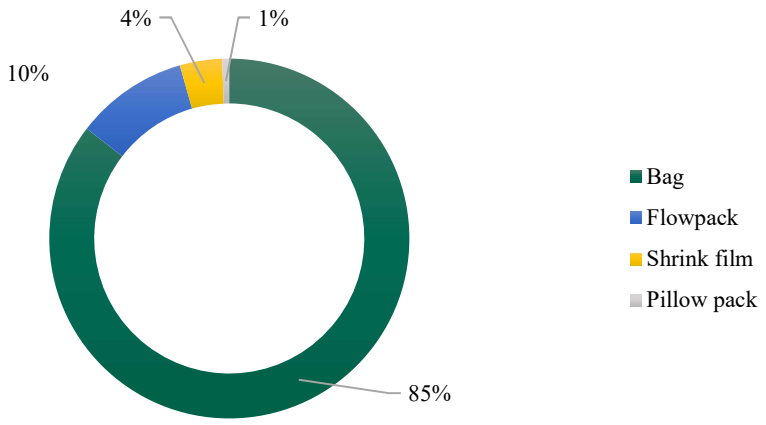


Fig. 2.18. Reflection of packaging shapes

Summarizing the information on the label on the package, it was concluded that 87.97% is printed on the package (D). On the other hand, 10.13% have a paper label without label material indication (PB), and 1.90% have a paper label with material indication (PA) on the label (see Fig. 2.19).

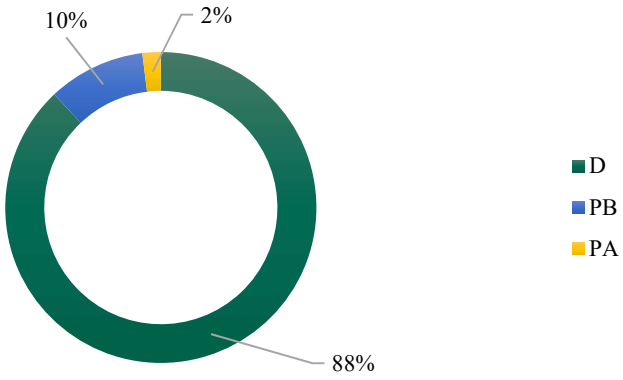


Fig. 2.19. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- PB – paper label without printed label material indication;
- PA – a paper label with a printed indication of the label material.

Analyzing the package printing for this group of products, 75.32% of the packaging was fully printed, 16.46% partially printed and 8.23% without printing (see Fig. 2.20).

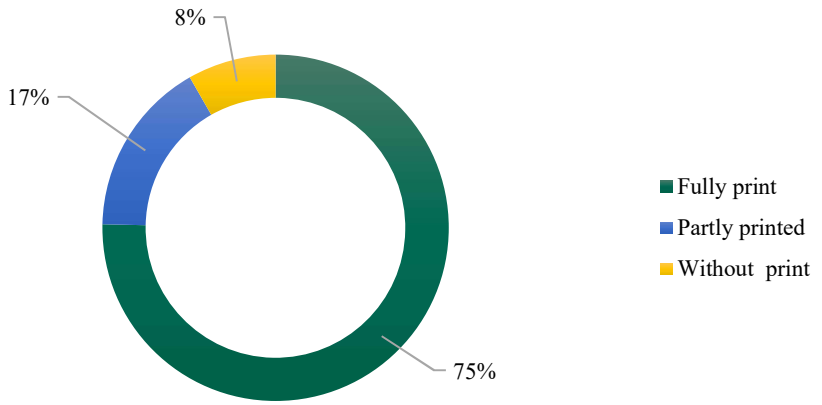


Fig. 2.20. Print volume of packaging

Analyzing the samples of this group, it was concluded that the packaging was too big for most of the samples, i.e. 51.90%, while for the remaining 48.10% it was adequate. It was also concluded that 1.27% of the samples had double packaging, which does not affect the expiration date.

2.6. Packaging of beverages

In this category, 296 packaging units are analysed, which include packaging for non-alcoholic carbonated and non-carbonated drinks, mineral waters, energy drinks, kvass, juices, nectars. The obtained data can be seen in 2.21. until 2.24. Figures.

Summarizing the labels indicated on the packaging (see Fig. 2.21) regarding the packaging material, it was concluded that 40.88% of the products on the packaging indicated 1(PET), 33.45% indicated 84(C/PAP), 0.68% indicated 90(C/LDPE) and 0.68% biodegradable. On the other hand, on 24.32% of the packages there is no indication of the type of packaging material.

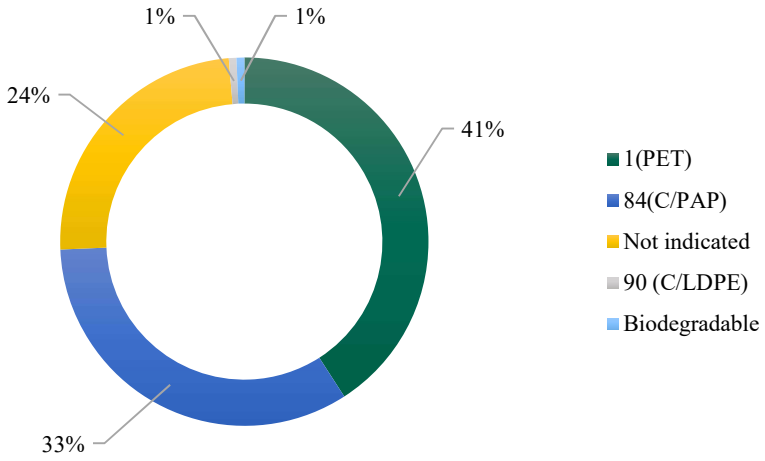


Fig. 2.21. Indication on the packaging of the decoding of the packaging material

Analyzing the shape of the packaging material of the samples, it was concluded that more than half were packed in a bottle - 55.41%, while 42.9% were packed in a laminated cardboard package, and the remaining 1.69% in a stand-up package or doypack (see Fig. 2.22).

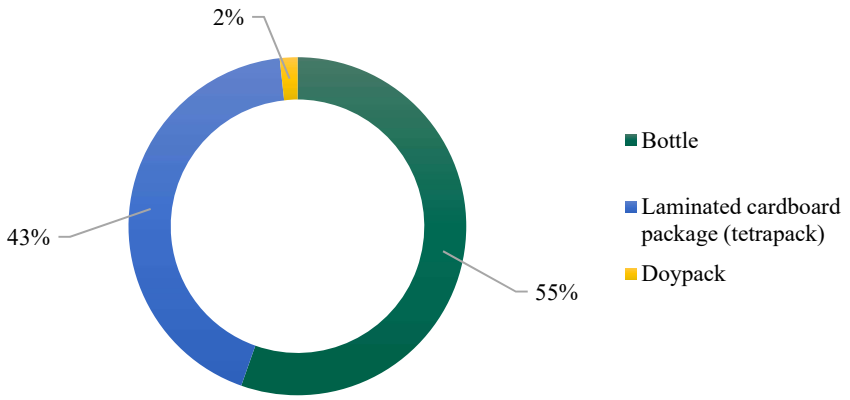


Fig. 2.22. A reflection of packaging shapes

Summarizing the information on the label on the package (see Fig. 2.23), it was concluded that the label of 46.96% of the samples is printed on the polymer label without indication (PLB), 44.58% of the samples are printed on the package (D). For remaining samples, 3.72% printed on paper label without indication (PB), 3.04% on paper label without indication and polymer label without indication (PB_PLB), 1.01% on polymer label with printed indication of label material (P) and 0.68% print on package and on a paper label with no indication.

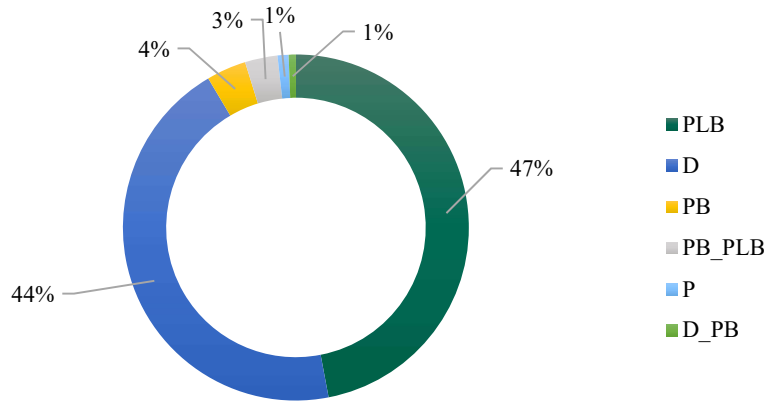


Fig. 2.23. The label, its type and an indication of the label material, where:

- PLB – polymer label without label material indication;
- D – information printed on the package;
- PB – paper label without printed label material indication;
- PB_PLB - paper label without printed label material indication and polymer label without label material indication;
- P – polymer label with a printed indication of the label material;
- D_PB - printing on the package and on the paper label without indication.

Analyzing the printing of the basic material of this group on the packaging (see Fig. 2.24), it was concluded that 53.04% of the packaging is without printing (which is usually bottles), while 46.96% of the packaging is fully printed, which is laminated cardboard packages and stand-up packages.

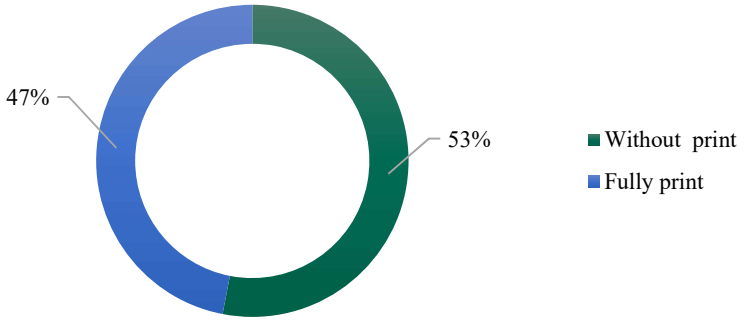


Fig. 2.24. Print volume of packaging

Analyzing the samples of this group, it was concluded that all the packaging samples have the appropriate size and none had double packaging, which does not affect the expiration date.

2.7. Packaging of milk and milk products

In this category, 569 packaging units have been analyzed, covering packages of milk, yogurt, cheese, cream cheese and other dairy products. The obtained data can be seen in 2.25. until 2.44 Figures. Looking at the markings indicated on the packaging of dairy products regarding the packaging material (see Fig. 2.25), it was concluded that, in total, 39.37% of the products on the packaging of dairy products have 5(PP) on the packaging, of which 3.6% have the indication 5(PP) and 2 (HDPE), 0.4% with indication 5(PP) and 7(OTHER) and 1.8% with indication 5(PP) and 84(C/PAP).

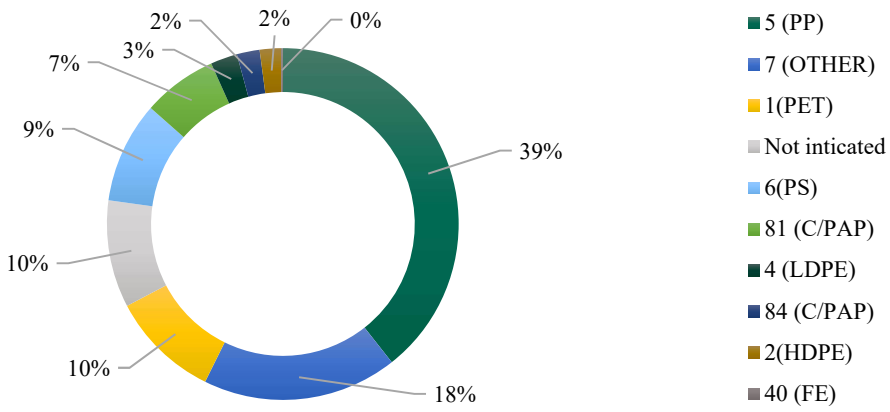


Fig. 2.25. Indication on the packaging of the decoding of the packaging material

Of all the products of the common group of dairy products, 17.93% were marked with 7(OTHER) and 10.2% -1(PET), of which 5.3% were marked with 1(PET) and 2(HDPE) and 3(PVC), as well as 1.8% with indicate 1(PET) and 5(PP). Of the remaining samples, 6(PS), 6.85% - 81(C/PAP), 2.46% - 4(LDPE), 2.11% - 84(C/PAP), 1.93% - 2(HDPE) were indicated in 9.31%. On the other hand, in 10.02%, the packaging does not indicate what material the packaging is made of.

Analyzing the shapes of the packaging materials of the samples (see Fig. 2.26), it was concluded that 23.02% were packed in a glass; 17.75% - in thermoformed packaging; 15.47% - in flowpack packaging; 13.53% - in container (hard container): 10.54% - in bottle; 9.94% - in a laminated package; 4.75% - doycpak; 3.51% - in shrink film; 1.58% - in a pillow-shaped package; 0.35% - in a box.

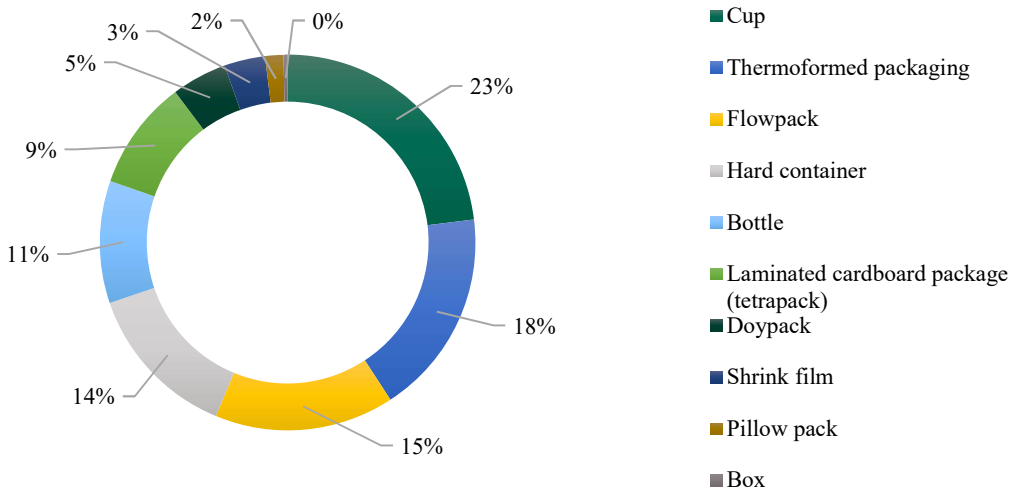


Fig. 2.26. Representation of packaging shapes

Analyzing the information on the package, it was concluded about the label (see Fig. 2.27) that the label is printed on the package (D) in the majority of samples, i.e. 54.48%. On the other hand, in 12.83% of packages it is on paper without label material indication (PB); 11.95% - the label is paper with an indication of the label material (PA); 8.44% - on polymer label without indication (PLB); 6.15% printed on packaging and on paper without indication (D_PB); 2.46% printing on a polymer label with the indication (P); 1.76% printed label on paper with label material indication and polymer label without label material indication (PA_PLB); 1.23% paper label without indication and polymer label without indication (PB_PLB); 0.18% printed on the package and on paper with label material indication (D_PA); 0.18% printed on packaging and paper without indication and on polymer without label material indication (D_PB_PLB); 0.36% paper label with indication and paper label without indication (PA_PB).

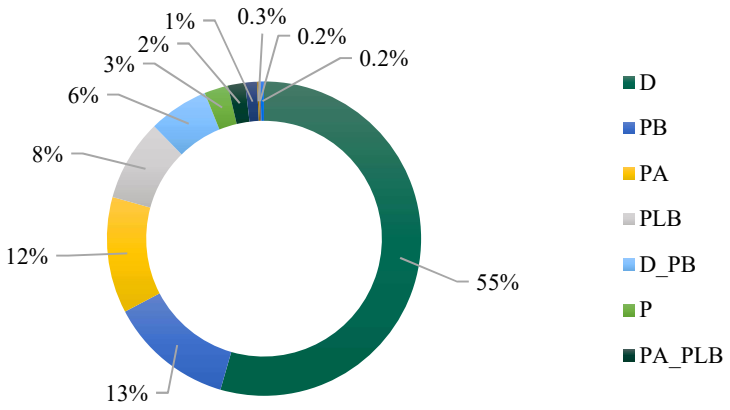


Fig. 2.27. The label, its type and indication of the material of the label, where:

• D – information printed on the package;
• PB – paper label without printed label material indication;
• PA – paper label with printed indication of label material;
• PLB – polymer label without label material indication;
• D_PB - printing on the package and on the paper label without indication;
• P - polymer label with indication of label material;
• PA_PLB - paper label with label material indication and polymer label without label material indication;
• PB_PLB - paper label without printed label material indication and polymer label without label material indication;
• D_PA - printing on the package and on paper with the indication of the label material;
• D_PB_PLB - printing on packaging and paper label without indication and polymer label without material indication;
• PA_PB – paper label with indication of label material and paper label without indication of label material.

Analyzing the print on the packaging of the dairy product group (see Fig. 2.28), it was concluded that half of the samples, or 50.44% of the packaging, were fully printed. Without printing - 39.19% of the packaging samples, while 10.37% of the packages are partially printed. Therefore, it can be seen that it is possible to reduce the amount of printing in the dairy products group. But due to the fact that this group of products is sensitive to the effect of light on product quality during storage, dairy products are analyzed in more detail by subgroups.

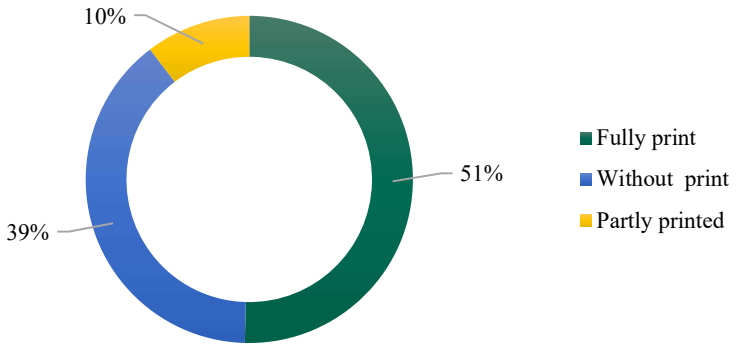


Fig. 2.28. Print volume of packaging

Therefore, it can be seen that it is possible to reduce the amount of printing in the dairy products group. Milk and milk products were divided into groups - milk, cheese, yogurt, cream cheese and other dairy products, and the results are reflected from 2.29. until 2.48 Fig.

2.7.1. Milk and fermented (drinkable) milk products – milk and fermented milk products are analyzed in this subgroup, with the exception of yogurts, which form a separate subgroup, a total of 74 product units are analyzed in this subgroup. Analyzing the markings indicated on the packaging regarding the types of packaging materials (see Fig. 2.29), it was concluded that 31.08% indicated 81(C/PAP); 18.92% - 1(PET), of which 21.43% is indicated for 1(PET) and 2(HDPE) and 3(PVC). On the other hand, 7.14% is indicated for 1(PET) and 5(PP). But 84(C/PAP) is indicated on 16.22% of samples; 13.51% indicated 5(PP), of which 80.00% indicated 5(PP) and 2(HDPE); 9.46% indicated 2(HDPE); 4.05% specified for 4(LDPE); 2.70% stated in 6(PS). On the other hand, for 4.05% of samples, the type of packing material used was not indicated on the packaging. As can be seen, the range of product packaging in this subgroup is diverse, and it is likely that reducing the diversity will not worsen the quality of the products.

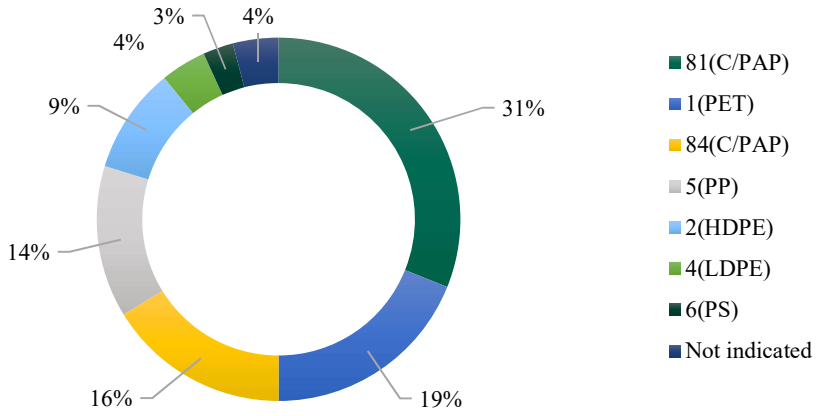


Fig. 2.29. Indication on the packaging of the decoding of the packaging material

Analyzing the shapes of the sample packaging material (see Fig. 2.30) it was concluded that half of all packages, or 50.00% are packed in laminated cardboard packages, 40.54% are packed in bottles; 4.05% packed in pillow-shaped packages; 2.70% packaged in glasses; 1.35% packed in cans and 1.35% packed in flowpack type packages.

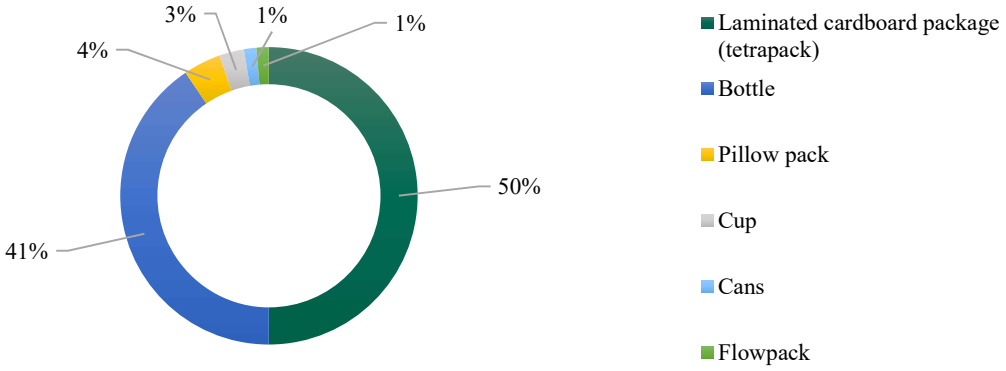


Fig. 2.30. Representation of packaging shapes

Analyzing the label information on the package (see Fig. 2.31), it was concluded that 58.11% of the packages have label information printed on the package (D); 16.22% label information is printed on a polymer label, but the type of label material (PLB) is not specified; 10.81% label printed on paper with indication and label on polymer without indication (PA_PLB); 8.11% label printed on paper without indication (PB); 5.41% paper label without printed label material indication and polymer label without label material indication (PB_PLB) and 1.35% paper label printed on paper without indication and polymer label with label material indication (PB_P).

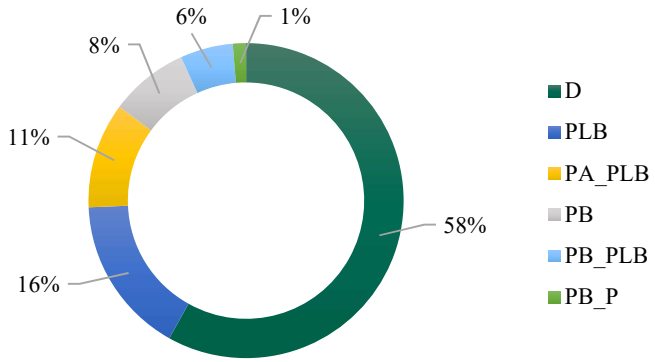


Fig. 2.31. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- PLB – polymer label without label material indication;
- PA_PLB - paper label with label material indication and polymer label without label material indication;
- PB – paper label without printed label material indication;
- PB_PLB - paper label without printed label material indication and polymer label without label material indication;
- PB_P – paper label without printed label material indication and polymer label with label material indication.

Analyzing the printing of the basic material, it was concluded for this subgroup that 59.46% of the basic packaging material is fully printed, while 40.54% is without printing (see Fig. 2.32).

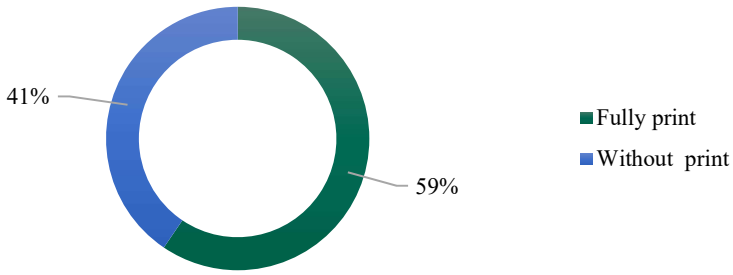


Fig. 2.32. Print volume of packaging material

Analyzing the samples of this group, it was concluded that all samples had the appropriate package size, but 13.51% of all samples in the group had double packaging, which does not affect the expiration date.

2.7.2 Yogurts – a total of 170 sample units (both edible and drinkable yogurts) were analyzed. Summarizing the markings indicated on the packaging regarding the packaging material (see Fig. 2.33), it was concluded that 47.06% of the samples have 5(PP) indicated on the packaging; 16.47% indicated 1(PET); 15.88% indicated in 6(PS); 3.53% specified in 81(C/PAP); 2.94% specified in 7(OTHER); 2.35% specified for 2(HDPE) and 1.18% specified for 4(LDPE) (see fig.). On the other hand, 10.59% of the samples in this group had no indication of the material used for packaging.

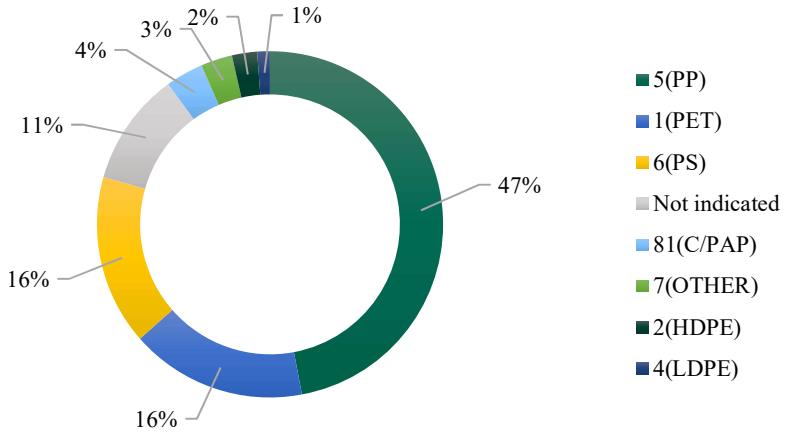


Fig. 2.33. Indication on the packaging of the decoding of the packaging material

Analyzing the variety of shapes of packaging material of the samples (see Fig. 2.34), it was concluded that 51.18% were packed in cups; 17.65% bottled; 13.53% packed in thermoformed packaging; 6.47% packed in stand-up package (doypack); 4.71% packed in a laminated cardboard package; 4.12% packed in flowpack; 1.18% packed in cushion packaging and 1.18% packed in hard container.

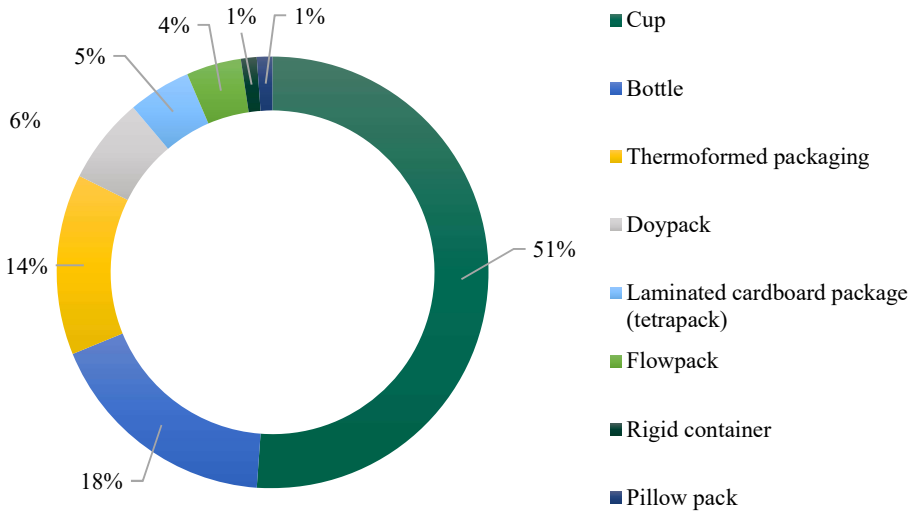


Fig. 2.34. Representation of packaging shapes

Analyzing the information on the package, it was concluded about the label (see Fig. 2.35) that for this subgroup of products 33.53% of the label information is printed on the package (D); 31.18% paper label with reference to transcript of label material (PA); 20.00% printing on polymer label without indication (PLB); 8.24% printing on a polymer label with the indication (P); 5.29% printing on paper label without indication (PB); 1.76% print on paper label without indication and print on polymer label without indication (PB_PLB).

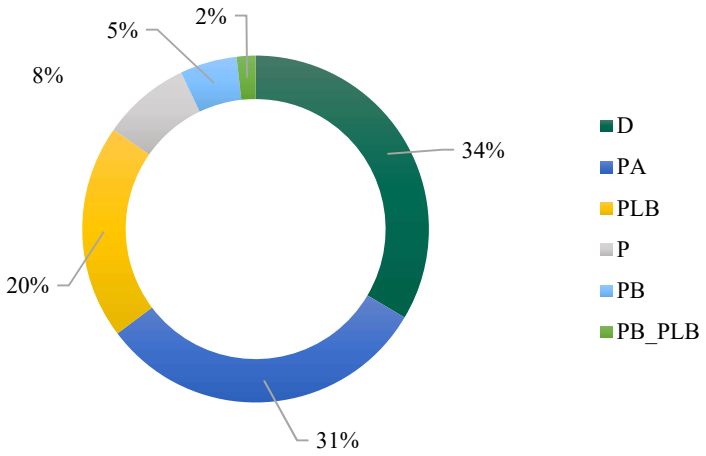


Fig. 2.35. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- PA – paper label with printed indication of label material;
- PLB – polymer label without label material indication;
- P – polymer label with indication of label material;
- PB – paper label without printed label material indication;
- PB_PLB - paper label without printed label material indication and polymer label without label material indication.

Analyzing the packaging printing of this subgroup (see Fig. 2.36), it was concluded that the basic material of the packaging is unprinted for the majority, i.e. 68.24%, while the remaining 31.76% have fully printed packaging.

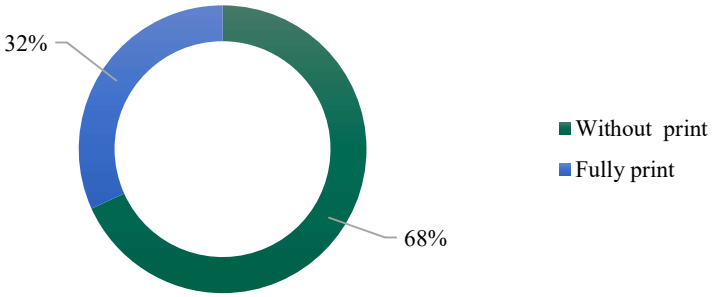


Fig. 2.36. Print volume of packaging

Analyzing the samples of this group, it was concluded that 0.59% of the samples did not have the appropriate packaging size, while 61.76% of all the samples of the group had double packaging, which does not affect the expiration date.

2.7.3. Cheeses – a total of 116 sample units were analyzed in the subgroup. This subgroup includes various types of soft, hard and semi-hard cheeses, except for cream cheeses and cheese snacks, which are packed in different packaging technologies, both in air and in a modified gas environment (vacuum (VP) and modified atmosphere packaging (MAP)). The analyzed samples covered both sliced and unsliced cheese.

Summing up, the designations indicated on the package regarding the packaging material (see Fig. 2.37) concluded that 63.79% of the samples have 7(OTHER) indicated on the package; 10.34% indicated 1(PET); 6.03% indicated in 5(PP); 0.86% indicated in 6(PS); 0.86% indicated 81(C/PAP), but 18.10% did not indicate any information about the material used in the packaging. As you can see, the bulk is taken up by the package marked with the numerical code "7", indicating that it is a multi-layer material. The second largest group is unopened packaging, which is also most likely multi-layer packaging, because cheese is a perishable product, and in order to ensure its longer shelf life, it is necessary to store it in a changed gas environment.

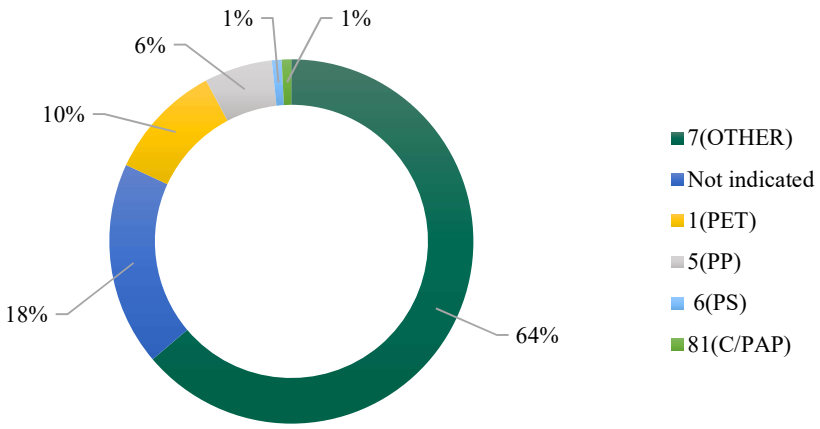


Fig. 2.37. Indication on the packaging of the decoding of the packaging material

Analyzing the shapes of the packaging materials of the samples (see Fig. 2.38). it was concluded that 41.38% of the samples were packed in thermoformed packaging; 18.10% packed in a hard container (cup); 18.10% packed in flowpack type packaging; 11.21% packed in a stand-up package (doypack); 10.34% packed in shrink film, 0.86% packed in cushion packaging.

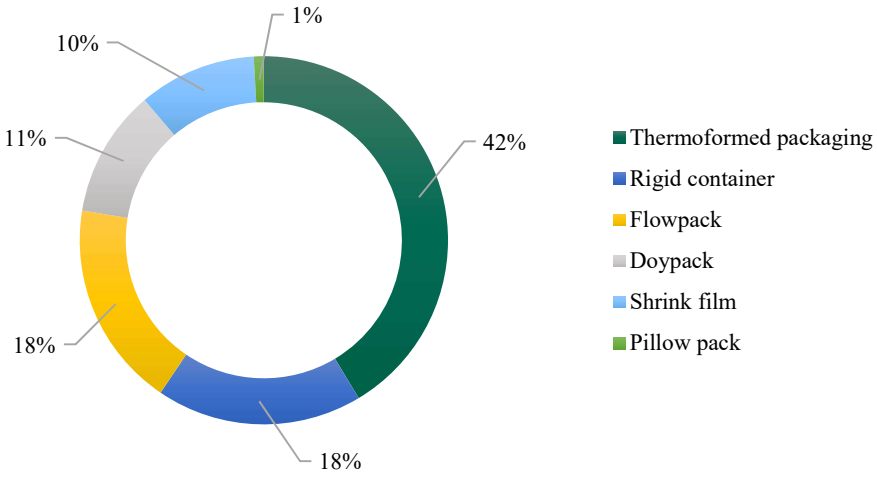


Fig. 2.38. Representation of packaging shapes

Analyzing the information on the package, it was concluded about the label (see Fig. 3.39) that the label of 36.21% of the samples is printed on the basic package (D); 34.48% - information is printed on a paper label without an indication of the transcript of the label material (PB); 18.97% label is printed on the package and on paper without indication (D_PB); 7.76% label is printed on paper with indication (PA); 1.72% printing on paper label without indication and on polymer label without indication (PB_PLB); 0.86% print on packaging, on paper without indication and on polymer without indication (D_PB_PLB).

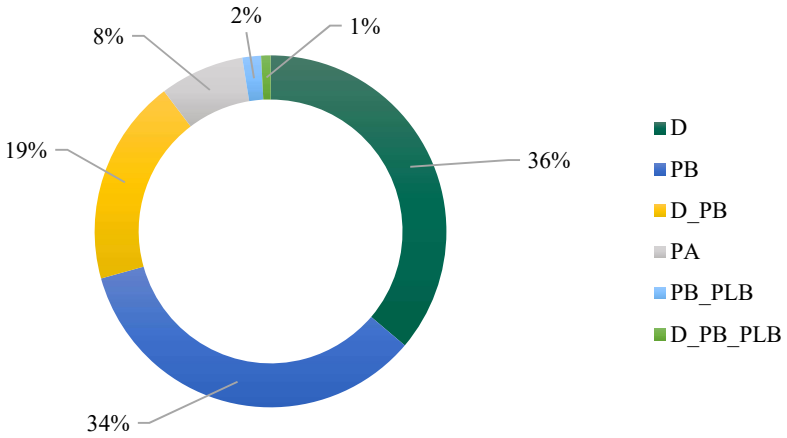


Fig. 2.39. The label, its type, and an indication of the material of the label, where:

- D – information printed on the package;
- PB – paper label without printed label material indication;
- D_PB - printing on the package and on the paper label without indication;
- PA – paper label with printed indication of label material;
- PB_PLB - paper label without printed label material indication and polymer label without label material indication;
- D_PB_PLB - printing on packaging and on paper label without indication and polymer label without material indication.

Analyzing the packaging printing of this subgroup (see Fig. 2.40), it was concluded that the basic packaging of 43.97% of the samples was not printed; 30.17% - fully printed and 25.86% - partially printed.

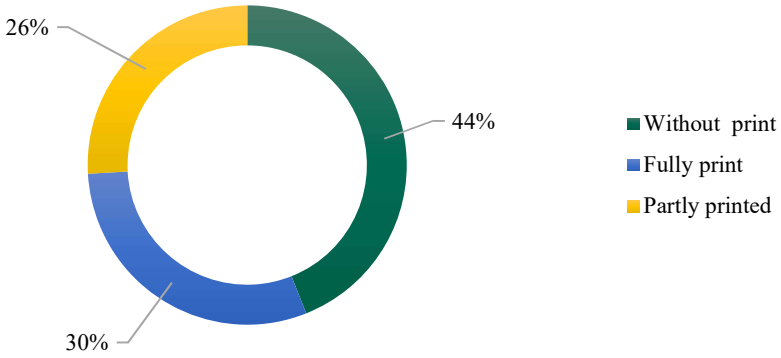


Fig. 2.40. Print volume of packaging

Analyzing the samples of this group, it was concluded that 84.48% of the samples had the appropriate package size, while the remaining 15.52% were too large. On the other hand, 16.38% of the samples had double packaging, which does not affect the expiration date.

2.7.4. Cream cheeses, curds, sweet curd cheeses, fresh cheeses, cheese treats, cream - a total of 175 sample units were analyzed. Summarizing the markings indicated on the packaging regarding the packaging material (see Fig. 2.41), it was concluded that the majority, or 60.77%, of the samples indicated 5(PP) on the packaging, of which 3.15% indicated 5(PP) and 84(C/ PAP), 0.79% with indication 5(PP) and 7(OTHER); 11.00% with indication 6(PS); 11.00% with indication 7(OTHER), of which 4.35% with indication 7(OTHER) and 5(PP); 4.31% with indication 81(C/PAP); 4.31% with indication 4(LDPE); 1.44% with the indication 1(PET) and 7.18% of the samples have no indication of the packaging material.

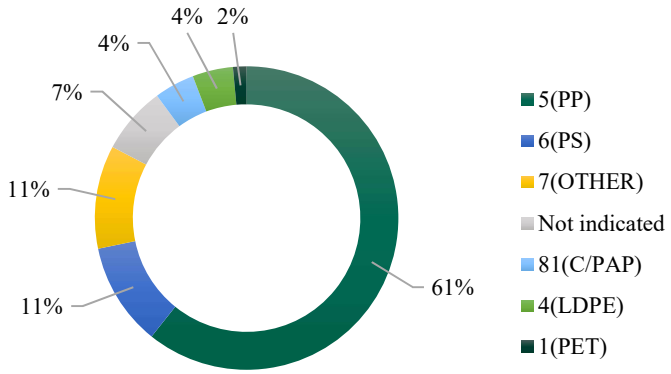


Fig. 2.41. Indication on the packaging of the decoding of the packaging material

Analyzing the types of shape of sample packaging material (see Fig. 2.42). it was concluded that 31.43% were packed in flowpack packaging, 25.36% were packed in hard containers (cups); 20.10% packed in glasses; 14.35% packaged in thermoformed packaging; 4.31% packed in a laminated cardboard package, 1.44% in a stand-up package (doypack); 1.44% packed in cushion packaging and 3.83% packed in shrink film.

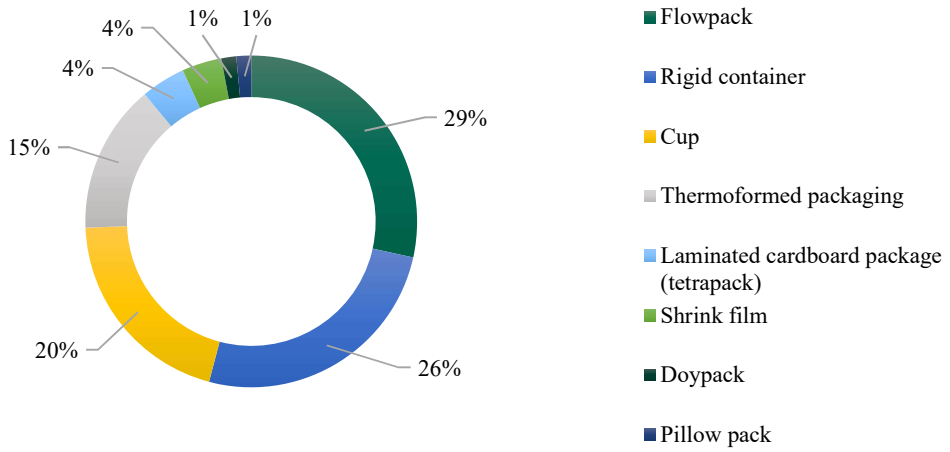


Fig. 2.42. Representation of packaging shapes

Analyzing the information on the label on the package (see Fig. 2.43), it was concluded that the label information of 80.38% of the samples was printed on the basic package (D); 8.61% on paper without indication (PB); 6.22% on packaging and on paper without indication (D_PB); 3.35% on paper with indication (PA); 0.96% on polymer label without indication (PLB), 0.48% on packaging and paper label with indication (D_PA).

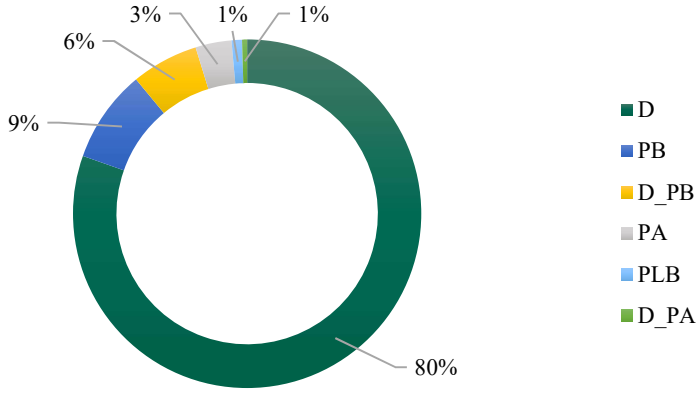


Fig. 2.43. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- PB – paper label without printed label material indication;
- D_PB – printing on the packaging and on the paper label without indication;
- PA – a paper label with an indication of the label material printed on it;
- PLB – polymer label without an indication of the label material;
- D_PA – printing on the package and on the paper label with the printed indication of the label material.

Analyzing the print for this subgroup (see Fig. 2.44), it was concluded that for most of the samples, or 73.68%, the packaging is fully printed; 13.88% partially printed, and 12.44% packaging is without printing.

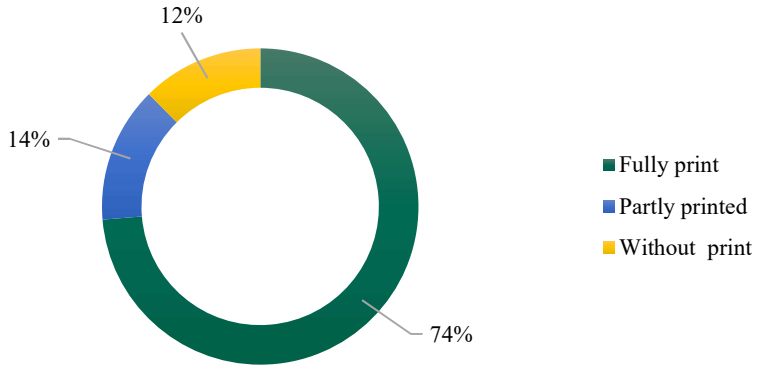


Fig. 2.44. Print volume of packaging

Analyzing the samples of this group, it was concluded that 95.43% of the samples had the appropriate package size, while the remaining 4.57% were too large. On the other hand, 41.14% of all samples in the group had double packaging, which does not affect the expiration date.

2.8. Packaging of dry products

In this category, 305 packaging units are analyzed, for example: flour, pasta, ready-made flour mixes, semolina, briquette flakes, mussels, salt, sugar, etc. For the products of this group, it is important to protect the products from air moisture during storage. The obtained data can be seen in 2.45. until 2.48 Figures.

Summarizing the packaging material designations indicated on the package (see Fig. 2.45), it was concluded that 52.46% of the samples were packed in packaging with the indication 5(PP), including 3.8% with the indication 5(PP) and 21(PAP), 14.75% of the samples with reference 21(PAP) including 16% with reference 21(PAP) and 81(C/PAP) and 2.22% with reference 21(PAP) and 7(OTHER), 11.15% with reference 7(OTHER) including 2.94% with indication 7(OTHER) and 21(PAP), 3.93% with indication 2(HDPE), 2.62% indicated other used material, 1.64% with indication 4(LDPE), including 60% with indication 4(LDPE) and 21(PAP); 1.64% with indication 84(C/PAP), 1.31% with indication 90(C/LDPE) and 0.66% with indication 93(C/LDPE). On the other hand, 9.84% of the samples from all packages of this group do not indicate what material the package is made of.

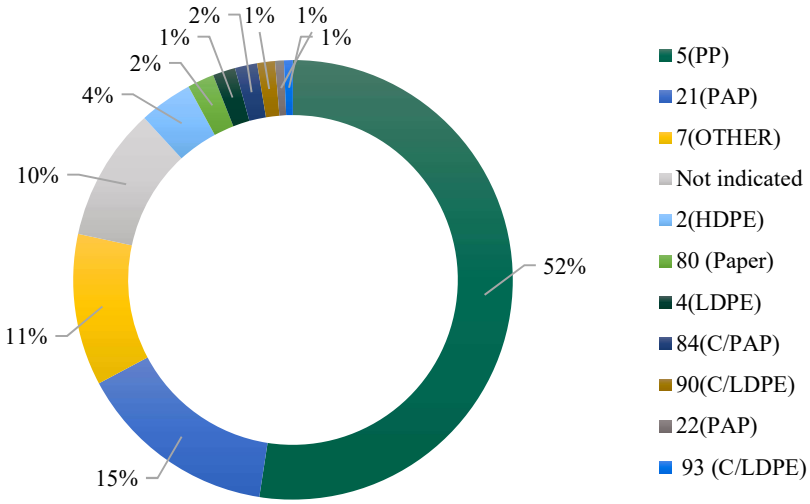


Fig. 2.45. Indication on the packaging of the decoding of the packaging material

Analyzing the shape of the sample packaging material, it was concluded that more than half, or 57.70%, of the samples were packed in flowpack (see Fig. 2.46). 23.61% of samples were packed in pillow-shaped packaging, 55.56% of them in pillow-shaped packaging and box, in box - 6.89%, including 4.76% in box and packet, in flowpack and box - 6.56%, in doypack - 2.30%, in glass - 1.97%, in cylinder - 0.66% and 0.33% samples in the container.

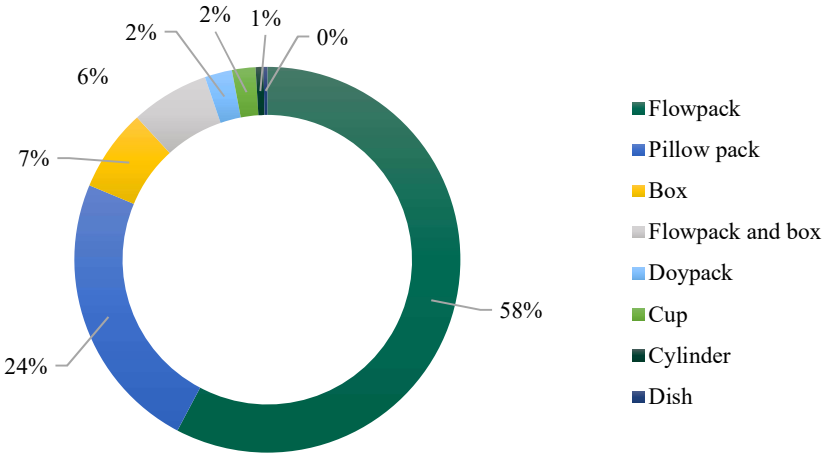


Fig. 2.46. Representation of packaging shapes

Analyzing the label material on the package, it was concluded that for most of the samples, or 76.72%, the label information is printed on the package (D); 17.05% printed on the package and on the polymer label without indication (D_PLB); 4.26% label printed on packaging and on paper without indication (D_PB); 1.64% printed on the packaging and on the polymer with the indication of the material and 0.33% printed on the paper label without indication (PB) (see Fig. 2.47).

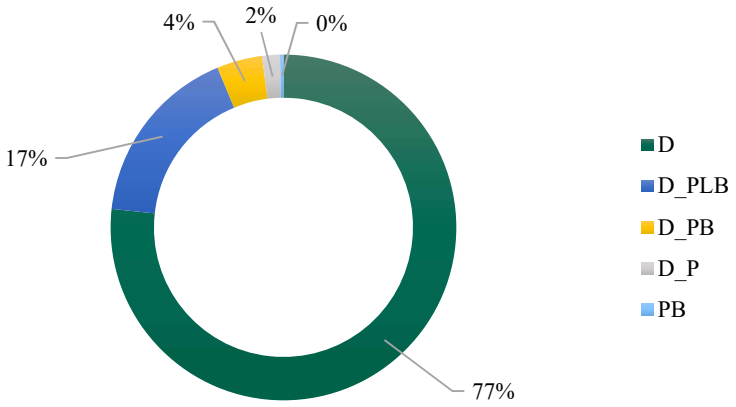


Fig. 2.47. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- D_PLB – printing on the package and on the polymer label without label material indication;
- D_PB – printing on the packaging and on the paper label without indication;
- D_P – print on the package and on the polymer label with the indication of the label material;
- PB – paper label without printed label material indication.

Analyzing the packaging printing of the products of this group (see Fig. 2.48), it was concluded that almost half of the samples, or 49.51% of the packaging, were fully printed; 39.34% - a lot of printing on the package; 9.84% packaging partially printed and 1.31% packaging without printing.

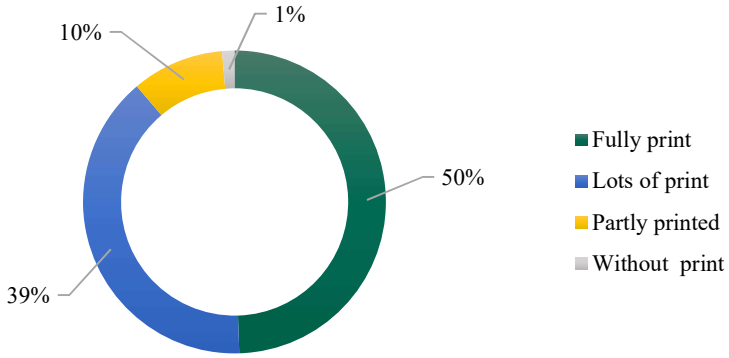


Fig. 2.48. Print volume of packaging

Analyzing the samples of this group, it was concluded that all the samples had the appropriate size, but 2.30% of the samples had double packaging, which does not affect the expiration date.

2.9. Spices

In this category, 227 packaging units are analyzed, covering different types of spice packaging. The obtained data can be seen in 2.49. until 2.52 in pictures.

By summarizing the designations of the packaging material indicated on the package (see Fig. 2.49), it was concluded that 32.16% of the samples were packed in a package marked 7(OTHER), of which 1.37% were marked 7(OTHER) and 84(C/PAP) and 22 (PAP); 13.22% with indication 5(PP), of which 13.33% with indication 5(PP) and 21(PAP) and 41(ALU); 9.69% with indication 90(C/LDPE); 6.61% with indication 81(C/PAP); 6.17% with indication 1(PET); 4.41% with indication 84(C/PAP); 3.08% with indication 21(PAP) of which 42.86% with indication 21(PAP) and 41(ALU); 2.64% with designation 70 (GL), but the type of polymer that is visually visible has not been deciphered, 0.44% with designation 6(PS) and 0.44% with designation 70(GL). On the other hand, in 21.15% of the samples, the packaging made of any material is not indicated on the packaging.

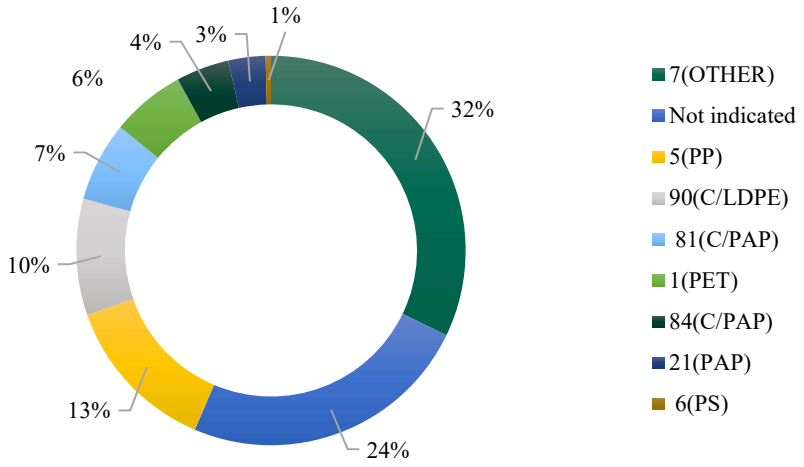


Fig. 2.49. Indication on the packaging of the decoding of the packaging material

Analyzing the shapes of the packaging material of the samples (see fig. 2.50), it was concluded that 43.17% of the samples are in pillow-shaped packaging; 18.50% in flowpack packaging; 14.10% in a container with a lid, of which 46.88% a container with a lid and a sleeve and 20% a container with a lid and a shrink film; 13.66% in doypack, 8.37% in bottle with cork, of which 52.63% bottle with cork and cardboard sheet and 10% bottle with cork and shrink film; 1.76% in can and tube and 0.44% in carton with flowpack.

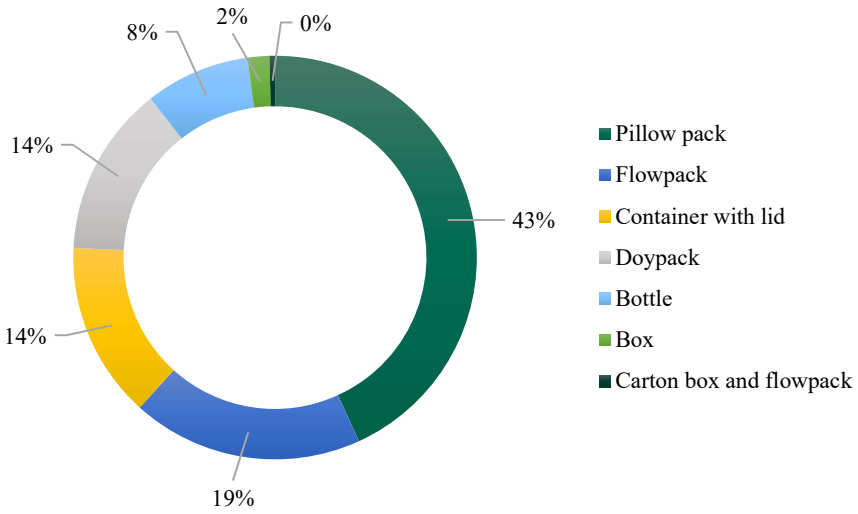


Fig. 2.50. Representation of packaging shapes

Analyzing the information on the package (see Fig. 2.51), it was concluded that for most of the samples, or 62.11%, the label information was printed on the package (D); 24.23% printed on the package and on the polymer label without indication (D_PLB); 9.69% printed on polymer label without indication (PLB) and 3.96% information printed on packaging and paper label without indication (D_PB).

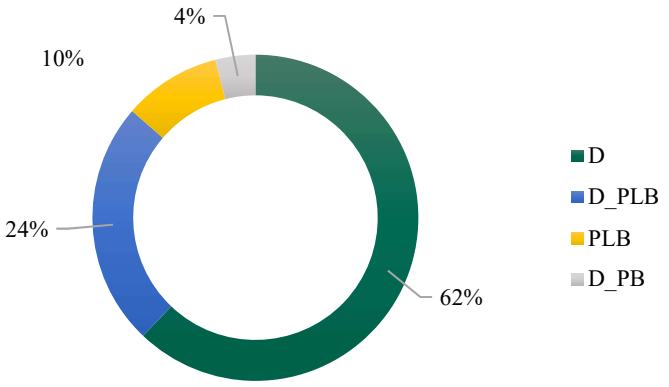


Fig. 2.51. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- D_PLB – printing on the package and on the polymer label without label material indication;
- PLB – polymer label without an indication of the label material;
- D_PB – printing on the packaging and on the paper label without indication.

Analyzing the printing of the base material, it was concluded for this group of products (see Fig. 2.52) that for most of the samples, or 68.28%, the packaging is fully printed; 21.15% there is a lot of print on the package; 7.05% packaging is unprinted and 3.52% packaging is partially printed.

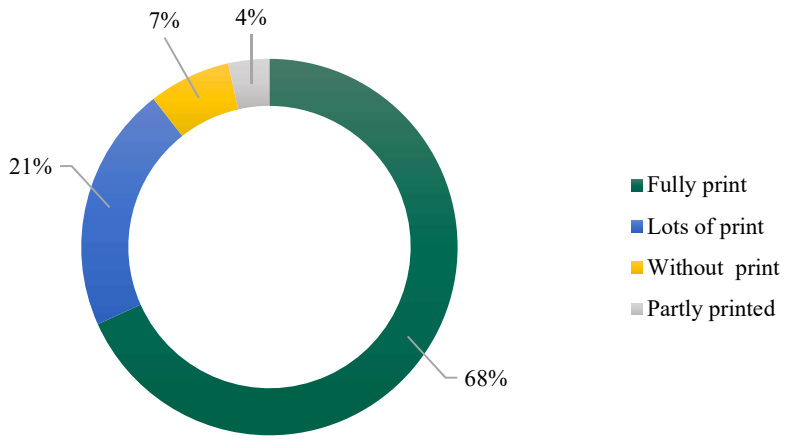


Fig. 2.52. Print volume of packaging

Analyzing the samples of this group, it was concluded that all samples were of the appropriate size and no sample had double packaging, which does not affect the shelf life.

2.10. Packaging of sweets and snacks

In this category, 56 packaging units were analyzed, which include bars, chips, corn snacks. The obtained data can be seen in 2.53. until 2.55 Fifures.

Summarizing the packaging material designations indicated on the packaging (see Fig. 2.53), it was concluded that 42.86% of products have 5(PP) on the packaging; 23.21% - 90(C/LDPE); 16.07% - 7(OTHER), of which 88.89% are labeled 1(PET) and 7(OTHER). 1.79% - 21(PAP). On the other hand, from the samples of this whole group, 16.07% of packages do not have an indication of what material was used to make the package.

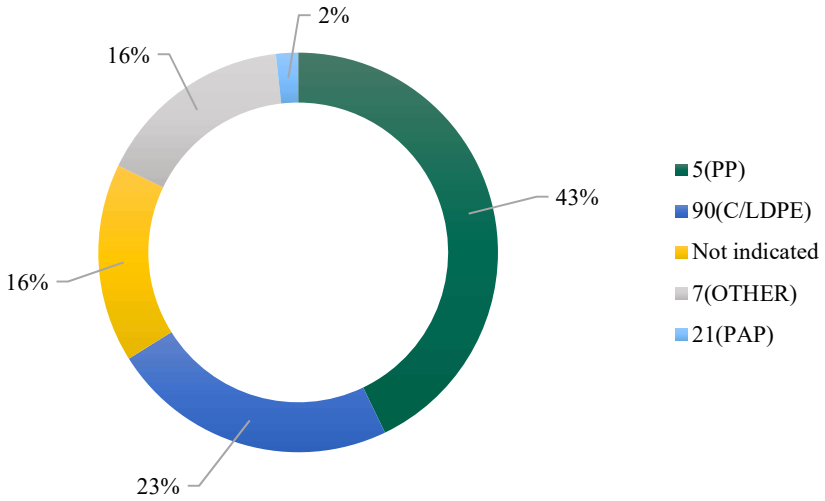


Fig. 2.53. Indication on the packaging of the decoding of the packaging material

Analyzing the shapes of the packaging materials of the samples (see Fig. 2.54), it was concluded that all the samples of this group were packed in a flowpack type package. 80.36% of samples are packed in flowpack only; 14.29% in flowpack and dish (corex); but 5.36% packed bars in flowpack, which are placed in a box.

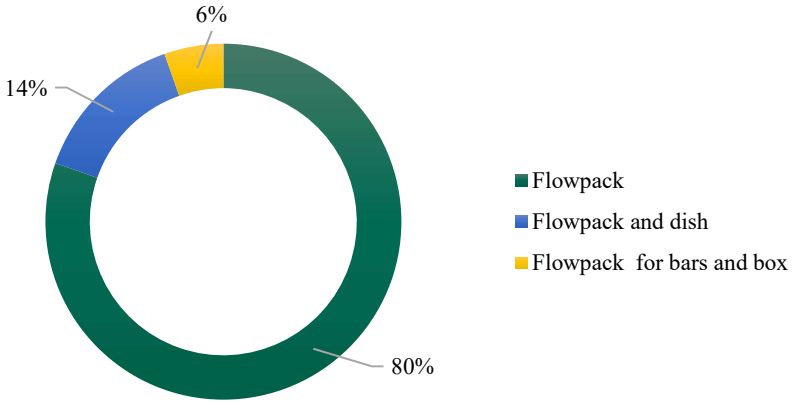


Fig. 2.54. Representation of packaging shapes

Analyzing the information on the package (see Fig. 2.55), it was concluded that of all the samples of this group, 82.14% of the label information is printed on the package (D), while 17.86% is printed on the package and on the polymer label without label material indication (D_PLB).

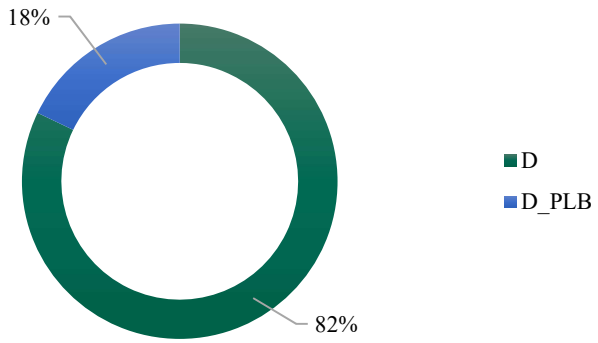


Fig. 2.55. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- D_PLB – printing on the package and on the polymer label without label material indication.

Analyzing the print for this group concluded that all packages in this group are fully printed. Analyzing the package sizes of the samples of this group, it was concluded that it was appropriate for 73.21% of the samples, while for the remaining 26.79% it was too big. On the other hand, none of the samples had double packaging, which does not affect the expiration date.

2.11. Packaging of candies and cookies

In this category, 265 packaging units are analyzed, which include cookies, chewing gums, chocolate bars, marshmallows, marmalades, dragees, caramels, cotton candy, cookies, chocolate bar candies. The obtained data can be seen in 2.56. until 2.59 Figures.

Summarizing the numerical codes or their corresponding abbreviations indicated on the package (see Fig. 2.56), regarding the decoding of the packaging material, it was concluded that 58.87% of the samples were packed in packaging marked 5(PP), of which 8.33% were marked 5(PP) and 21(PAP); 2.56% with indication 5(PP) and 22(PAP); 0.64% with indication 5(PP) and 20(PAP); 0.64% with indication 5(PAP) and 84(C/PAP), 0.64% with indication 5(PP) and 90(C/LDPE). On the other hand, 5.28% of the samples had the indication 1(PET), of which 42.86% had the indication 1(PET) and 5(PP) and 21(PAP); 14.29% with indication 1(PET) and 21(PAP); 7.14% with indication 1(PET) and 5(PP); 7.14% with indication 1(PET) and 7(OTHER). 7.14% with indication 1(PET) and 21(PAP). The indications on the packaging of the other samples were: 4.91% with the indication 7(OTHER); 3.02% with indication 21(PAP), of which 7.14% with indication 21(PAP) and 20(PAP); 1.89% with indication 4(LDPE); 1.89% with indication 90(C/LDPE); 1.13% with indication 81(C/PAP); 0.38% with indication 20(PAP) and 0.38% with indication 93(C/LDPE). Out of all the samples of this group, 22.26% of the samples did not have an indication on the package of what material the package was made of.

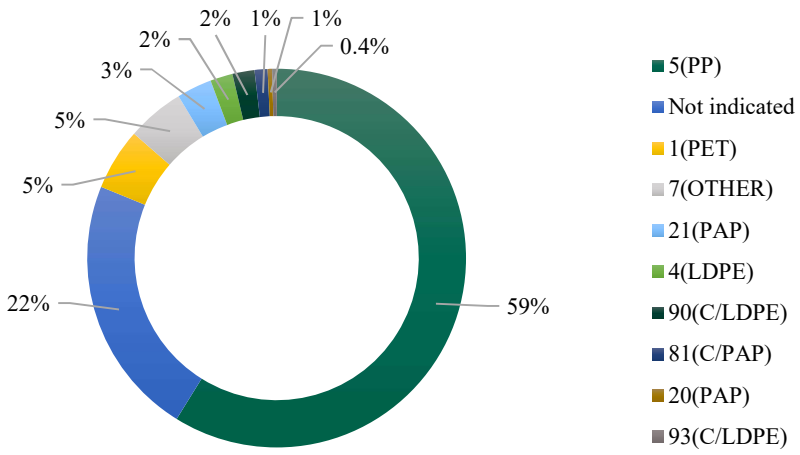


Fig. 2.56. Indication on the packaging of the decoding of the packaging material

Analyzing the shape of sample packaging materials, it was concluded that 71.32% of the samples were packed in a flowpack, of which 12.17% were in a flowpack and a container (corex); 8.47% in flowpack and box (see Fig. 2.57). 10.57% of all samples of this group are packed in a cardboard box, of which 46.43% are packed in a box and a bottle; 12.17% packaged in a box, bottle and thermoformed package; 7.14% packed in box and flowpack. On the other hand, the other samples are packed respectively: 6.42% in doypack; 4.15% in container of which 36.36% in container and box; 9.09% in container and flowpack; 9.09% in container, can and thermoformed package and 9.09% in container and thermoformed package; 3.77% in cushion packaging, 1.89% in thermoformed packaging; 1.13% in the bottle; 0.38% in glass and 0.38% wrapped.

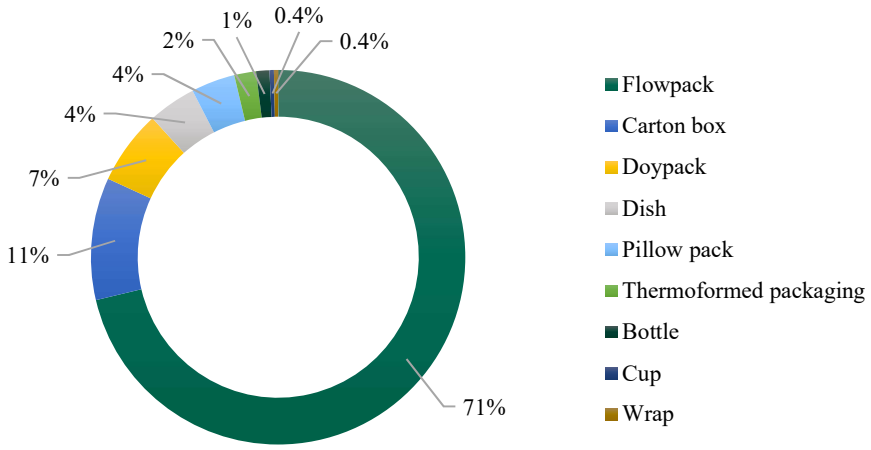


Fig. 2.57. Representation of packaging shapes

Analyzing the label information on the package (see Fig. 2.58), it was concluded that the label information of 67.55% of the samples was printed on the basic packaging (D); 23.02% printed on packaging and paper label without indication (D_PB); 7.17% printed on paper label without indication (PB); 1.13% printing on a paper label with indication (PA); 0.75% on polymer label without label material indication (PLB) and 0.38% print on paper label without indication and on polymer label without indication (PB_PLB).

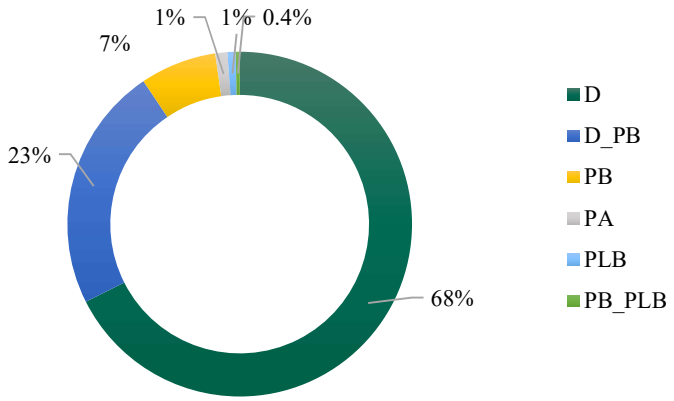


Fig. 2.58. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- D_PB - printing on the package and on the paper label without indication;
- PB – paper label without printed label material indication;
- PA – paper label with printed indication of label material;
- PLB – polymer label without label material indication;
- PB_PLB - paper label without printed label material indication and polymer label without label material indication.

Analyzing the type of packaging printing of this product group (see Fig. 2.59), it was concluded that the packaging of 68.68% of the samples was fully printed; 22.26% have no print; 8.86% are partially printed and 0.38% are multi-printed (high print volume) packages.

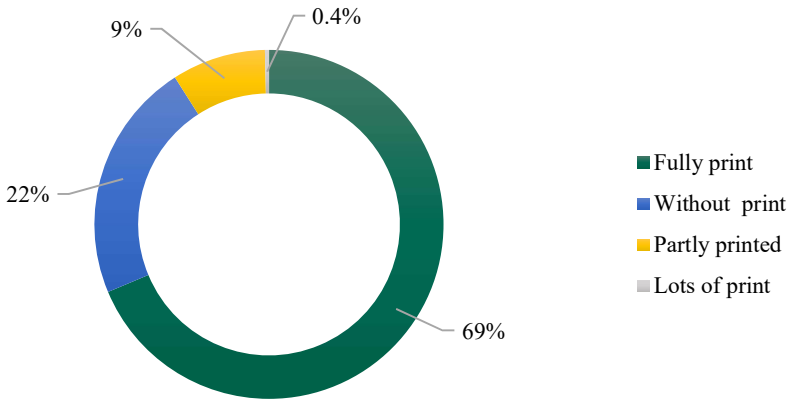


Fig. 2.59. Print volume of packaging

Analyzing the samples of this group, it was concluded that 66.79% of the samples had the appropriate package size, while 33.21% of the samples were too large. On the other hand, 16.60% of the samples had double packaging, which does not affect the expiration date.

2.12. Packaging of animal feed

In this category, 108 packaging units are analyzed, which include the following products: dry cat and dog food, canned cat and dog food, treats for dogs. The obtained data can be seen in 2.60. until 2.63 in pictures.

Summarizing the designations indicated on the package (see Fig. 2.60), regarding the packaging material, it was concluded that 32.41% of all samples indicated 7(OTHER); 19.44% indicated 4(LDPE); 12.96% indicated 5 (PP), of which 6.25% sample indicated 5.21 (PP; PAP); 7.41% specified 90 (C/PP); 5.56% stated 21(PAP), but no polymer type; 5.56% group packaging (6 pcs), where PET is indicated on the package, of which 66.66% samples are indicated (PET/PE) and 16.66% are indicated (PET/HDPE) and 1.85% are indicated 81(C/PAP); 5(PP); 31(ALU); 84(C/PAP). On the other hand, for 12.96% of the samples, the packaging does not indicate what material was used for the packaging.

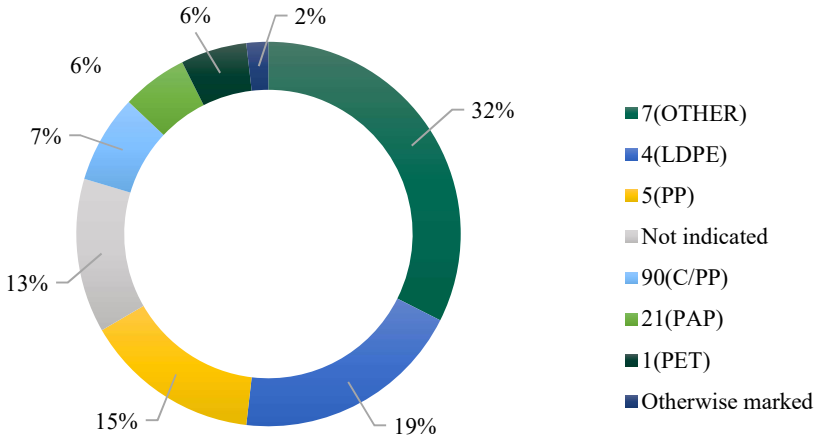


Fig. 2.60. Indication on the packaging of the decoding of the packaging material

Analyzing the shape of the packaging material of the samples (see Fig. 2.61), it was concluded that 40.74% of the products were packed in doypack; 28.70% packed in flowpack; 22.22% packed in cushion packaging; 4.63% packed in a bag, of which 40% packed in a bag with a paper edge and a metal clip; 20% packed in bag with cardboard edge and metal clip and 20% packed in bag and paper sheet; 1.85% packaged in container; 0.93% packed in shrink film and 0.93% packed in film and carton box.

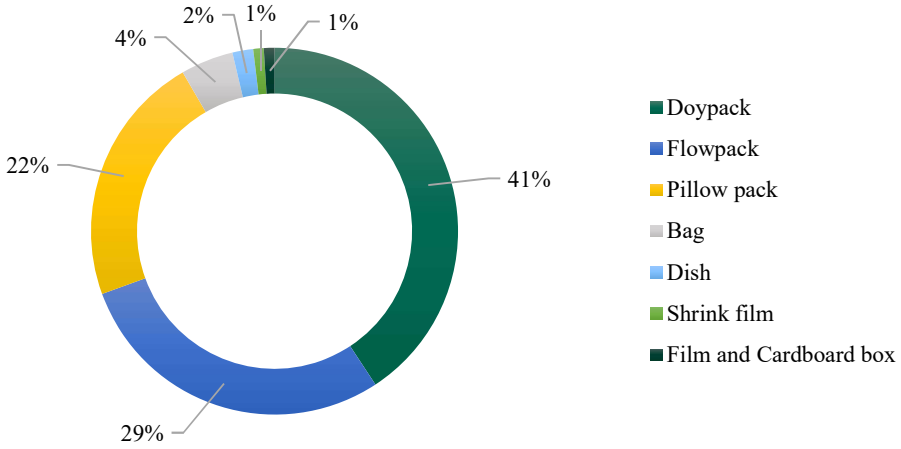


Fig. 2.61. Representation of packaging shapes

Analyzing the information on the package, about the label material (see Fig. 2.62), it was concluded that out of all the samples, 82.41% of the label information was printed on the package (D); 12.04% printing on packaging and paper label without indication (D_PB); 4.63% printing on polymer label without indication (PLB) and 0.92% printing on packaging and on polymer label without indication (D_PLB).

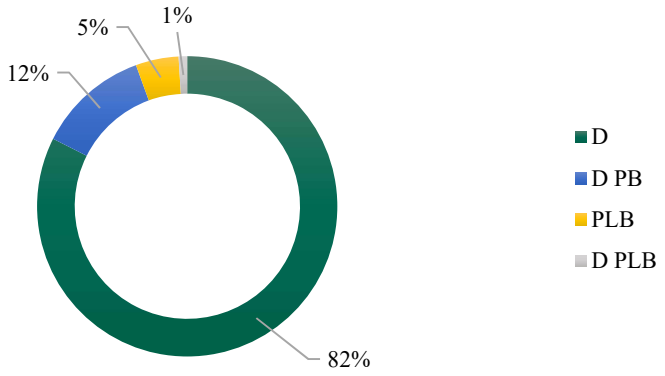


Fig. 2.62. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- D_PB – printing on the packaging and on the paper label without indication.
- PLB – polymer label without an indication of the label material;
- D_PLB – printing on the package and on the polymer label without label material indication.

Analyzing the packaging print of this group (see Fig. 2.63), it was concluded that the majority of all packaging samples, or 88.89%, were fully printed; 5.56% of packages are without printing; 4.63% packages partially printed and 0.93% packages printed using a lot of printing.

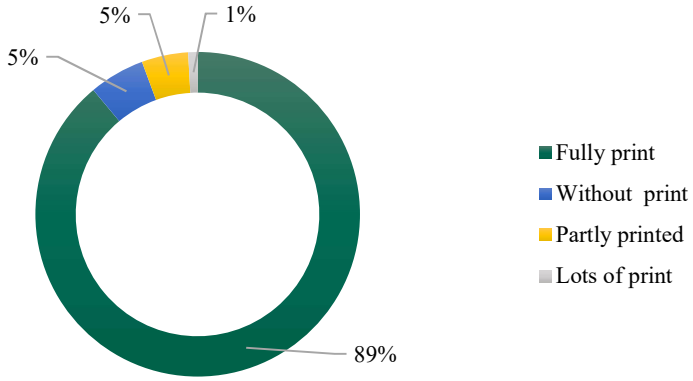


Fig. 2.63. Print volume of packaging

Analyzing the samples of this group, it was concluded that 91.67% of the samples had the appropriate package size, while the remaining 8.33% had it too big. On the other hand, none of the samples in this group had double packaging, which does not affect the shelf life.

2.13. Packaging of children's goods

In this category, 101 packaging units are analyzed, which include children's toys, children's development goods, board games. The obtained data can be seen in 2.64. until 2.67 Figures.

Analyzing the designations of the packaging material indicated on the package (see Fig. 2.64), it was concluded that almost half of the packages, or 51.49%, do not indicate the used packaging material. On the other hand, 1 (PET) is indicated in 14.85% of samples; 8.91% specified 4 (LDPE); 7.92% specified 7 (OTHER); 6.93% specified 3(PVC), 4.95% specified 5 (PP); 2.97% stated 81(C/PAP); 1.98% indicated on 22(PAP).

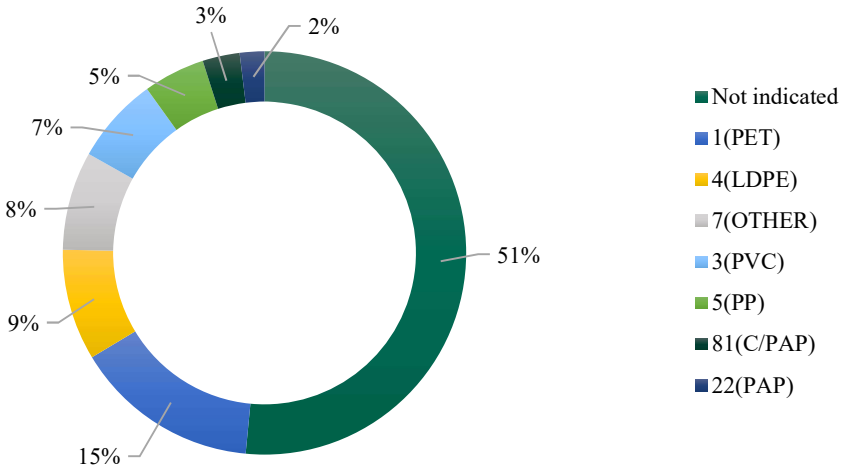


Fig. 2.64. Indication on the packaging of the decoding of the packaging material

Analyzing the shape of the packaging material of the samples (see Fig. 2.65), it was concluded that most of the samples of this group consist of several packages. Almost half, or 49.50%, of the samples of this group were thermoformed packaging, including 56% thermoformed packaging and a cardboard box, and 44% thermoformed packaging with a cardboard sheet; 19.80% packed in flowpack, of which 5% in flowpack and shrink film and 5% in flowpack and with lid; 18.81% in cushion packaging, 4.95% packed in a container with a lid and shrink film; 1.98% cardboard sleeve, container with lid and shrink film. On the other hand, the remaining 4.95% are packed, each in different materials: in a bag; film, cardboard box, thermoformed packaging; shrink film and paper sheet; mesh and cardboard sheet; bag thermoformed packaging and cardboard sheet.

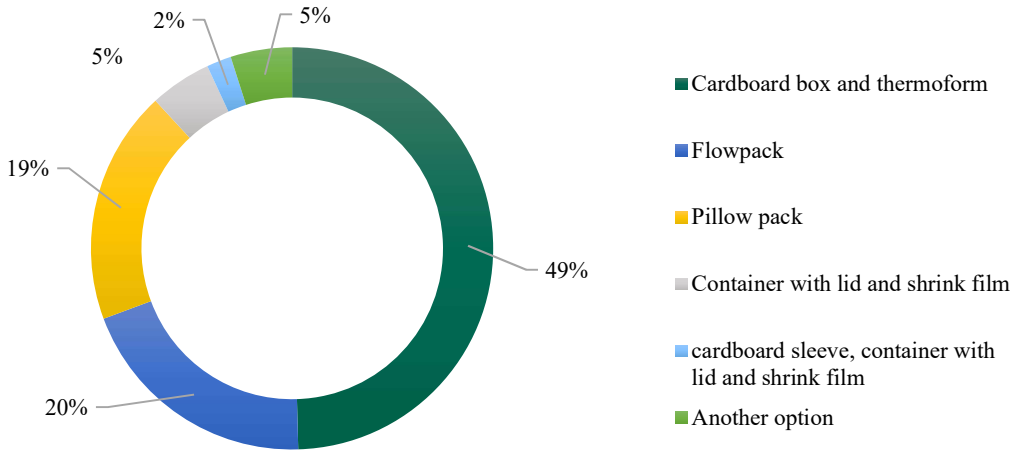


Fig. 2.65. Representation of packaging shapes

Analyzing the information on the label on the package (see Fig. 2.66), it was concluded that 44.55% of the given samples had the label printed on the package and on the paper label without indicating the label material (D_PB); 39.60% information printed on the package (D); 13.86% information is printed on paper label without indication (PB) and 1.98% is printed on packaging and polymer label without indication (D_PLB).

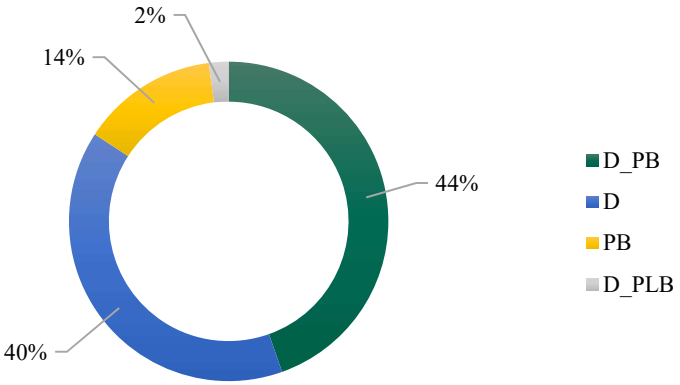


Fig. 2.66. The label, its type and an indication of the label material, where:

- D_PB – printing on the packaging and on the paper label without indication;
- D – information printed on the package;
- PB – paper label without printed label material indication;
- D_PLB – printing on the package and on the polymer label without label material indication.

Analyzing the packaging print, it was concluded for this group (see Fig. 2.67) that 58.42% of the packaging is without print; 18.81% - fully printed; 16.83% - partially printed and 5.94% used a lot of printing.

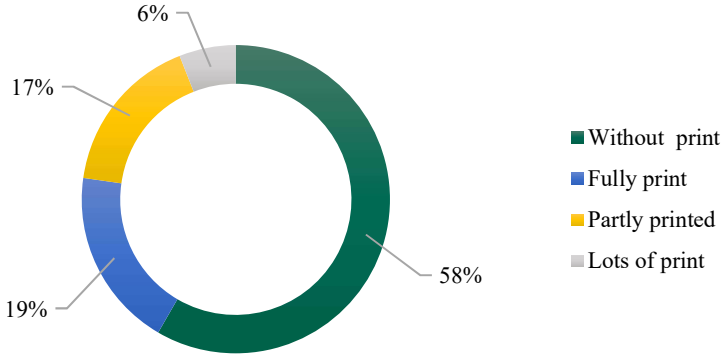


Fig. 2.67. Print volume of packaging

Analyzing the samples of this group, it was concluded that 66.34% of the samples had the appropriate package size, while the remaining 33.66% had it too big. On the other hand, none of the samples had double packaging, which does not affect the expiration date.

2.14. Packaging of hygiene products and cosmetics

In this category, 476 packaging units were analyzed, for example: men's and women's shampoos, hair conditioners, balms, oils and masks, hairspray, foam and wax packages, women's and men's shower gels, body scrubs, gels, creams were also analyzed. Packaging of sanitary napkins, pads, condoms, as well as facial care products, deodorants, antiperspirants and other packaging. The obtained data can be seen in 2.68. until 2.71. Figures.

Summarizing the markings indicated on the packaging (see Fig. 2.68), regarding the packaging material, it was concluded that 18.49% of the samples do not have an indication of what material the packaging is made of. On the other hand, 23.32% of the samples were packed in a package marked 2 (HDPE); 19.33% with indication 1(PET); 15.55% with indication 5(PP); 7.35% with indication 4(LDPE); 5.67% with indication 7(OTHER); 4.41% with indication 21(PAP); 3.78% with indication 41(ALU); 1.05% with indication 90(C/LDPE); 0.42% with indication 40(FE); 0.21% with indication 81(C/PAP); 0.21% with indication 95(glass/plastic) and 84% with indication 84(C/PAP). As you can see, there are three types of packaging most often used for this product/goods group: HDPE, PP and PET. A relatively large part is also a group of materials where the type of packaging material is not specified.

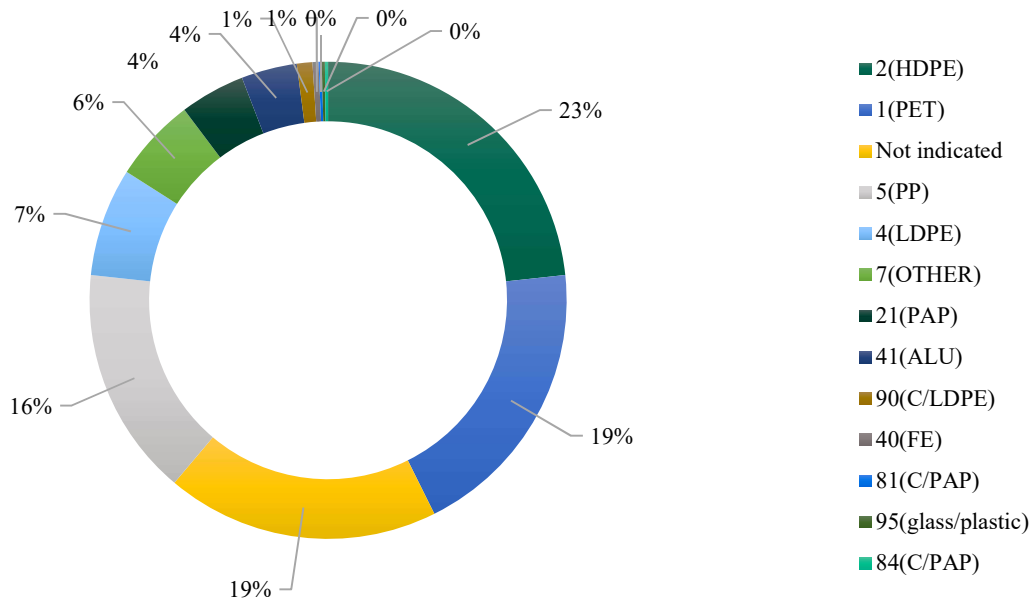


Fig. 2.68. Indication on the packaging of the decoding of the packaging material

Analyzing the shape of the packaging material of the samples (see Fig. 2.69), it was concluded that 35.8% is in a bottle with a cork; 26.05% vessel; 8.82% aluminum bottle with polymer cap; 7.56% flowpack type packaging; 7.56% in a bottle with a dispenser (pump); 4.41% pillow pack; 3.99% thermoformed packaging; 2.73% doypack with cork; 1.68% film; 1.05% bottle with cork and heat-shrinkable label; 0.63% flowpack with cap and 0.42% bottle with dispenser (pump) and cap.

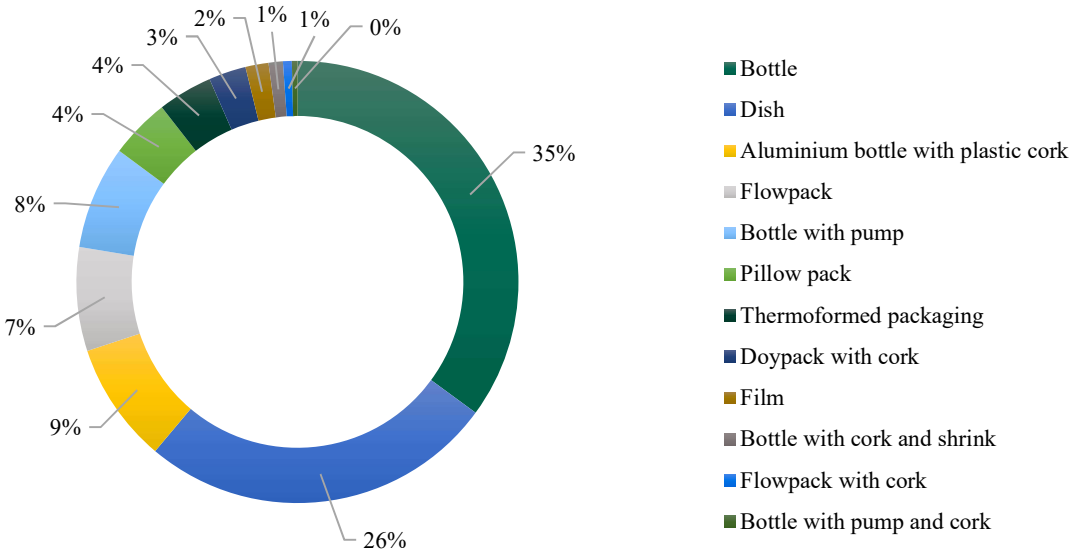


Fig. 2.69. Representation of packaging shapes

Analyzing the information on the package (see Fig. 2.70) regarding the label, it was concluded that for half of the packages of this group, or 50.84%, the label information is printed on the polymer without label material indication (PLB); 31.93% label printed on the package (D); 6.09% label printed on the package and on the polymer without indication (D_PLB); 5.46% label printed on packaging and on paper without indication (D_PB); 4.62% label printed on polymer without indication and on paper without indication (PB_PLB) and 1.05% label printed on polymer with indication (P).

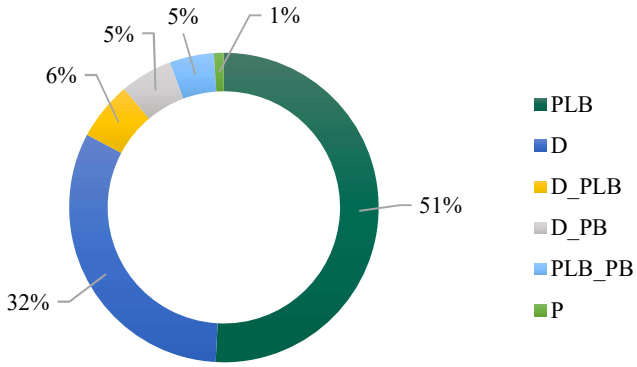


Fig. 2.70. The label, its type and an indication of the label material, where:

- PLB – polymer label without an indication of the label material;
- D – information printed on the package;
- D_PLB – printing on the package and on the polymer label without label material indication;
- D_PB – printing on the packaging and on the paper label without indication;
- PB_PLB – paper label without printed label material indication and polymer label without label material indication;
- P – polymer label with indication of label material.

Analyzing the printing of the products of this group (see Fig. 2.71), it was concluded that 43.49% of the packages are partially printed, 35.71% of the packages are without printing; 17.44% of packages are fully printed and 3.36% of samples have a lot of printing on the package.

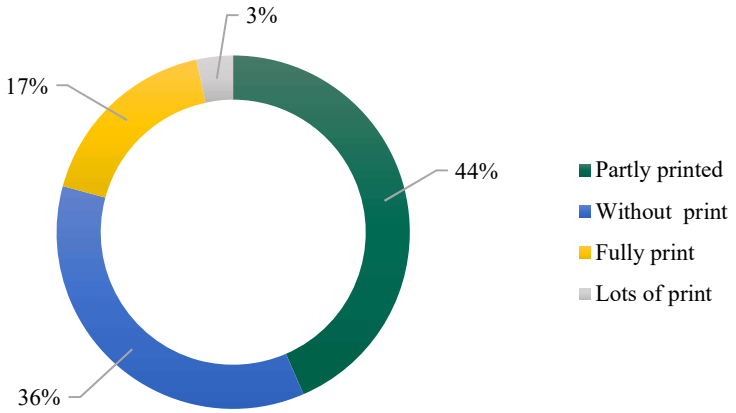


Fig. 2.71. Print volume of packaging

Analyzing the samples of this group, it was concluded that 98.95% of the samples had the appropriate package size, while the remaining 1.05% had it too big. On the other hand, 6.30% of the samples had double packaging, which does not affect the expiration date

2.15. Packaging of household chemicals

In this category, 170 packaging units were analyzed, covering the packaging of products such as fabric softeners, stain removers, bleaches, laundry capsules, laundry powders, toilet cleaners, all-purpose cleaners, etc. The obtained data can be seen in 2.72. until 2.75 Figures.

Summarizing the information on the package designations indicated on the package (see Fig. 2.72), it was concluded that 29.41% of the samples have the indication 4(LDPE), of which 0.59% have the indication 4(LDPE) and 21(PAP) and 22(PAP); 27.06% packages with the indication 2(HDPE), of which 2.35% with the indication 2(HDPE) and 5(PP); 15.29% with designation 1(PET), including 1.17% with designation 1(PET) and 2(HDPE). 0.59% with indication 1(PET) and 21(PAP); 11.18% with indication 5(PP), of which 0.59% with indication 5(PP) and 6(PS); 3.53% with indication 7 (OTHER); 1.18% with indication 6(PS) and 5.29% other materials used in packaging. On the other hand, 7.06% of the samples did not have any indication of the used packaging material on the packages.

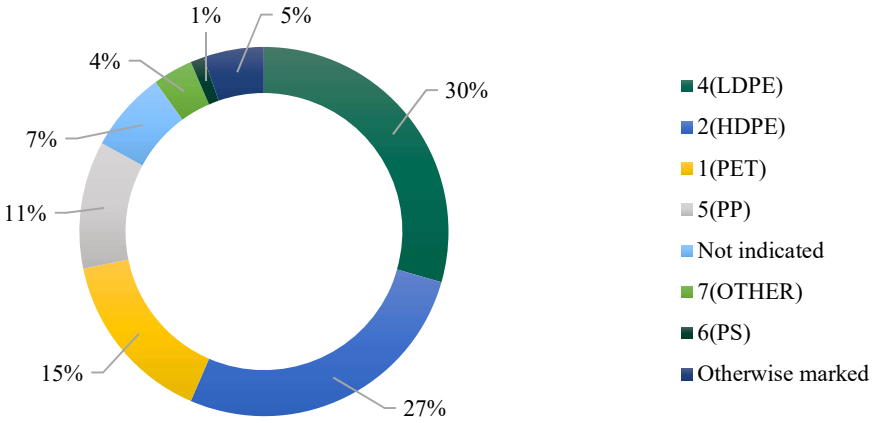


Fig. 2.72. Indication on the packaging of the decoding of the packaging material

Analyzing the shapes of product packaging materials (see Fig. 2.73), it was concluded that 43.53% of products are packed in polymer bottles, of which 64.86% are in polymer bottles with corks; 22.97% packaged in bottles with cork and heat-shrinkable label; 6.75% packaged in bottles with a dispenser (pump); 5.40% packaged in bottles with a dispenser (pump) and a heat-shrinkable label. On the other hand, the other samples from this group are respectively packed - 25.29% in flowpack-type packaging, of which 4.65% are packed in flowpack and with a sheet of paper; 10.59% packed in a container with a lid, of which 22.22% in a container with a lid and a paper sleeve; 10.00% packed in doypack, of which 29.41% in doypack with cork; 2.94% packed in thermoformed packaging, of which 60% in thermoformed packaging with a paper sheet and 20% in thermoformed packaging with a paper sheet and in an aluminum bottle with a polymer cap. 2.35% of products from this group are packed in pillow-shaped packaging; 1.76% packed in a metal bottle with a polymer cap; 1.76% packaged in an aluminum bottle with a polymer cap; 1.18% packed in a glass and 0.59% packed in shrink film and paper sheet.

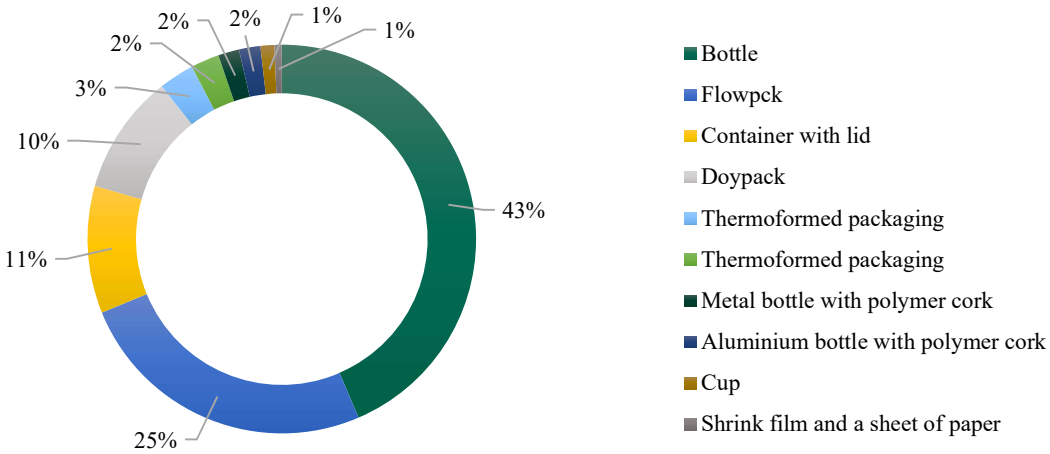


Fig. 2.73. Representation of packaging shapes

Analyzing the information on the package, it was concluded about the label (see Fig. 2.74) that 40.59% of the samples have a label printed on the package (D); 20.59% label printed on the package and on the polymer label without indication (D_PLB); 20.59% - printing on a polymer label without indication (PLB), 17.65% of samples printing on paper and on polymer labels without indication (PB_PLB).

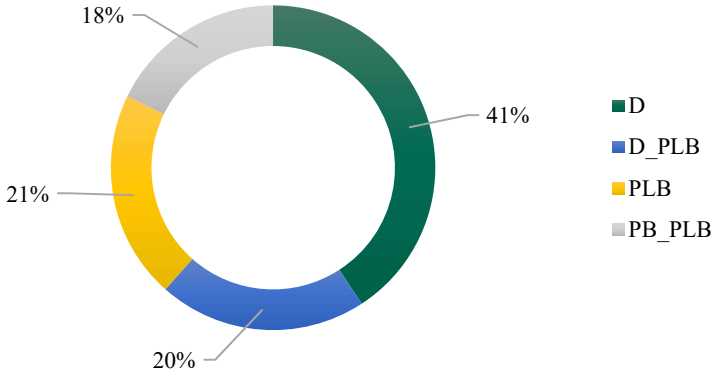


Fig. 2.74. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- D_PLB – printing on the package and on the polymer label without label material indication;
- PLB – polymer label without an indication of the label material;
- PB_PLB – paper label without printed label material indication and polymer label without label material indication.

Analyzing the packaging print of this group (see Fig. 2.75), it was concluded that half of the products of this group, or 50.59%, have no print; 27.06% packages partially printed; 18.24% of packages are fully printed and 4.12% of packages are printed with a large amount of printing areas.

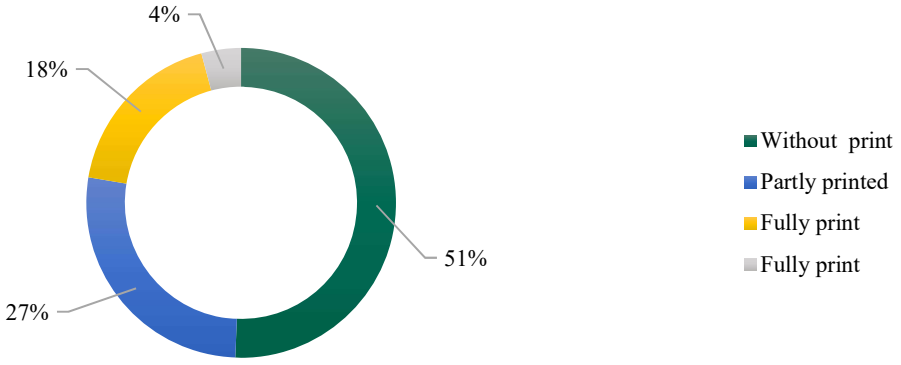


Fig. 2.75. Print volume of packaging

Analyzing the samples of this group, it was concluded that 84.12% of the samples had an appropriate package size, while the remaining 15.88% were too large. On the other hand, 1.76% of all samples in the group had double packaging, which does not affect the expiration date.

2.16. Packaging of household goods

In this category, 80 packaging units have been analyzed, which cover the following goods such as car care and maintenance goods, packages of various tools, etc. The obtained data can be seen in 2.76. until 2.79 Figures.

Summing up the packaging material designations indicated on the package (see Fig. 2.76), it was concluded that 41.25% did not indicate what material the package is made of. On the other hand, 22.50% of samples indicated 1(PET), of which 66.67% indicated 1(PET) and 21(PAP) and 11.11% indicated 1(PET) and 5(PP), while 10.00% indicated 5(PP) of which 62.50% with indication 5(PP) and 2(HDPE) and 25.00% with indication 5(PP) and 20(PAP). On the other hand, for the other samples from this group, 8.75% indicated 3(PVC), 5.00% indicated 2(HDPE); 5.00% specified 4(LDPE); 5.00% indicated on 21(PAP).

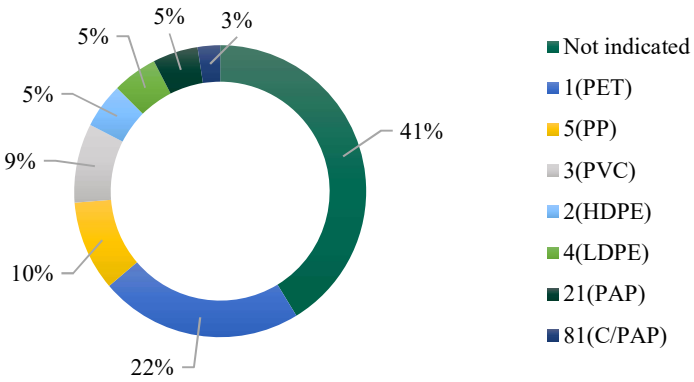


Fig. 2.76. Indication on the packaging of the decoding of the packaging material

Analyzing the forms of product packaging materials (see Fig. 2.77), it was concluded that 41.25% of the samples were packaged in bottles, of which 54.55% had a cork and 45.45% had a dispenser (pump). Of all the samples of this group, 32.50% were packed in thermoformed packages with a cardboard sheet; 17.50% packed in a flowpack, of which 64.29% packed in a flowpack with a cardboard sheet and a metal clamp; 2.5% packaged in a tube; 2.5% packed in a bag, 1.25% used cardboard sheet and polymer holder and 1.25% cushioned packaging. The remaining 1.25% - without any packaging.

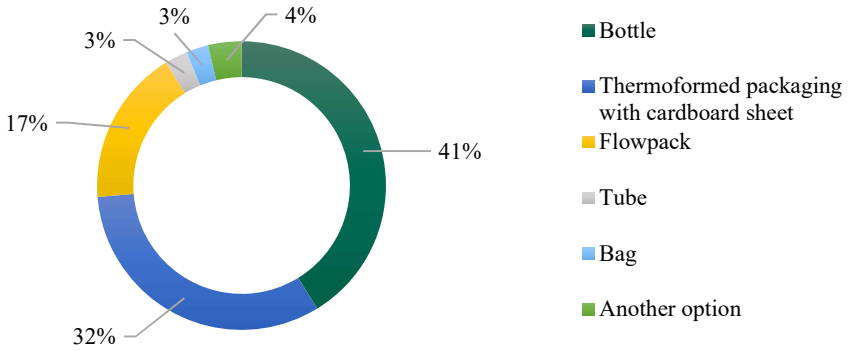


Fig. 2.77. Representation of packaging shapes

Analyzing the information on the label on the package (see Fig. 2.78), it was concluded that 37.50% of the information is printed on the polymer label without indication (PLB); 33.75% printed on the package (D); 27.50% printed on packaging and paper label without indication (D_PB); 1.25% printed on paper label without indication and on polymer label without indication (PB_PLB).

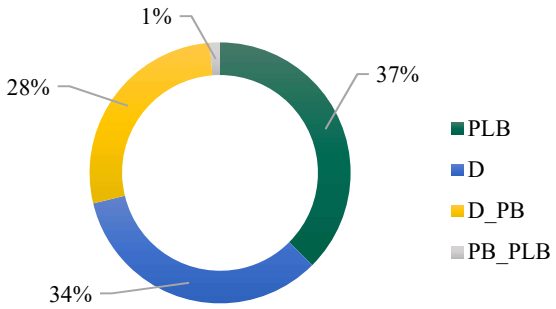


Fig. 2.78. The label, its type and an indication of the label material, where:

- PLB – polymer label without an indication of the label material;
- D – information printed on the package;
- D_PB – printing on the packaging and on the paper label without indication;
- PB_PLB – paper label without printed label material indication and polymer label without label material indication.

Analyzing the packaging print of this product group (see Fig. 2.79), it was concluded that 85.00% of the base material of all samples of this group is without print; while 12.50% - fully printed and 2.50% - partially printed

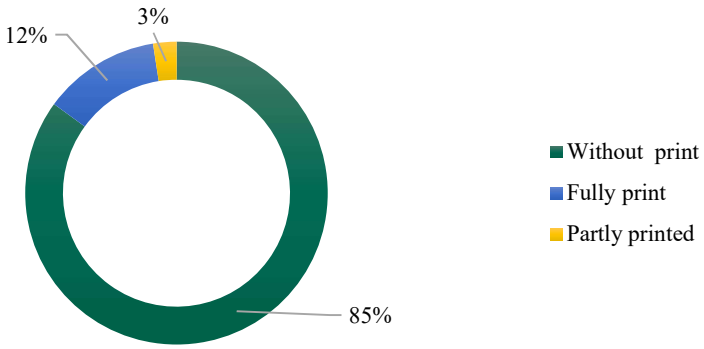


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Fig. 2.79. Print volume of packaging

Analyzing the samples of this group, it was concluded that 70.00% of the samples had an appropriate package size, while the remaining 30.00% were too large. On the other hand, none of the samples had double packaging, which does not affect the expiration date.

2.17. Packaging of garden products

In this category, 50 packaging units are analyzed, covering the following goods, such as different types of fertilizers, mineral mixtures, seeds, substrates, composts and other packaging. The obtained data can be seen in 2.80. until 2.83 Figures.

Summarizing the packaging labels of the analyzed products (see Fig. 2.80), it was concluded that 24.00% of the samples do not have any indication of what packaging material was used. At the same time, the other samples from this group were indicated on the packaging: 12.0% indicated 7(OTHERS), of which 16.6% indicated LDPE and OTHER; 8% will indicate 5(PP); 42% indicated 2(HDPE); 10% specified 1 (PET); 4% will indicate 4(LDPE).

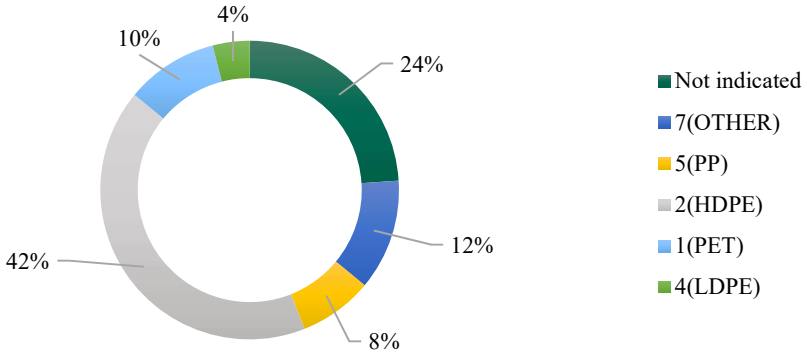


Fig. 2.80. Indication on the packaging of the decoding of the packaging material

Analyzing the shape of the packaging material (see Fig. 2.81), it was concluded that 34.00% of all goods are packed in bottle-type packaging. Of them, 88.2% with a cork and 11.8% with a dispenser (pump) and additionally packed in shrink film. The other samples in this group are packed: 24.00% in flowpack packaging, of which 50.00% in flowpack with cardboard sheet and metal clamp; 20.00% packed in thermoformed packaging, of which 70.00% thermoformed packaging and with a cardboard sheet; 8.00% packed in doypack type packaging; 4.00% in cushion packaging and 2.00% in cardboard box.

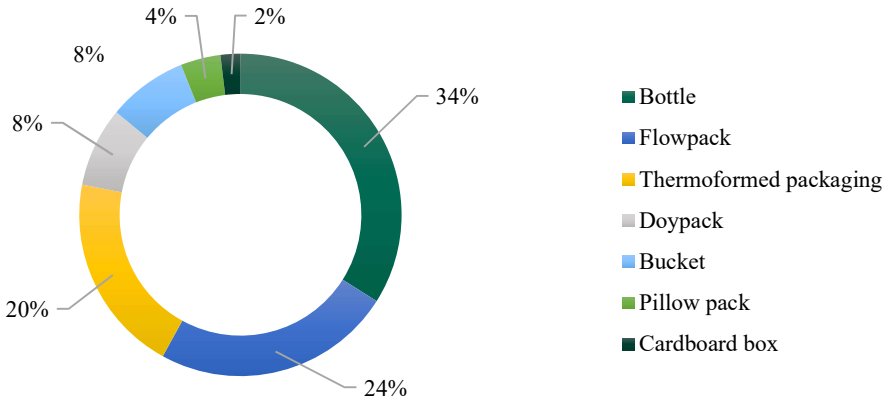


Fig. 2.81. Representation of packaging shapes

Analyzing the information on the label on the package (see Fig. 2.82), it was concluded that 46% of all the samples of this group had the label printed on the package (D); 22.00% on paper without indication (PB); 20.00% on polymer label without indication (PLB); 10.00% printed on the package and on the polymer label without indication (D_PLB); 2.00% printed on the package and on the paper label without indication.

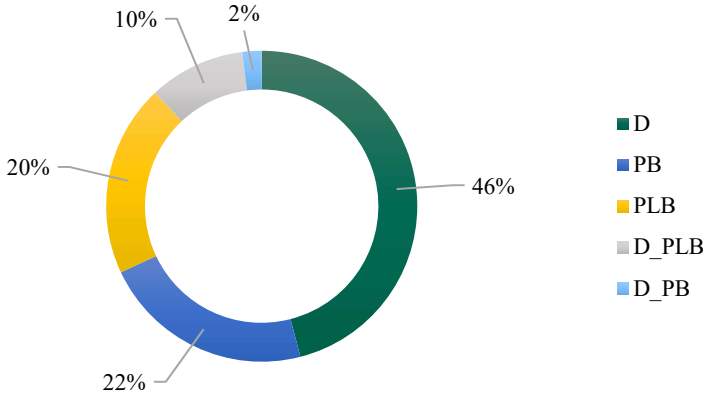


Fig. 2.82. The label, its type and an indication of the label material, where:

- D – information printed on the package;
- PB – paper label without printed label material indication;
- PLB – polymer label without an indication of the label material;
- D_PLB – printing on the package and on the polymer label without label material indication;
- D_PB – printing on the packaging and on the paper label without indication.

Analyzing the printing of the basic material of the goods of this group (see Fig. 2.83), it was concluded that 38% have a lot of printing, 34% - partially printed; 18% - fully printed and 10% packages without printing.

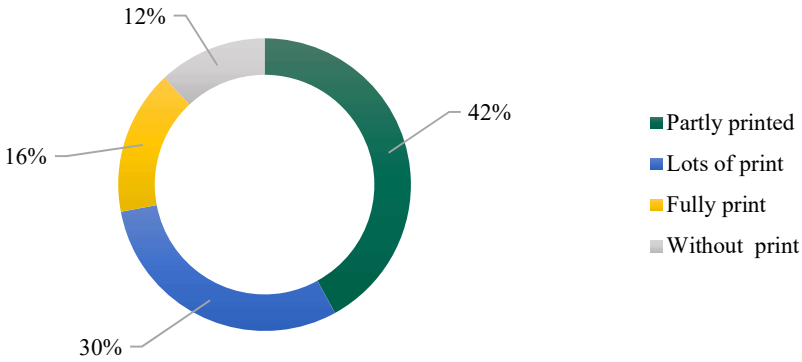


Fig. 2.83. Print volume of packaging

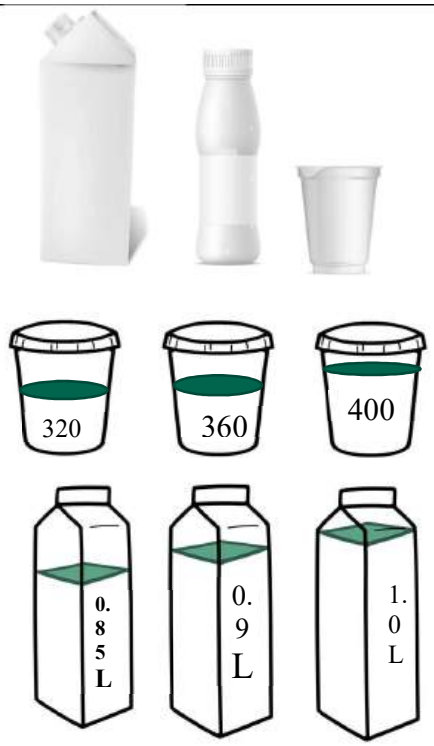
Analyzing the samples of this group, it was concluded that 88.00% of the samples had the appropriate package size, while the remaining 12.00% were too large. On the other hand, 2.00% of all samples of the group had double packaging, which does not affect the expiration date.

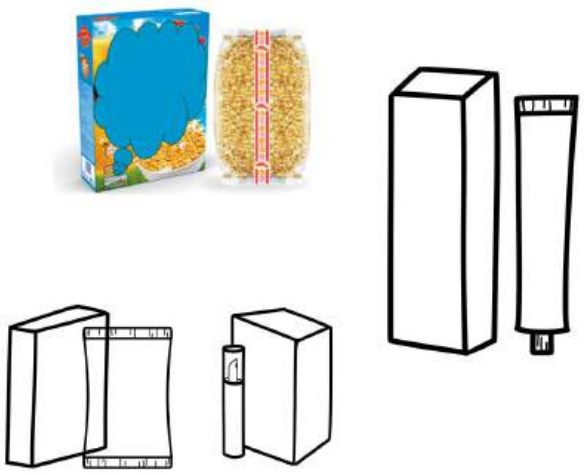
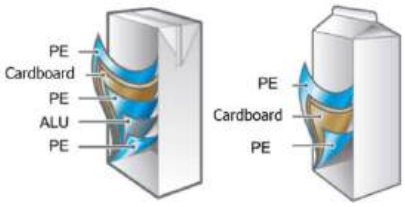
3. ANALYSIS OF OBTAINED DATA

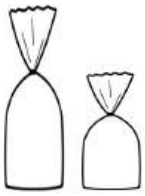
Analyzing the obtained data, a noticeable trend emerges: products imported from different countries, including those within the European Union, exhibit significant variations in their packaging indications. Specifically, there are differences in the presence or absence of numerical codes and the labeling of packaging materials. For example, a substantial portion of products imported from Poland lacks packaging labels. Additionally, when various materials are used for packaging, it is common for not all materials to be represented with numerical codes or designations on the packaging. These observations and illustrations of various products and factual findings are summarized in Table 3.1.

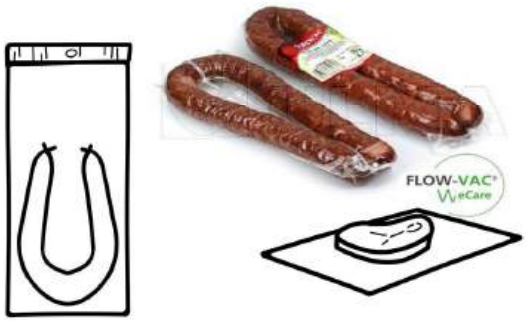
Table 3.1.

Illustration and analysis of the obtained data (pictures are illustrative)

Illustration	Findings and comments
	✓ **Compliance of the volume with the packaged product -** - (grams - 500 - 400 - 360 - 320 ....); - (liters - 1.0 – 0.9 – 0.85 .....). ✓ **Variety of packaging materials for one packaging unit:** - container PP, PET or PS; - reusable cap PS or PET; - fusible cap ALU; - a cardboard label that completely covers the glass. ✓ **Packages are often larger than necessary.** ✓ **Different packaging materials are often used for one packaging unit.**
	

	
	There are many packages containing a polymer package inside a cardboard package, effectively making the polymer package "hidden" since the packaging does not indicate the presence of both materials. Often the cardboard box serves primarily as a design and marketing element and facilitates logistics, but is not essential for maintaining the product's shelf life.
	**Drinks in plastic bottles.** ✓ Relatively well-organized packaging sector in terms of the presenc of packaging material type designations (such as PET) and volume filling. ✓ PET bottles often come with HDPE caps, but many manufacturers do not indicate the cap material on the packaging. ✓ There is a trend that the colors of PET bottles are mostly transparent, green or brown. The variety of bottles in other colors is relatively small.
	**Beverages in laminated cardboard packages.** ✓ Primarily, there are two types of packaging: Tetra Brik and Tetra Rex. ✓ Caps that are non-detachable from the package upon opening.

 	**Bread packaging.** ✓ Compliance of the volume with the packaged product. ✓ The two most common materials are PP or LDPE (monolithic materials), and there are also multi-layer packages indicated by the numerical code 7. ✓ It is very rare for the packaging material to be indicated on the packaging. ✓ If a label is attached to the package, the material of the label is often not indicated. ✓ Some packages have a fairly large unused portion behind the closure, often due to the choice of packaging equipment.
J 	**Cookies, chocolates, candies.** ✓ A large variety of packaging types: - Single layer; - Single layer metallized; - Multi-layered; - Combination of different materials for one packaging unit. ✓ There is an issue with candy packaging where the ends are twisted.
 	**Packaging of perishable products (cheese, sausage, fresh meat).** ✓ There are a wide range of multi-layer materials to provide gas and moisture barrier properties. ✓ Most often used packaging forms are: - Bags, - Dishes, - Thermoforming films.

	✓ There's a broad product group where the majority of materials do not qualify as recyclable packaging. ✓ Often the package size is too large.
	Packages containing larger quantities of products: - "STRETCH" – stretch film; - Shrink film.

As mentioned at the beginning of the research, our focus lies not on analyzing the quantity (volume) of packaging, but rather its diversity. To roughly estimate the package volume, we weighed the packaging units, and the resulting data are summarized in Table 3.2.

Table 3.2.

Weight of the most commonly used packages

Type of packaging	Volume, ml/g	Weight, g
PET bottle with cap	500 ml	24 - 30
	750 ml	30 - 32
	1000 ml	35 - 45
	1500 ml	35 - 47
	2000 ml	40 - 50
	3000 ml	75 - 85
	5000 ml	75 -77
PET cosmetic bottle 0.25 L	250 ml	30 - 33
HDPE cosmetic/hygiene bottle with cork	30 ml	12 - 18
	50 ml	15 - 17
	100 ml	15 - 17
	125 ml	20 - 21
	200 ml	24 - 26
	250 ml	26 - 28
	300 ml	30 - 32
	400 ml	50- 52
	500 ml	45 - 47

	1000 ml	56 - 60
HDPE household chemical bottles with cork	450 ml	28 -30
	500 ml	35 - 39
	750 ml	50 - 55
	1000 ml	40 - 50
Laundry detergent in a polymer bottle	500 ml	30 - 35
	1000 ml	60 - 63
	1500 ml	100 - 102
	2000 ml	98 - 100
	3000 ml	130 - 135
Plastic tube	10 ml	3 - 5
	30 ml	5 - 6
	50 ml	10 - 12
	100 ml	13 -16
	150 ml	20 -24
	200 ml	20 - 25
Packaging bag (800 g of bread) LDPE, 20 - 25 microns	800 g	5 - 6
Packaging bag (300 g of bread) LDPE, 20 - 25 microns	300 g	4 - 5
Packaging bag (300 g of bread) PP, 20 - 25 microns	400 g	4 - 5
PP Flowpack cookie/candy packaging 300 g	200 g	3- 4
Cream, yogurt container/glass PP (450 g) with a lid	450 g	13 - 15
PP container (for packaging 500 g of meat semi-finished products)	500g	15 - 17
OTHER (7) thermoformed container for meat products 300g	300 g	15 -16
PP bucket (container) with lid 770 ml	770 ml	32 - 36
PP bucket (container) with lid 900 ml and handle	900 g	44 - 48
Six-bottle grouping thermal film	900 ml	22 - 30
The polymer film used to wrap the products of one pallet	various	250
Laminated carton package (without aluminum layer)	500 ml	30 - 35
Laminated cardboard package (without aluminum layer) 1 L and cork	1000 ml	32 - 34
Laminated cardboard package (without aluminum layer) 1.5 L	1500 ml	36 - 39
Laminated cardboard package (with aluminum layer) 1L and cork	1000 ml	47 - 49
BAG-in_box polymer packaging with valve metalized packaging 3 L	3000 ml	50 - 60

4. PROVISIONAL INVESTMENT CALCULATION FOR SWITCHING FROM NON-RECYCLABLE PLASTIC PACKAGING TO RECYCLABLE ALTERNATIVES

In order to describe what kind of investments companies will need to switch from non-recyclable to recyclable packaging, interviews were conducted with packaging manufacturers, packaging distributors and food manufacturing companies. For anonymity, specific company names are withheld in the research report. However, the interviewed entities operate in both domestic and export markets, distributing products and packaging materials across various European destinations. Preliminary calculations are outlined in sections 4.1, 4.2, and depicted in Figure 4.3.

Fig. 4.1. Preliminary price comparison €/m² when changing multilayer packaging to VS Mono PET packaging (both have high barrier properties)

Figure 4.1 displays data from a packaging manufacturer based in Germany, whose packaging materials are distributed across Europe. The company has a subsidiary in Latvia, which offers both packaging materials and packaging equipment. This price representation includes only the packaging price without considering packaging equipment and customization costs. It should be mentioned here that the price of the package will also depend on the ordered quantity. The price comparison shown in this figure is for the same amount of packaging material. However, it should be noted that PET material tends to be more expensive compared to many of the packaging materials used previously, and the fusing/remelting process for PET material is somewhat more complex. Nevertheless, PET material holds good potential for usage.

Despite extensive discussions in recent years regarding the transition to recyclable materials, the data presented in Figure 4.2, sourced from the packaging manufacturer/distributor, indicate that users of packaging, such as product manufacturers, are not eager to adopt recyclable packaging. This reluctance stems from the current legislative framework in the European context. Entrepreneurs are adopting a wait-and-see approach until legislative changes occur. As illustrated

in Figure 4.2, only 12% of the total volume sold comprises recyclable packages, reflecting this cautious stance.

Fig. 4.2. Total sales volume (%) multi-layer packaging and VS Mono packaging (data from packaging manufacturer/trader)

It is essential to continue looking for solutions for the packaging of perishable products (cheese, meat, etc.) particularly in light of the Regulation of the European Parliament and the Council on packaging and packaging waste. This regulation, which amends Regulation (EU) 2019/1020 and Directive (EU) 2019/904 while repealing Directive 94/62/EC, grants entrepreneurs an additional two-year transition period after its entry into force. This extension allows for the exploration and implementation of recyclable packaging materials in food packaging, underscoring the urgency of finding sustainable solutions in this sector.

One of the solutions to this problem is soft (flexible or flexible) packaging with a thin layer of EVOH.

Referring to conversations with experts in the field of packaging, the prices of packaging materials are very variable, as an example, the prices of cheese ripening materials could be mentioned. In May 2023, the price of cheese ripening packaging - polymer material multi-layer heat shrink packaging: EVA/PE/EPC/PVDC was from 10,60 EUR to 11,00 EUR per kg. Packaging manufacturers and processors indicate that due to changing prices, changing non-recyclable packaging to packaging more suitable for recycling is 7-10% more expensive based on the price per kg. The price is also significantly affected by the amount of purchased packaging, which is different for each company.

However, it should be remembered that upon the entry into force of the new legislation, it will be prohibited to use materials whose recyclability will be lower than 70% in product

packaging. As mentioned in the regulatory enactments, packages are marked with a recycling mark depending on recyclability (EP Regulation Proposal No. 2022/0396, 2022):

E - less than 70%,
D – at least 70%,
C – at least 80%,
B – 90%,
A – 95%.

By researching regulatory acts, scientific articles and discussing with the participants of the packaging supply chain (packaging manufacturers, food manufacturers and packers, waste managers, consumers, the government) it has become evident that manufacturers need to prioritize educating buyers and consumers about the value, sustainability, functionality, and proper sorting of food packaging. An insufficient level of consumer knowledge about food waste, packaging waste, as well as their sorting process was found. There's a pressing need to shift focus towards altering existing marketing techniques. Emerging trends indicate that for packaging to be effectively recycled, it should ideally comprise minimal layers or types of packaging. The manufacturer needs to choose a package that is light in weight and small in volume. It would be necessary to avoid the use of redundant packaging in the packaging of a food product that fulfills marketing functions.

Interactions with stakeholders involved in various stages of the packaging process reveal that while sustainability concerns are increasingly urgent, substantial changes are unlikely until tax policies regulate packaging prices.

In order to compare the price difference between recyclable and non-recyclable packaging, a preliminary price comparison was made, expressing it as a percentage for the same packaging volumes, which can be seen in the table.

Table 4.1.

Preliminary price comparison of recyclable and non-recyclable packaging

Average material costs, EUR/kg, %	**Recyclable structure vs standard non-recyclable**	**Recyclable, high-barrier structure versus standard high-barrier, non-recyclable**
	MOPE/PE vs PET/PE, %	MOPE/PE-EVOH-PE vs PET/PE-EVOH-PE, %
Flowpack (film)	+ 27.3%	+ 22.1%
Quadseal packages	+ 27.3%	+ 22.1%
Four stitch packs	+ 34.2%	+ 34.7%

As can be seen in Table 4.1., a comparison is made for packages of different shapes, as this is an important factor for companies to understand the possibilities of using the equipment. Which is also closely related to the issue of the maximum possible release of food residues from packaging

forms, especially viscous products, because if the packaging is not sufficiently freed from food residues, then it will not be suitable for processing, or it will significantly complicate it.

To assess the efficiency of emptying various types of packages, we conducted an experiment involving over 30 participants from diverse age groups. Each participant was tasked with emptying a viscous product (mayonnaise) from packages of different shapes. As illustrated in Fig. 4.3, the results indicate that the pillow-shaped package can be emptied most efficiently, whereas the figurative bottle made of polymer material proved to be the most challenging to empty.

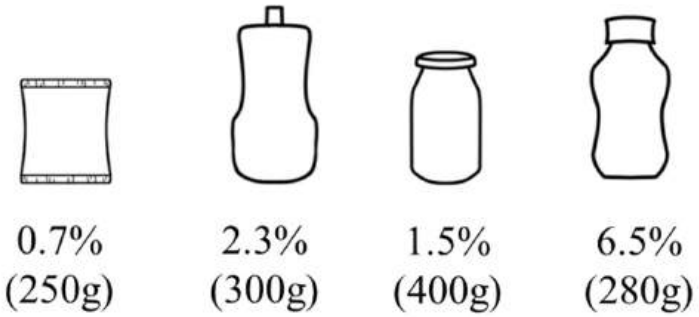


Fig. 4.3. Illustration of the amount of residual viscous product in packages of different shapes after emptying them

In order to fully understand the consumption of packaging material in a food company in Table 4.2. the quantities of packaging used by a food company that produces/processes perishable products are illustrated. It clearly shows the annual consumption of packaging, which totals 52.3 tons.

Table 4.2.

Provisional volume of packaging and (data of the packaging manufacturer), a total of 52.3 tons

Type of packaging shape	Material thickness	Packaging losses (cut edges) packaging adjustment by adjusting the machine when changing packaging rolls	Amount of film used km/year	Packaging units, dimensions	Packaging units, weight	Total tons per year
For thermoforming equipment (top film, printed)	60 μm	1.5%	300 km/year	1 pc (200x 122 mm) x2 (because 2 packages are packed in the machine at	Weight 3g x2	7.4

				the same time)		
For thermoforming (bottom film)	250 µm	1%	300 km/year	1 pc (200x 122 mm) x2 (because 2 packages are packed in the machine at the same time)	Weight 8g x2	39.3
Flowpack film (printed)	50 µm	2%	300 km/year	1 gb 160 mm	Weight 3 yrs	5.6

Considering the aforementioned factors, Figure 4.4 highlights the necessity of assessing packaging changes comprehensively. While reducing packaging volume is essential, it must be done in a manner that preserves product quality. As the research indicates, optimizing packaging usage in Latvia requires careful consideration of various aspects.

Fig 4.4. Aspects affecting packaging change.

INSIGHTS DERIVED FROM DISCUSSIONS WITH MANUFACTURERS IN THE PACKAGING AND FOOD INDUSTRY

1. The upcoming regulation will replace the directive, resulting in uniformity of EU legislation across all member states and providing greater legal certainty. However, during the transition phase, this poses challenges for both packaging manufacturers and product manufacturers, making business operations more complex.
2. The shift towards minimal packaging and diversity, as indicated by labeling, not only results in reduced packaging waste but also mitigates environmental impact and resource consumption. Packaging must be environmentally friendly and sustainable, it is the only possible path for further development. However, **achieving this necessitates cost-effective packaging solutions that align with circular economy principles.**
3. It is expected that, in response to the forthcoming legislative changes, extensive and vigorous discussions will occur in all EU countries to formulate and implement sustainable and cost-effective packaging solutions.
4. Addressing this challenge will be equally difficult in Latvia.

Concerns and threats packaging manufacturers have expressed regarding the implementation of the regulation:

1. Possible increase in competition and further segmentation in terms of packaging raw material resources available to small, local and international companies:
   - Access to raw materials and resources.
   - Access to technology.
2. Compliance with all the legal requirements will increase bureaucratic processes and document preparation.
3. The industry id facing significant implementation costs across all levels:
   - Development and implementation of new technologies for packaging reuse are necessary.
   - New infrastructure capacity for packaging manufacturers, product manufacturers and procesors is required.
   - Creation of a unified infrastructure for shared collection and efficient sorting throughout the EU is essential.
4. Changes in packaging raw materials must be implemented in a manner that ensures the safety of both consumers and goods:
   - Alternative solutions are required, which may involve reducing, replacing, or even banning current options.
   - Price adjustments may accompany the adoption of new solutions.
   - There may be limitations or shortages in the availability of raw materials.

Entrepreneurs are expressing concerns regarding:

1. **Color fastness of packaging printing**. Typically, printing on packages occurs within the layers of the material, forming a laminate where the print layer resides between material layers. This method, currently the most prevalent, ensures the color within the package is more durable. However, without a laminate layer protecting the color layer, there is a heightened risk of color wear and tear due to direct exposure to environmental factors. Damaged packaging not only fails to attract consumers but also fosters distrust in the entrepreneur and the products they produce. For buyers and consumers, worn packaging is synonymous with low quality, creating a direct correlation. Additionally, deteriorating packaging may become illegible/unreadable, contravening legislative requirements and internal quality standards of companies.
2. **Packaging processors often lack clarity on certain matters.** For instance, an entrepreneur producing food items with fats or oils, who chooses recyclable packaging materials, encounters an issue where packaging processors classify the packaging as non-recyclable. Packages with fat and oil residues are deemed non-recyclable in Latvia due to the absence of suitable technological solutions for recycling. However, in Europe, such packages can be recycled using a hot washing method before recycling. In Latvia, the cold washing method is utilized before recycling, failing to effectively remove fat and oil residues, thus rendering the packaging non-recyclable.
3. **Lack of a unified classification system at the national level**. Manufacturers express a desire to provide clear guidance on packaging regarding which waste container should be used for disposing of the packaging from a specific entrepreneur's food products. However, given that waste sorting requirements vary across different regions of Latvia, it is difficult for manufacturers to easily and comprehensively indicate to consumers (using pictograms) which container a particular package should be placed in.
4. **Buyers' and consumers' convenience and preference for recyclability.** Entrepreneurs express concerns about potential decrease in sales volumes due to preference for existing product packaging. Since the current consumer-friendly packaging used in production is typically multi-layered and composed of various materials.
5. **Possibility of recycling small (by size) packaging, such as candy wrappers.**
6. Packaging and food manufacturers find the packaging recycling stage as the weakest link in Latvia's packaging circulation, emphasizing that **recycling is much more advanced in many other European regions**. Failure to address issues related to processing packaging from fatty products in Latvia, as well as finding solutions to separate the paint content in packaging, could lead to food production companies in Latvia falling behind their counterparts in other countries in the global food market. This could significantly slow down the development of products in Latvia and hinder export opportunities, ultimately negatively impacting the growth and advancement of the national economy. Without resolution, materials categorized as recyclable in the EU may not be effectively recycled in Latvia, potentially leading to their incineration, which does not align with EU recycling regulations.

FINDINGS AND CONCLUSIONS

1. The variety of packaging types in Latvian retail supermarkets is very extensive and should be significantly streamlined.
2. Research in Latvian retail supermarkets reveals the following distribution of packaging types:
   - The largest group, accounting for 25.31% (one-fourth) of the packaging, is polypropylene (PP). However, this group includes various types of PP packaging.
   - The second largest group, making up 21.88%, consists of packages where the type of packaging is not indicated.
   - A significant group, comprising 12.59%, consists of packaging materials marked with the numerical code 7. These are mostly difficult to recycle due to their multi-layer composition.
   - PET packaging follows, representing 11.65%, primarily consisting of bottle packaging, which is relatively well recyclable in Latvia.
   - Lastly, polyethylene (PE) packaging accounts for 13.53%, divided into 7.25% LDPE and 6.28% HDPE.
3. The most organized and uniform packaging group is the packaging of non-alcoholic beverages.
4. Many packaging solutions in the Latvian market can be optimized to reduce the overall volume of packaging.
5. Many packages in Latvian retail are covered with printing that serves solely marketing purposes and provides no information.
6. In most cases, replacing multi-layer packaging materials with barrier properties (which are not recyclable) with recyclable materials will increase costs by approximately 30%, using current packaging materials.
7. Product and goods manufacturers are concerned about additional cost increases that will arise when ordering packaging materials from a different supplier if the existing one cannot provide recyclable options. The cost of remaking clichés is also a concern, as this will incur additional expenses.
8. Changing packages may require adapting the packaging equipment, such as adjusting fusing temperatures from approximately 130°C to 200°C. Depending on the existing equipment, these modifications can cost up to 20,000 EUR.
9. Some existing equipment may not allow for temperature adjustments, necessitating the purchase of new packaging equipment. Depending on the type of equipment, the cost can be up to 200,000 EUR.

RECOMMENDATIONS

FOR PACKAGING MANUFACTURERS. Expand the range of packaging materials while maintaining functionality. When fulfilling orders for customers, propose packaging solutions with reduced varnish and paint to streamline the recycling processes. Search for solutions for the developing recyclable packaging, aiming to minimize the costs as much as possible.

FOR PRODUCT / GOODS MANUFACTURERS. Conduct a comprehensive internal audit of the packaging area (packaging materials and packaging equipment) within their companies to assess the sustainability of the packaging practices. During the audit, focus on factors such as the compatibility of the package sizes with products and goods to maximize volume utilisation (so that the package volumes are filled to the maximum), the recyclability of the packaging materials and the necessity of double primary packaging (packaging within a package). Review the amount of printing on manufactured goods/products packaging, aiming to redesign towards sustainability. Reduce the use of a multiple of packaging materials for a single unit aiming for consistency (for example: a cup from one type of material, a label from another, a fused coating from a third, but a reusable and removable cap from a fourth type of packaging material). Assess packaging equipment to minimize waste during packaging adjustments in the process of changing packaging rolls, etc., as well as how much packaging remains in packaging scraps from the packaging molding and/or fusing processes. Explore possibilities of switching from non-recyclable packaging to recyclable packaging, considering factors like fusible packaging, equipment usage, product expiration dates, and supplier change risks. Introduce innovative solutions where feasible, such as incorporating relief or embossing instead of print color. Develop technologies to minimize the number of packages and types of packaging used for products.

FOR RETAILERS. To encourage more widespread adoption of reusable packaging. Reduce and limit the use of packaging bags. When selecting the range of products for inclusion in sales points, prioritize sustainability in packaging alongside factors like product variety, quality, expiration date, and price.

FOR WASTE MANAGERS. The study identified the final stage of the packaging waste lifecycle, after products have been removed, as the weakest link in the packaging circulation system. Improvements are needed in waste sorting infrastructure to ensure consistent practices across all regions of Latvia, as current discrepancies confuse consumers. Efforts should focus on collecting all types of packaging post-use to gather larger volumes, as inadequate collection often results from an inability to meet minimum quantity requirements for profitable logistics and recycling processes. Consumer education is crucial, as many are unaware, for example, that packaging labeled as PP can be disposed in the same container as packages with the numerical code 5 or 05, nor is it clear to them that all these three variants represent the same thing - polypropylene. Enhanced communication is also needed to inform producers and consumers about which packages are recyclable in the Latvian context, ensuring alignment between theoretical knowledge and practical recycling capabilities.

FOR REGULATORY BODIES. Enhance the implementation of European legislation aimed at reducing packaging waste across all stages of the packaging circulation system to ensure that entrepreneurs in Latvia are in an equal situation with entrepreneurs from other EU countries. Establish and enforce unified waste sorting standards nationwide to prevent inconsistencies and promote fair competition. Combat greenwashing by enforcing stringent packaging labeling requirements, drawing inspiration from systems like Italy's comprehensive labeling approach, which delineates the materials and components used in each package. Legislators have a lot of power in driving sustainable packaging practices as evidenced by insights from interviews indicating that few company are inclined to introduce changes on their own initiative. Instead, many interviewed companies await changes in legislation due to substantial impact of costs and regulations on their decision-making processes.

FOR THE EDUCATION SECTOR. Enhance public education initiatives targeting individuals of all age groups, spanning from preschoolers to seniors, to raise awareness about methods for minimizing packaging, diverse packaging types, recycling, waste sorting, and the utilization of secondary packaging options.

FOR THE GENERAL PUBLIC. Consider functionality when making purchases. Opt for quantities that minimize waste, ensuring you won't discard the product along with its packaging. Prioritize products with sustainable packaging principles in mind: avoid half-empty or excessively decorated packages, and bring reusable shopping bags. Purchase only what you truly need and opt for reusable packaging when available. Responsibly sort waste according to established guidelines. Remove food residues before disposing of packaging in the appropriate waste container. Educate yourself and others about the packaging life cycle, develop critical thinking skills, and scrutinize information to identify misrepresentation, whether intentional or unintentional.

FOR EVERYONE AND ANYONE. All participants in the packaging life cycle, including those involved in raw material development, packaging production, product/packaging filling, marketing, purchasing, usage, emptying, legislative regulation, and waste recycling, bear collective responsibility. The study highlights the pivotal role of education in ensuring the success of the packaging life cycle. Legislators, producers, recyclers, and retailers must allocate resources for public education initiatives. While the public plays a crucial role in the packaging life cycle, a lack of understanding among the populace hinders effective functioning of the cycle.

PRESENTATIONS OF RESULTS
(during the implementation of the project)

1. 13/04/2023. Presentation "Research and Analysis of Plastic Packaging on the Latvian Market" in the workshop "Sustainable Packaging: From Design to Recycling 2023" co-organized by LBTU in Jelgava, in the premises of LBTU. Program: https://www.llu.lv/sites/default/files/files/articles/Programma_0.pdf
2. 11/05/2023. Participation in the international scientific conference "16th Baltic Conference on Food Science and Technology FOODBALT 2023: Traditional Meets Non-Traditional in Future Food", with a presentation "Packaging Analyzis for a Sustainable Future", held in Jelgava. Program:
   (Paralel session III. Presentation O9)
   file:///C:/Users/Lietotajs/Downloads/Foodbalt%202023%20program%20final%20(2).pdf
   Reference to the project in the book of abstracts pp7 and 43
   file:///C:/Users/Lietotajs/Downloads/FoodBalt_2023_Abstract_book.pdf
3. 07/06/2023. Rentae Ruska had defended her Bachelor Thesis: Ruska R. (2023) "The Impact of Packaging on Cheese Quality for Sustainability in the Circular Economy: A Bachelor's Degree Thesis", Latvia University of Life Sciences and Technologies, Jelgava: LBTU, 41 p.
4. 29/06/2023. Presentation in the Congress "V World Congress of Latvian Scientists "Science for Latvia"", Riga, Latvian National Library, section Green Transformation (Green Transformation of Energy: Challenges and Opportunities) https://www.zinatneskongress.lv/programma (Section: Green Transformation, where the posters selected by the Scientific Committee of the Congress were presented in an oral report).
5. 16/11/2023. Presentation in the event "Latvia – a Country with No Waste". Research paper: "5000 Packages to be Recycled".
6. 06/02/2024. Presentation to the EC reprasentatives online about the planned research on the composition and quantity of plastic packaging offered on the Latvian market, VARAM.
7. 24/04/2024. Presentation "A Study on Packaging Sustainability in Retail in Latvia: Facts, Challenges and Potential Solutions" in the workshop "Sustainable Packaging: From Design to Recycling 2024" co-organized by LBTU in Jelgava, in the premises of LBTU. Program: https://www.lbtu.lv/lv/raksts/2024-04-15/lbtu-jelgava-norisinasies-seminars-par-ilgtspejigu-iepakojumu

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The information reflects only the LIFE Waste To Resources IP beneficiaries' view and the European Climate, Infrastructure and Environment Executive Agency is not responsible for any use that may be made of the information contained therein.

ANNEX

Annex 1

Waste processing companies in the Baltic States and Poland

Country/ company	Type of recycled materials	Location	Homepage	Designation
Latvia				
AS "Clean R"	LDPE film, HDPE plastic and PP big-bags	Ķekava	https://cleanr.lv	In the map
AS "Eco Baltia"	PET (bottles)	Jelgava	https://www.petbaltija.lv	In the map
SIA "Nordic Plast"	PET (bottles)	Olaine	https://www.nordicplast.lv	In the map
Lithuania				
Polymer Recycling	Combined packaging, coffee cup and other waste recycling, combined paper recycling. With plastic and aluminum	Molėtų g. 18A, 18169 Pabradė	https://polymer.lt/	In the map
Somlita	LDPE film	J.Matulaičio a. 5-27, LT-05111 Vilnius	https://somlita.lt	In the map
Plasta Group	PET (film)	Savanoriu ave. 180 LT-03154 Vilnius	https://plastagroup.com/	In the map
GEROVĖ, UAB	PET	Draugystės g. 19, LT-51126 Kaunas	http://www.maiseliai.lt/	In the map
ECSO	LDPE film	Sandėlių str. 18, LT-02248 Vilnius	http://ecso.lt/	In the map
Estonia				
Nores Plastic	PP, Trading with common plastics (LDPE, HDPE, PET...), engineering plastics (ABS, PC, PMMA, POM...) and hard-to-handle or exotic grades (coextruded films, mixed plastics...) from post-consumer or post-industrial sources	Vesivärava 13-5 10126, Tallinn	https://www.nores.ee/	In the map

Orkos Estonia OÜ	LDPE film	Orkos Estonia OÜ, Lao tn 5 Maardu 74114	https://www.orkos.ee/	In the map
Poland				
Aaglob SA	PVC	ul. Popiełuszki 84, 38-400 Krosno	https://aaglob.com	In the map
Atus Group	HDPE	Sadkowa Góra 12, 39-305 Borowa	https://www.atus.com.pl	In the map
GPR Guma i Plastik Recycling	PE, PP	ul. Świętego Jana Pawła II 18, 37-205 Zarzecze	https://www.gpr-guma.pl	In the map
Invest Raw	HDPE, LDPE, LLDPE	ul. Obornicka 117, 62-002 Suchy Las	https://invest-raw.com	In the map
EuroPlastic Polska	LPDE, HDPE, PP	Kawle Dolne 4e 83-304 Przodkowo	http://www.europlastic.pl/oferta.php	In the map
Novo Plastic	ABS, HDPE, LDPE, LLDPE, PA, PC, PMMA, PP, PS	ul. T. Kościuszki 2F, 58-160 Świebodzice	www.novoplastic.pl	In the map
PET recycling team	PET	PRT Radomsko Sp. z o.o. PL-97-500 Radomsko Ul. Geodetów 8	https://petrecyclingteam.com/pl	In the map
Pro-way	HDPE, LDPE, PP, PS	Warszawice 89 D, 08-443 Sobienie Jeziory	proway.pl	In the map
Recyklon	PP, LDPE HDPE	ul. Słowiańska 17A, 75-846 Koszalin	https://www.recyklon.pl/	In the map
Reko Prime	PE	ul. Jana Pawła II 104, 42-300 Myszków woj. śląskie	https://www.reko-odpady.pl	In the map
Oplast-Recykling	LDPE, PE, PP, PS	Winduga 6, 87-617 Bobrowniki	https://oplast-recykling.pl	In the map
Wtórplast-Recykling	PET, PP, PS, PC, PVC, ABS, POM, PBT	Czapury, ul. Poznańska 14B, 61-160 Poznań	https://www.wtorplast-recykling.pl	In the map

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