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3/2022

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OF THE PACKAGING INDUSTRY

THE FUTURE OF PLASTIC PACKAGING



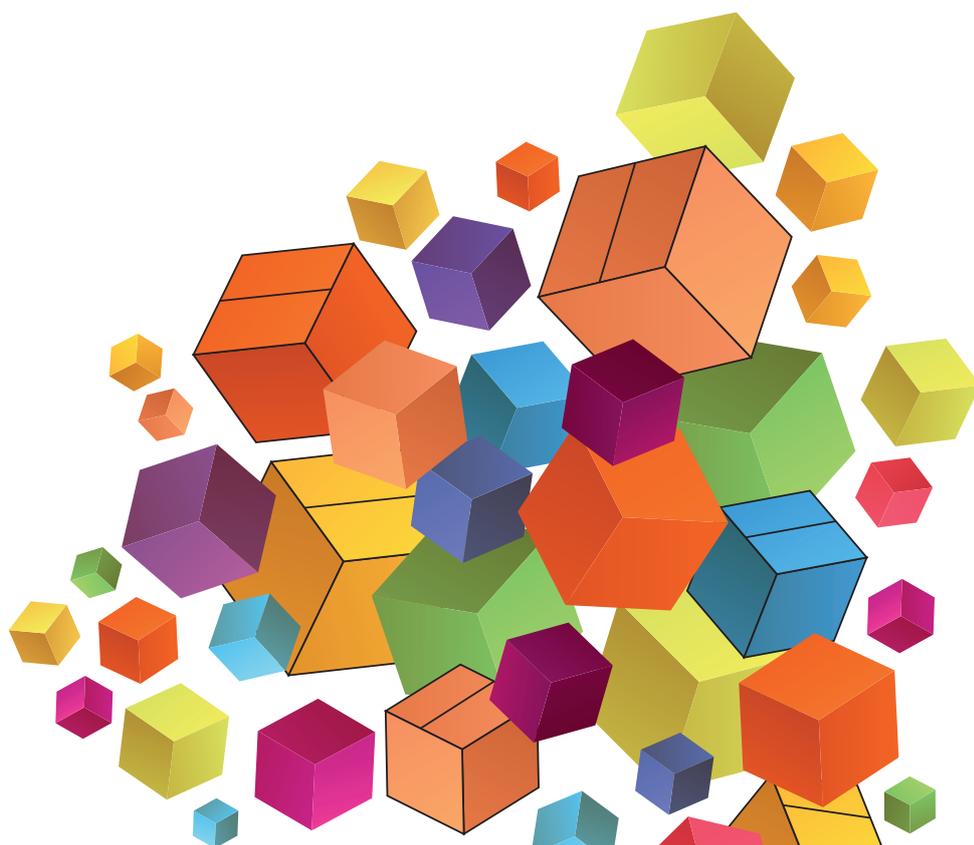
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Dear Readers!

On November 17-18th at Sheraton Hotel in Sopot, the 11th Conference „Safe Packaging” will be organized by the Publishing House Alfa-Print. The mentioned event promises to be extremely interesting!

On November 17th, the theoretical lectures, approximating the problems of design and production of safe, economic and effective packaging and, also, highlighting the technologies which facilitate their production, will be delivered. The exchange of the experience with the market leaders is also foreseen. A lot of attention will be paid to a circular economy in packaging industry. The mentioned event will be ended with the discussion panel – ML Polyolefins company will be its host.

At the evening, the gala dinner will take place. It will be combined with the ceremony of awarding the PCE Certificates (Packaging Circular Economy) to the successive printing houses which care of the appropriate management of production waste. The mentioned certificates will be granted by ML Polyolefins.

On November 18th, the participants will visit the laboratory of JS Hamilton (in Gdynia) which has been recently considerably developed.

The registration and detailed agenda of the meeting and the total event is available at the konferencja.opakowanie.pl

We invite warmly to the participation in the Conference!

Stefan Jakucewicz, DSc, PhD, Prof. emeritus Warsaw University of Technology. A graduate of Łódź University of Technology in the field of cellulose and paper technology, as well as Warsaw University of Technology in the field of printing. From 1974 he was a researcher at TU Warsaw. Since September 2018 he has been a pensioner. The editor of the sections in the periodicals: *Opakowania* (Packaging) and *Przegląd Papierniczy* (Paper Review). Research interests: printing materials science, paper technology and printing techniques of various substrates, with particular emphasis on plastics and the production of printed packaging, production of banknotes and postage stamps (security prints), certification of new base materials for both classic and digital printing techniques. Author or co-author of over 300 scientific articles published in Ukrainian, Slovak and German national journals, and 70 scientific and scientific-technical books published in Polish, German, Slovak and Ukrainian.

Drodzy Czytelnicy!

W dniach 17-18 listopada br. w hotelu Sheraton w Sopocie wydawnictwo Alfa-Print organizuje 11. edycję konferencji „Bezpieczne Opakowanie”, która zapowiada się wyjątkowo interesująco!

17 listopada będą miały miejsce prelekcje teoretyczne, przybliżające zagadnienia projektowania i wytwarzania bezpiecznych, ekonomicznych i skutecznych opakowań, a także prezentujące technologie umożliwiające ich produkcję oraz wymiana doświadczeń z rynkowymi liderami. Dużo uwagi poświęcimy gospodarce o obiegu zamkniętym w przemyśle opakowaniowym – wydarzenie zwieńczy panel dyskusyjny, którego gospodarzem będzie firma ML Polyolefins.

Wieczorem odbędzie się integracyjna kolacja, połączona z wręczeniem świadectw PCE (Packaging Circular Economy), które zostaną przyznane przez firmę ML Polyolefins kolejnym drukarniom dbającym o właściwe zagospodarowanie odpadów produkcyjnych.

18 listopada odwiedzimy laboratorium firmy JS Hamilton, które w ostatnim czasie zostało znacząco rozbudowane.

Rejestracja i szczegółowa agenda wydarzenia na konferencja.opakowanie.pl

Zapraszamy!

Dr hab. inż. Stefan Jakucewicz, em. prof. PW. Absolwent Politechniki Łódzkiej w zakresie technologii celulozy i papieru oraz Politechniki Warszawskiej w zakresie poligrafii. Od 1974 roku pracownik naukowo-dydaktyczny Politechniki Warszawskiej, od września 2018 emeryt. Redaktor działowy w czasopismach „Opakowanie” i „Przegląd Papierniczy”. Zainteresowania naukowe: materiałoznawstwo poligraficzne, technologia papieru oraz techniki drukowania różnych podłoży ze szczególnym uwzględnieniem tworzyw sztucznych i produkcji opakowań drukowanych, produkcji banknotów oraz znaczków pocztowych (druki zabezpieczone), atestacja nowych materiałów podłożowych przeznaczonych tak do klasycznych, jak i cyfrowych technik drukowania. Autor lub współautor ponad 300 artykułów naukowych opublikowanych w czasopismach krajowych, ukraińskich, słowackich i niemieckich oraz 70 książek naukowych i naukowo-technicznych wydanych w językach polskim, niemieckim, słowackim i ukraińskim.

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PHYSICAL HAZARDS OF FOOD PACKAGING MANUFACTURE

ABSTRACT: Physical contamination includes all material and foreign bodies which have incidentally penetrated foodstuffs. Packaging may become one of the sources of their occurrence. In the present paper, the results of the conducted studies and the conclusions, resulting from their identification as well as evaluation of importance of potential physical hazards which might occur in food packaging production, were presented. The mentioned hazards were indicated by Polish producers and certified in accordance with BRC GS Packaging Materials. The mentioned studies demonstrated also the areas of the enterprises' activity where the physical hazards were identified. They showed the significance of the discussed threats at a given stage of manufacturing process, as well.

Key words: food packaging, physical hazard, significance of physical hazards

STRESZCZENIE: Zanieczyszczenia fizyczne to wszystkie materiały i ciała obce, które przypadkowo dostały się do żywności. Jednym ze źródeł ich występowania mogą być opakowania. W artykule przedstawiono wyniki badań i wnioski z identyfikacji oraz oceny istotności potencjalnych zagrożeń fizycznych mogących wystąpić w produkcji opakowań do żywności, wskazanych przez polskich producentów, certyfikowanych na zgodność z brytyjskim standardem BRC Packaging Materials. Badania pokazały również obszary działalności przedsiębiorstw, w których identyfikowane są zagrożenia fizyczne oraz jaka jest ich istotność na danym etapie procesu.

Słowa kluczowe: opakowania do żywności, zagrożenia fizyczne, istotność zagrożeń fizycznych

INTRODUCTION

Food packages are industrial products, intended for placing food products inside them; they must guarantee health safety of the stored food and ensure health protection of the consumers. The aim of applying the packaging is to protect food against the factors which might cause food deterioration, such as inter alia, light, oxygen access, chemical contamination, presence of microorganisms and mechanical damages (Czerwińska, 2018). In turn, safety is a status which gives a feeling of certainty and calm to the man in a longer time perspective (Rybińska and Galińska, 2014). A package which is intended to come into contact with food should be treated as a product, being independently introduced to the market as well as a product, inherently connected with food (Lisińska-Kuśnierz and Kawecka, 2012). Food packaging production is a global industry, which is characterized by internal diversity and each of its sectors affects individually the situation at the market.

The requirements concerning packaging and articles, destined to come into contact with food are systematically growing. It happens so as the interest of the consumers in fresh products with the extended shelf-life and the controlled quality is constantly increasing. Additionally, it is expected that the packaging is modern and simultaneously safe. It is a challenge to the sector of food packaging and a driving force for development of new and improved ideas of packaging technologies (Barska and Wyrwa, 2017). If we want to ensure a safe food product to our customer, the problems of food safety must refer to all participants of the food chain. It includes also the producers of packaging materials. The participation in the food chain must incline each entity acting at the food market (from the farmers to retail merchants), to preserve the appropriate care and ensure that safety and quality of manufacture of the products are found on respectively high level. It must mean, inter alia, honesty and activity consistent with the binding law,

being demonstrated everyday and guaranteeing such values as safety of the product and its protection, quality, authenticity of the composition and origin, complex information about the product and traceability throughout the whole chain (Wiśniewska, 2017).

BASIC LEGAL REQUIREMENTS DEMANDED FROM FOOD PACKAGING PRODUCERS

Producers of food packaging have to observe the obligatory legal regulations. Consistency of packaging materials with the legal requirements for food producers means, inter alia, that they must know what material would be the best for packaging the specified products (Lenartowicz-Klik, 2020). Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety imposes the obligation to assess the safety of the products, taking into account all the relevant aspects, in particular the categories of the consumers. In Poland, the mentioned Directive is implemented via the Act on 12 December 2003 on general safety of the products. According to this Law, „the safe product is such product, which under the common conditions of use, or under the other conditions which might be foreseen in a justifiable way, with the consideration of the time of the product’s use and, also, depending on a type of the product, way of its launching and the requirements of installation and maintenance, does not make any risk to the consumers, or makes an insignificant risk, which might be reconciled with its common use and considers a high level of requirements concerning human health and life protection”. Therefore, when assessing the safety of the product, we have to consider as follows: properties of the product, including its composition and packaging, its effect on other products, appearance of the product, its labelling, precautions and instructions for its use and any guidelines and information relating to the product, being available to the consumer. Besides it, we should analyse the categories of the consumers who are exposed to the risk in connection with the use of the products, and in particular, children and older persons. The product which does not meet the mentioned above requirements is not a safe product and by this, it makes a risk. The serious risk is understood

as infringement of the safety requirements, requiring the immediate measures to be undertaken; when analysing such risk, we should consider the direct or later consequences of the product’s use, including the degree and probability of the consumer health and life loss, the degree of threat to the particular consumer categories and the possibility of the correct evaluation of the risk by the consumers and the possibilities of its avoidance.

When referring to the food packaging, we should pay attention to the fundamental legal law in this respect, i.e. Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with foodstuffs. The mentioned Regulation is applied in the case of materials and products which – in a ready-to-use state – are destined for the contact with food or remain already in the contact with food and are intended for this purpose. We may, additionally, reasonably expect that they will be brought to the contact with food or the migration of its components to food will happen in the case of their application under normal or foreseeable conditions. Regulation No 1935/2004 refers to Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority (EFSA)¹ and laying down the procedures in respect of food safety. In Article 5 of Regulation 1935/2004, there is a reference to categories of materials. Within the frames of the mentioned groups, we may distinguish, inter alia, plastics, paper and cardboard, metals and alloys and glass, i. e. the raw materials which are used for production of packaging and packaging materials intended to come into contact with food. The reference to Annex I of Regulation 1935/2004 and the indicated groups of materials is also found in the Commission Regulation (EC) 2023/2006 of 22 December 2006 on good manufacturing practice for materials and articles intended to come into

¹ European Food Safety Authority (EFSA) – agency of the European Union dealing with independent advisory scientific activity in respect of existing and occurring threats connected with the food chain

contact with food, indicating that they should be produced in compliance with general and detailed rules of good manufacturing practice (GMP). Good manufacturing practice means those aspects of quality assurance which ensure that materials and articles are consistently produced and controlled to ensure conformity with the rules applicable to them and with the quality standards appropriate to their intended use by not endangering human health or causing an unacceptable change in the composition of food or causing a deterioration in the organoleptic characteristics thereof (Article 3, point (a)). The confirmation of the conformity of the packaging material with GMP by the producer means that the system of quality assurance has been established including: choice of starting materials consistent with the earlier set requirements (ensuring the compliance of finished product with legal regulations), conducting the operations in accordance with the earlier established procedures and the methods of proceeding, ensuring the compliance of the finished product with the fixed procedures and establishment of the quality control system (Pawlicka, Mazańska and Barbarska, 2017).

Regulation 1935/2004 gives, first of all, the basis for development of detailed legal regulations; we should, however, add that only plastic packaging materials were comprehensively regulated at the EU level by the Commission Regulation (EC) No 10/2011 of 14 January 2011 on plastic materials intended to come into contact with foods. The remaining packaging materials are evaluated on the grounds of the regulations of a given country, adopted later on by the successive states, or of the regulations intended principally for other categories of products but employed also for the discussed type of packaging. The requirements concerning paper in the European Union were regulated by German Federal Institute of Risk Assessment (BfR – Bundesinstitut Für Risikobewertung), subordinate to Federal Ministry of Food, Agriculture and Consumer Protection of Germany when developing the Recommendation XXXVI – Paper and board for food contact (2019). Gradually, with the time, the successive countries adopted the mentioned recommendation concerning paper and cardboard as binding and at present it has become the basic interpretation which the producers and laboratories in area

of paper product safety are referring to. The successive regulations concerning paper were created by the Federation of the European Paper Industries (CEPI)². In March 2019, CEPI and FEFCO (European Federation of Corrugated Cardboard Producers), International Confederation of Paper and Cardboard Processors in Europe, paper suppliers and other associations, developed the new Guidelines concerning articles and materials made from paper and cardboard, intended to come into contact with food. The guidelines concern paper and cardboard products and tissue products (paper towels and serviettes) and they are expected to increase the support for the producers so that the production would be consistent with legal rules and the products would be safe for the customers (Werner, 2020). In the Guidelines, there were analysed the problems concerning the requirements of compliance with the law regulations in respect of components and manufacturing processes, tests of compliance and their methodology and frequency, guidelines concerning traceability and labelling of the products and, also communication in the supply chain. In turn, glass packages do not have developed legal requirements, being directly addressed to this material, so the attempts are undertaken to combine glass with ceramics which is subordinate to the requirements of the Commission Directive 2005/31/EC of 29 April 2005 in respect of declaration of compliance and criteria of effectiveness of the analytical method in the case of ceramic products, intended to come into contact with food. Metals are subjected to control on the grounds of guidebook: „Metals and alloys used in food contact materials and articles. A practical guide for manufacturers and regulators, 2013”). The guide was developed by the Committee of Experts on Packaging Materials for Food and Pharmaceutical Products and published by the European Directorate for the Quality of Medicines & Health Care (EDM) as guidelines for producers of metal packaging.

² CEPI is the all-European association, representing textile and paper industries. CEPI, via national associations, agglomerates several thousand papermaking plants in the whole Europe, which produce paper, cardboard, cellulose mass and other biodegradable products (from technology of wood fibres to advanced designing of paper)

The mentioned above rules and recommendations are aimed at support of national political decision-makers in order to increase harmonization of technical standards between the countries.

PHYSICAL HAZARDS IN PRODUCTION OF FOOD PACKAGING

Physical contaminants of food include all materials and foreign bodies which have incidentally penetrated foodstuffs (Sitarz and Janczar-Smuga, 2012). When considering various ways of food contamination with foreign bodies, we can classify the physical hazards in a following way:

- those which appeared in the product together with the raw materials (e. g. sand, sticks, leaves),
- those present in the raw materials (e. g. fragments of bones, fruit stones),
- those which were transferred to the products during the technological processes (e.g. metal elements, plastic elements),
- those which appeared in the products due to failure in observing the sanitary standards by the staff and of applying the correct protective clothes (e.g. jewellery, hair, buttons),
- those which appeared in the product as a result of non-observing the principles of good manufacturing practice (GMP) (e. g. glass, pieces of gypsum or paint),
- those which were intentionally introduced to the products (Kołóżyn-Krajewska and Sikora, 2010).

Analogically, with small exceptions, the mentioned sources of hazards and the hazards themselves may be transferred to

the packaging and their producers as the participants of the food chain.

The source of foreign body in food may be, inter alia, the packaging. Under normal conditions, the foreign bodies do not occur, so they come inside the product due to negligence or failures, taking place mainly during manufacture and storage (Wiśniewska, 2018). Foreign bodies represent various levels of hazard; apart from it, a degree of their elimination is also different. The basic physical hazards include: glass, wood, stones and sand, metal elements, plastic, elements of jewellery, nails and hair.

The sources of physical hazards may be different, commencing from raw materials, via the manufacturing process, elements of machines and equipment and packaging elements, to the staff, performing manufacture and storage work (Kołóżyn-Krajewska, 2013; Krzysztofik, 2016). The detailed presentation of physical hazards and the sources of their origin are given in Table 1.

THE RESULTS OF THE STUDIES

The studies were carried out in the second half of 2019, using survey questionnaire which was sent to the enterprises, certified on the compliance with BRC GS Packaging Materials³.

³ BRC GS Packaging Materials, as being developed by British Association of Retailers is – in Poland – the most popular certified voluntary standard concerning quality and safety in packaging sector; during performance of the mentioned studies, 5th version of standard – Packaging and Packaging Materials was a binding document. At present, the obligatory version is BRC Packaging Materials 6:2019

TAB. 1. PHYSICAL HAZARDS AND THE SOURCES OF THEIR ORIGIN

Type of hazard	Source of the hazards
Glass	Windows, electric bulbs, glasses, watches, screens
Wood	Pallets, mixing devices (agitators), tables
Stones, sand, dust	Raw materials, cleaning process, elements of buildings (e. g. dropping wall plaster)
Metal	Machines and equipment, buttons, edges, needles and other tools
Plastic	Machines and equipment, elements of work clothes, pallets, agitators, staff (objects, worn in the pockets)
Hair, nails	Staff

SOURCE: KOŁOŻYŃ-KRAJEWSKA, 2013; EMBLEM AND EMBLEM, 2014

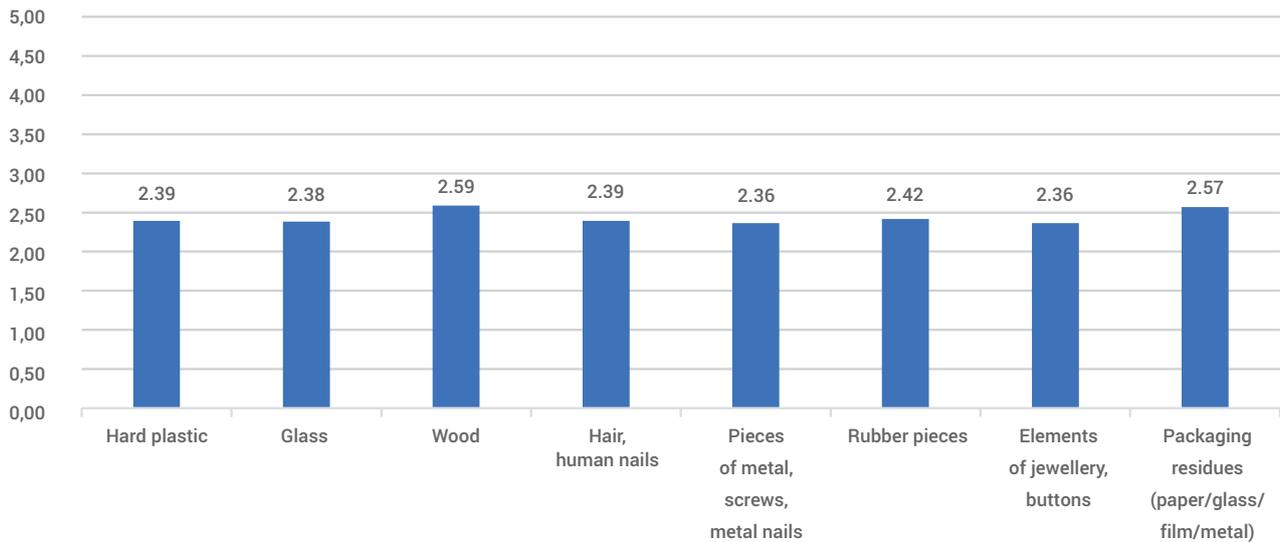


FIG. 1. SIGNIFICANCE OF PHYSICAL HAZARDS (SCALE 1-5)

SOURCE: OWN ELABORATION

The survey was participated by 122 enterprises, producing packaging from paper and cardboard, plastic, glass and metal. Within the frames of the studies, the enterprises were asked to indicate which physical hazards – according to their opinion – were most significant for the safety and quality of packaging (where 1 meant decisively insignificant hazard whereas 5 meant decisively relevant hazard). According to the respondent in general, the significance of all hazards was found on a similar level (Fig. 1). The enterprises indicated wood (2.59 in 5-score scale) as the most significant hazard. The source of wood

includes pallets, agitating devices or die-cut forms. Almost identical level of significance was indicated for packaging residues which would be not appropriately separated in manufacturing process. It includes the so-called „hairs“, i.e. thin threads of film, and, also, pieces of paper and cardboard, metal filings and very small glass particles. Successively, the enterprises indicates such hazards as rubber pieces, hair, human nails, elements of hard plastic or glass, metal pieces, screws, metal nails, buttons and jewellery elements. At the same time, the respondents had the possibility to indicate the

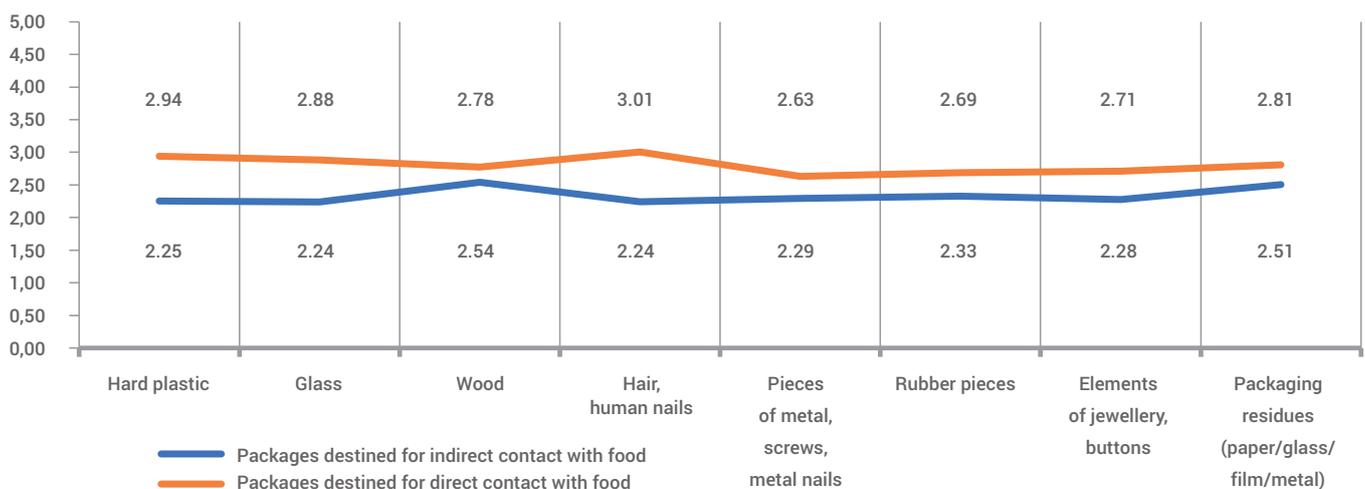


FIG. 2. SIGNIFICANCE OF PHYSICAL HAZARDS WITH CLASSIFICATION ACCORDING TO DESTINATION OF PACKAGING (SCALE 1-5)

SOURCE: OWN ELABORATION

additional physical hazards but they did not do it. It could include, for example, sand, elements of building such as plaster, or insects. The mentioned attitude may result from a very good state of infrastructure, high sanitary standards and high awareness of the employees but also, from a small awareness of the importance of different physical hazards in manufacturing process. The respondents could indicate such hazards but they could assess them as having a low importance.

Fig. 2 shows the significance of the indicated above hazards with classification into packaging intended for direct and indirect contact with food. In case of all hazards, the consumers recognized that the significance in the case of direct use packaging was higher than the importance of materials used in indirect contact with food. In the case of the direct contact packaging, physical hazards in a form of hair and nail elements (significance level 3.01), then hard plastic (2.94) and glass (2.88) were most significant. In the case of packaging for the indirect contact with food, the most relevant hazard came from wood (2.54) and packaging residues which have not been properly separated (2.51).

The tested enterprises had also the task to indicate the stage of manufacturing process where the physical hazards were

identified (Fig. 3). All the enterprises identified physical hazards in the following areas: storage of raw materials, implementation of the particular stages of production and storage of finished products. The smallest number of enterprises identified the physical hazards in area of the storage of semi-products (74% of enterprises).

Besides it, the task of the enterprises was to assess the significance of physical hazards, indicated in the respective areas (scale 1-5, where 1 meant decisively insignificant hazard whereas 5 meant decisively significant hazard). The summary of the assessment of significance of physical hazards in the particular areas was given in Fig. 4. The enterprises indicated implementation of manufacturing processes as the area where the occurrence of physical hazards is most significant (significance level 2.77). Besides it, raw materials and packaging process were the most relevant source from a viewpoint of identified physical hazards (significance at the level of 2.57 and 2.56, respectively). On the other hand, the least significant area in the context of physical hazards, as indicated by the respondent included areas of loading and transport of the products to the customer (the product is found, most frequently, packed on the pallets and protected by the packaging of stretch

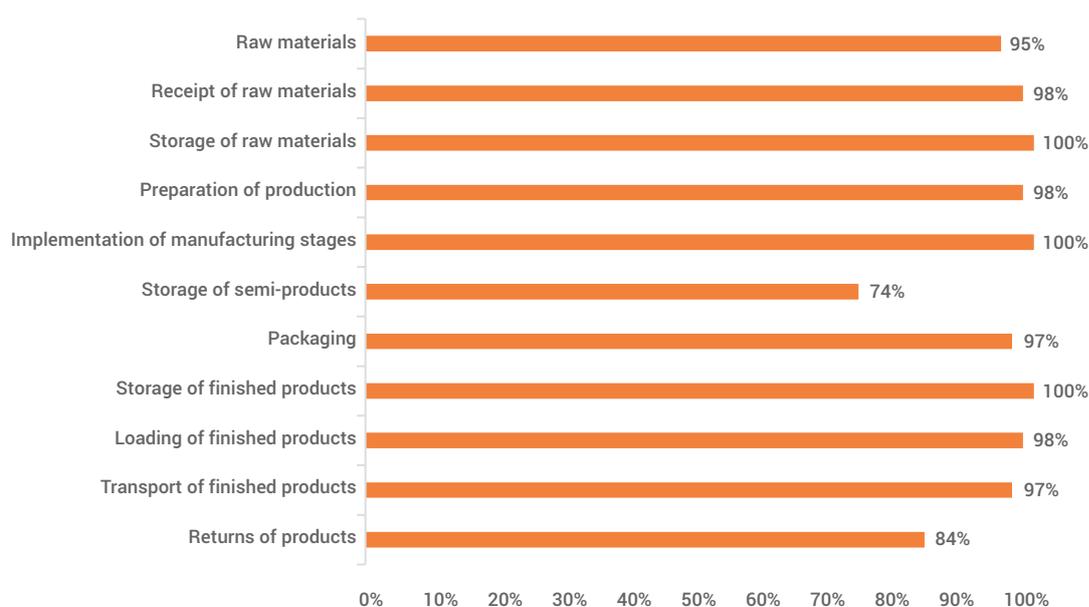


FIG. 3. AREAS OF ACTIVITY WHERE THE ENTERPRISES IDENTIFIED PHYSICAL HAZARDS (IN %)

SOURCE: OWN ELABORATION

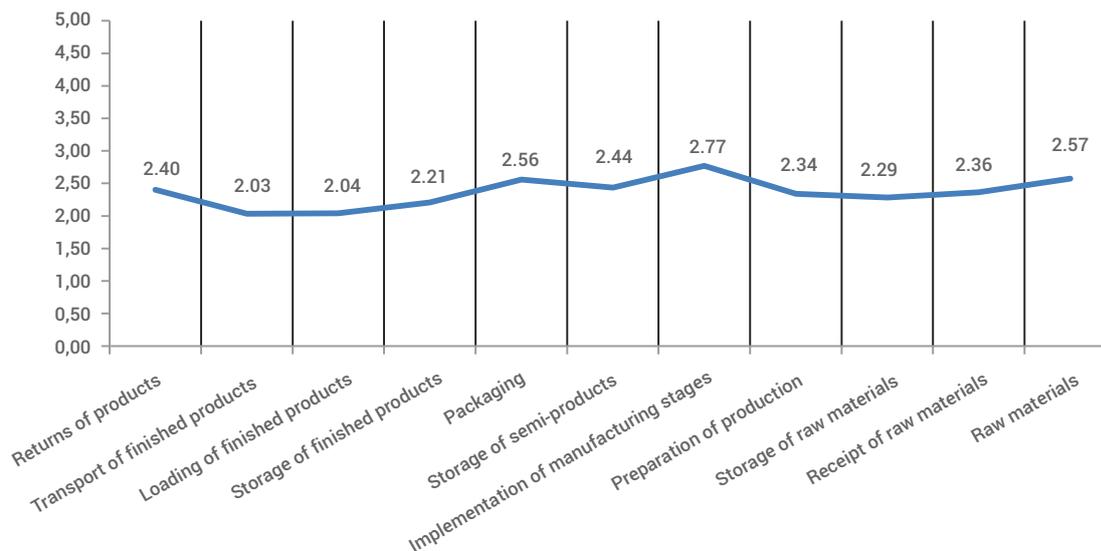


FIG. 4. SIGNIFICANCE OF PHYSICAL HAZARDS IN RELATION TO STAGES OF MANUFACTURING PROCESS (SCALE 1-5)

SOURCE: OWN ELABORATION

film type; by this, the possibility of foreign bodies" penetration inside seems to be much limited).

CONCLUSIONS

The appropriate and comprehensive identification of physical hazards in production of packaging intended to come into contact with food is extremely important from the viewpoint of food safety and by this, consumer health and life. The results of the conducted studies among the producers of food packaging showed that the producers identified the most significant physical hazards and assessed their importance at the medium level. It may confirm the justness of areas, which require control, as indicated by BRC GS Packaging Materials. Standard imposes a special supervision of glass, wood and hard plastic, puts the pressure on the appropriate maintenance and repairs of machines, stresses the role of observing the principles of hygiene in respect of working clothes and jewellery (inter alia, cover of head, gloves, ban on jewellery and nail tips or lacquering the nails). In relation to the enterprises which have not introduced any quality and safety assurance system and have a lot of quality troubles or a great number of complaints, the results of the tests may be the confirmation of the justness of implementing and certifying the quality and safety management systems.

BIBLIOGRAPHY:

1. Barska, A., Wyrwa, J. (2017). *Innovations in the Food Packaging Market – Intelligent Packaging – a Review*. Czech J. Food Sci. 35 (1).
2. BfR Recommendation XXXVI – Paper and board for food contact. 2019. Bundesinstitut Für Risikobewertung, Berlin.
3. Czerwińska, D. (2018). *Dobrze zapakowane*. Przegląd gastronomiczny. Nr 6/18. (In English: *Well packaged*. Gastronomic Review, No 6/18)
4. Dyrektywa 2001/95/WE Parlamentu Europejskiego i Rady z dnia 3 grudnia 2001r. w sprawie ogólnego bezpieczeństwa produktów. Dziennik Urzędowy Wspólnot Europejskich (OJ L 11/4 03.12.2002). (In English: Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety. Official Journal of Laws of the European Communities, OJ L 11/4 03.12.2002)
5. Dyrektywa Komisji 2005/31/WE z dnia 29 kwietnia 2005r. zmieniająca dyrektywę Rady 84/500/EWG w odniesieniu do deklaracji zgodności i kryteriów skuteczności metody analizy w przypadku wyrobów ceramicznych przeznaczonych do kontaktu ze środkami spożywczymi. Dziennik Urzędowy Unii Europejskiej. (OJ L 110/3630.4.2005). (In English: Commission Directive 2005/31/EC of 29 April 2005 amending Council Directive 84/500/EEC as regards a declaration of compliance and performance criteria of the analytical method for ceramic articles intended to come into contact with foodstuffs. Official Journal of the European Union, OJ L 110/3630.4.2005)

6. Emblem A., Emblem, H. (2014). *Technika opakowań*. Warszawa: Wydawnictwo Naukowe PWN. (In English: *Packaging Engineering*. Warsaw, Scientific Publications PWN)
7. Kołożyn-Krajewska, D. Sikora, T. (2010). *Zarządzanie bezpieczeństwem żywności: teoria i praktyka*. Wydawnictwo C. H. Beck. (In English: *Food safety management. Theory and practice*. Publication C. H. Beck)
8. Kołożyn-Krajewska D. (2013). *Higiena produkcji żywności*. Warszawa: Wydawnictwo SGGW. (In English: *Food production hygiene*. Warsaw, Publication of Warsaw University of Life Sciences)
9. Krzysztofik, B. (2016). *Bezpieczeństwo żywności i systemy kontroli jakości*. Kraków. Wydawnictwo: Krakowska Szkoła Promocji Zdrowia. (In English: *Food safety and quality control systems*. Cracow. Published by Kraków School of Health Promotion)
10. Lenartowicz-Klik, M. (2020). *Materiały opakowaniowe do kontaktu z żywnością*. Przemysł spożywczy. Nr 74.
11. Lisińska-Kuśnierz M., Kawecka A. (2012). *Zapewnienie bezpieczeństwa opakowań produktów żywnościowych w łańcuchu dostaw*, Handel wewnętrzny. Nr 1. (In English: *Ensuring safety of food packaging in the supply chain*. Doestic Trade no 1).
12. Metals and alloys used in food contact materials and articles – 1st Edition (2013). European Directorate for the Quality of Medicines & HealthCare Council of Europe, Strasbourg.
13. Pawlicka, M., Mazańska, M., Barbarska, R. (2017). *Opakowania do żywności-dokumenty, potwierdzenie zgodności*. Przemysł spożywczy. Nr 71. (In English: *Packaging for food – documents, confirmation of compliance*. Food Industry, No 71).
14. Rozporządzenie (WE) Nr 1935/2004 Parlamentu Europejskiego i Rady z dnia 27 października 2004r. w sprawie materiałów i wyrobów przeznaczonych do kontaktu z żywnością oraz uchylające dyrektywy 80/50/EWG i 89/109/EWG. (OJ L 338, 13.11.2004). (In English: Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/50/EEC and 89/109/EEC (OJ L 338, 13.11.2004).
15. Rozporządzenie Komisji (WE) Nr 2023/2006 z dnia 22 grudnia 2006 r. w sprawie dobrej praktyki produkcyjnej w odniesieniu do materiałów i wyrobów przeznaczonych do kontaktu z żywnością. (OJ L 384/75, 29.12.2006). (In English: Commission Regulation (EC) No 2023/2006 of 22 December 2006 on good manufacturing practice for materials and articles intended to come into contact with food (OJ L 384/75, 29.12. 2006).
16. Rozporządzenie Komisji (WE) Nr 10/2011 z dnia 14 stycznia 2011 r. w sprawie materiałów i wyrobów z tworzyw sztucznych przeznaczonych do kontaktu z żywnością z późniejszymi zmianami. Dziennik Urzędowy Unii Europejskiej. (OJ L 12, 15.01.2011). (In English: Commission Regulation (EC) No 10/2011 of 14 January 2011 on plastic material s and articles intended to come into contact with food. (OJ L 12, 15.01.2011)
17. Rozporządzenie (WE) Nr 178/2002 Parlamentu Europejskiego i Rady z dnia 28 stycznia 2002 r. ustanawiającego ogólne zasady i wymagania prawa żywnościowego, powołującego Europejski Urząd ds. Bezpieczeństwa Żywności oraz ustanawiającego procedury w zakresie bezpieczeństwa żywności. Dziennik Urzędowy Unii Europejskiej. (OJ L 31, 1.02.2002). (In English: Regulation (EC) 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, OJ. L 31, 1.02.2002)
18. Rybińska, K., Galińska, B. (2014). *Bezpieczeństwo żywności w łańcuchu dostaw*. Logistyka. Nr 3/2014. (In English: *Food safety in the supply chain*. Logistics. No 3/2014)
19. Sitarz S., Janczar-Smuga M. (2012). *Współczesne zagrożenia bezpieczeństwa żywności i możliwości ich kontroli oraz eliminacji*. Nauki Inżynierskie i Technologie. Nr 2 (5). (In English: *Contemporary risks to food safety and the possibilities of their control and elimination*. Engineering Sciences and technologies. No 2 (5).
20. Ustawa z dnia 12 grudnia 2003 r. o ogólnym bezpieczeństwie produktów (Dz. U. 2003 Nr 229 poz. 2275 z późn. zm). (In English: Act of 12 December 2003 on general safety of products (Official Journal of Laws, no 229, item 2275 with later amendments)
21. Werner, A. (2020). *Wytyczne dotyczące artykułów i materiałów z papieru i tektury przeznaczonych do kontaktu z żywnością*. Przegląd Papierniczy. Nr 6/2020. (In English: *Guidelines concerning the articles and materials made from paper and cardboard, as intended to come into contact with food*. Paper Review, No 6/2020).
22. Wiśniewska, M. (2017). *Future – przyszłe kierunki potrzeb i uwarunkowań w zapewnieniu jakości żywności*. W: Skrzypek, E., Piasecka, A, Sagan S. *Nowa jakość a zadowolenie interesariuszy*. Lublin: Wydawnictwo UMCS. (In English: *Future directions of needs and conditions in ensuring food quality*. In: Skrzypek, E., Piasecka, A., Sagan S. *A new quality and satisfaction of stakeholders*. Publication Lublin, UMCS)
23. Wiśniewska, M. (2018). *Kultura bezpieczeństwa żywności*. Warszawa: CeDeWu Sp. z o.o. (In English: *Culture of food safety*. Warsaw CeDeWU Ltd.)

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THE FUTURE OF PLASTIC PACKAGING

ABSTRACT: Plastic packaging is an important segment of the packaging market. Producers and users of some single-use polymer packaging will have to prepare for the constraints associated with the introduced legal regulations and higher costs connected with the extended producer responsibility, as well with the adaptation of packaging to recycling.

Key words: packaging, plastic packaging, recycling

STRESZCZENIE: Opakowania z tworzyw sztucznych stanowią ważny segment rynku opakowań. Producenci i użytkownicy niektórych opakowań jednorazowego użycia z tworzyw polimerowych będą musieli przygotować się na ograniczenia związane z wprowadzanymi regulacjami prawnymi oraz wyższymi kosztami związanymi z rozszerzoną odpowiedzialnością producenta, a także dostosowaniem opakowań do recyklingu.

Słowa kluczowe: opakowania, opakowania z tworzyw sztucznych, recykling

INTRODUCTION

The beginnings of plastic industry (polymer plastic) date back to the half of 19th century; the first-in-history artificially produced polymer materials were derivatives of the natural ones. The development of petrochemical industry caused, however, that during the successive decades it became the main supplier of technology and polymer materials. Plastic has found application as comprehensive packaging material due to its numerous advantages (e.g. low weight, high mechanical resistance, barrier properties, easiness of moulding and overprint, low price, etc.). Its production utilizes a high range of polymers, characterized by the properties which are suitable for the viewpoint of optimization of packaging processes, storage and transport of different products. The appropriately chosen polymers (co-polymers) together with the property-modifying additives render the appropriate physico-mechanical and chemical properties to the products; they enable processing and ensure the correct protection of the packaged articles.

It should be stressed that more than 50% of the products present at the European market are packed in plastic packaging; the total mass of the mentioned packaging is only 17%. During

the recent 10 years, a considerable reduction of packaging mass was recorded— by ca. 28%. Plastic packaging is perfectly suitable for protection and securing of foodstuffs and contributes to reduction of food waste quantity as they protect the perishable food products in the hygienic way and ensure their longer shelf-life.

Single-use plastic packaging create however many problems at the stage of waste production and the obtained level of recycling is considerably lower as compared to other materials such as paper, glass or metals:

- Diversity of polymer materials in packaging is a significant barrier in recycling processes and affects the quality and value of plastic coming from recycling. The uniform polymers are subjected to reprocessing what requires careful waste segregation and increases the costs of selective collection.
- A big group of plastic packaging and the packaging with plastic participation is not suitable for recycling due to the composition (non-approved combination of different polymers and other materials), construction or residues of packaged product.

- Littering of the earth environment and contamination of waters of seas and oceans. The situation becomes worse together with the increase of consumption of single-use packaging which is discarded after a short use, being seldom subjected to recycling.
- The waste may become a new source of releasing the plastic particles to the environment what creates additional possible risk. Micro-particles of plastic – small fragments of plastic material (size below 5mm) – are accumulated in the seas and their small dimensions make that they are easily swallowed by the sea organisms. They may also penetrate the food chain. The newest studies demonstrated also the presence of microgranules of plastic in the air, drinking water and foodstuffs although the consequences to health have not been yet known.

LEGAL RESTRICTIONS CONCERNING SINGLE-USE PLASTIC PACKAGING

Into legal system of the European Union, the specified restrictions for single-use plastic packaging have been introduced. They are contained in the following Directives:

- Directive 2015/720/EU¹ introducing instruments aiming at the reduction of the quantity of the lightweight plastic carrier bags, used in trade. In Poland, on the grounds of *Act on management of packaging and packaging waste*², the bags

1 Directive of the European Parliament and of the Council no 2015/720/EC of 29 April 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags (Official Journal of Laws of EU L 115/11 of 26.5. 2015)

2 Act of 13 June 2013 on management of packaging and packaging waste (i.e. Official Journal of Laws of 2020, item 114, 2361, of 2021, item 2151)

TAB.1. SINGLE-USE PACKAGING COVERED WITH THE PROVISIONS OF DIRECTIVE 2019/904/EU

No .	Types of packaging	Legal and economic instruments
1.	Cups for drinks beverages	Reduction of the applied quantity in the years 2022-2026 Marking requirements ROP* costs
2.	Containers for food intended for direct consumption	Reduction of the applied quantity in the years 2022-2026 ROP costs
3.	Oxydegradable plastic packaging	Ban on the use
4.	Plates	Ban on the use
5.	Containers for food intended for direct consumption made from of EPS	Ban on the use
6.	Beverage containers made of EPS	Ban on the use
7.	Cups for beverages made of EPS	Ban on the use
8.	Containers for drinks, capacity up to 3 litres	Closures connected permanently for the period of intended use ROP costs <ul style="list-style-type: none"> • obligatory targets of collection for recycling: • up to 2025 r. collection of 77% of the weight of the introduced to turnover • up to 2029 r. collection of 90% of the weight of the introduced to turnover
9.	PET bottles, capacity up to 3 litres	Participation of raw material coming from recycling: <ul style="list-style-type: none"> • from 2025, at least 25% • from 2030, at least 30%
10.	Packaging (bags) and wrappings made from flexible film, containing foodstuffs destined for direct consumption without any treatment	ROP costs
11.	Lightweight carrier bags	ROP costs

* Costs of the extended responsibility of producer (in Polish: ROP): costs of knowledge popularization in respect of counteracting the generation of the waste, costs of the waste collection, transport and processing



PIC. 1. MULTI-USE COTTON BAGS

IN CARREFOUR AND AUCHAN TRADE NETWORKS

[[HTTPS://WWW.RP.PL/HANDEL/ART9066101-AUCHAN-I-CARREFOUR-ZASTAPILY-PLASTIK-BAWELNIANYMI-WORKAMI](https://www.rp.pl/handel/art9066101-auchan-i-carrefour-zastapily-plastik-bawelnianymi-workami)]

with bag wall thickness above 15 microns have been covered by recycling tax, equal to Polish PLN 0.2 / piece.

- Directive 2018/852/EU³ increasing the applicable recycling targets of all types of packaging waste, including plastic waste. The target of recycling in 2025 is equal to 50% and in 2030 as much as 55% what will be connected with the designing of packaging with the consideration of recycling.
- Directive 2019/904/EU (the so-called SUP, *Single-Use Plastics*)⁴ on the impact of certain plastic products on the environment considered certain types of single-use packaging. The types of packaging and the legal and economic instruments, as provided for the mentioned packaging, have been presented in Tab.1. The conception of the single-use plastic packaging (performed completely or partially from plastic) includes all polymer packaging: those derived from oil, from renewable sources as well as the biodegradable and compostable ones. The provisions of the Directive were not sufficiently clear; therefore, in June 2021, guidelines, précising the types of packages covered with the mentioned restrictions, were published⁵. Although the date of implementing the discussed Directive passed in July 2021, eleven EU member states, including Poland have not introduced the guidelines to the Directive to their legal system, whereas sixteen EU member states have already implemented the mentioned Directive; however, practically, each of them has a different approach to its provisions.

EQUIVALENTS OF SINGLE-USE PLASTIC PACKAGING

During the recent years, plastic packaging industry has been found under the extremely high pressure. The introduced legal regulations, limiting the consumption of the mentioned packaging and negative opinions of ecological and consumer environment have intensified the tendencies to replace plastic with other materials. The producers and trade networks try to answer the expectations of the consumers and to eliminate plastic from packaging.

As it is followed from the report of British analytical-advisory organization Green Alliance, the manufacturers employ often solutions and materials which may burden the natural environment in a greater degree (e.g. higher GHG emissions, high water consumption, lack of waste receipt systems, etc.). In many cases, activities in favour of reduction of polymer plastic consumption are chaotic and little effective in solving the problems of the correct management of packaging waste coming from single-use packaging. There are some examples given below of the commercial trade networks which replace plastic bags with those ones made from other materials, and they apply their own subjective criteria of *friendliness to the environment*.

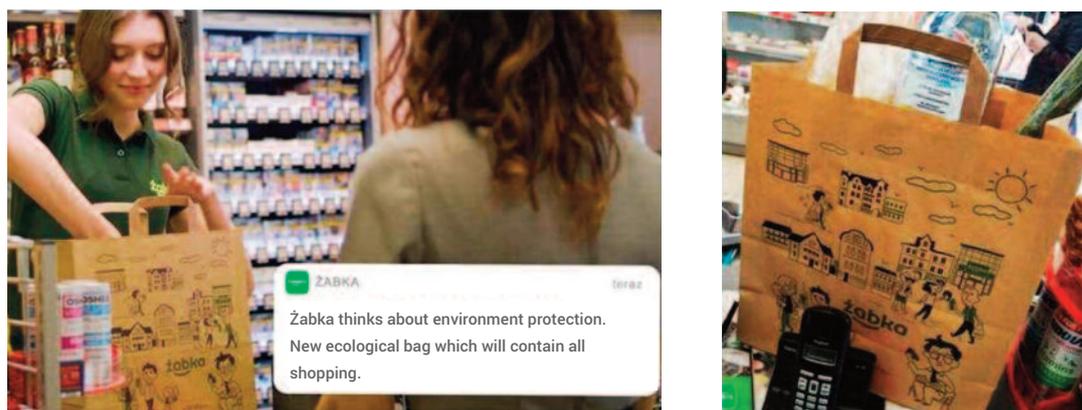
Carrefour and Auchan (Pic. 1) promote – among the customers – multi-use cotton bags for fruits and vegetables at the price of PLN 5, 99/pcs, although it is well known that cultivation of cotton is connected with a high load to the environment: high consumption of water, plant protection agents and herbicides, etc.

Żabka trade network (Pic. 2) remembers about the environment and introduces paper bags which are promoted as ecological.

3 Directive of the European Parliament and of the Council (EC) of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste. (Official J. of Laws UE L 150/141, 14.6. 2018)

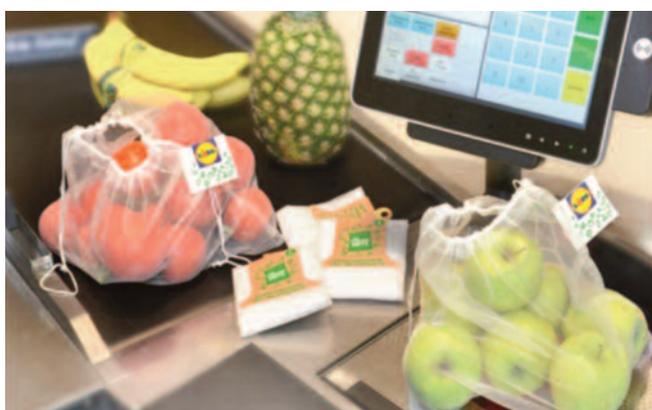
4 Directive of the European Parliament and of the Council (EC) 2019/904 of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. (Official J of Laws EU L 155/1. 12.6. 2019)

5 Commission Notice – Commission guidelines on single-use plastic products in accordance with Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment (2021/C216/01), 7.06. 2021



PIC. 2. PAPER BAGS IN ŻABKA TRADE NETWORK

[[HTTPS://WWW.ZABKA.PL/BIURO-PRASOWE/ZABKA-WYCOFUE-PLASTIKOWE-TORBY-Z-SCIECI](https://www.zabka.pl/biuro-prasowe/zabka-wycofue-plastikowe-torby-z-scieci)]



PIC. 3. POLYESTER BAGS, AS INTRODUCED BY LIDL POLSKA NETWORK

[[HTTPS://WWW.WIRTUALNEMEDIA.PL/ARTYKUL/WIELORAZOWE-WORECZKI-NA-WARZYWA-I-OWOCE-W-LIDLU](https://www.wirtualnemedia.pl/artykul/wielorazowe-woreczki-na-warzywa-i-owoce-w-lidlu)]

Lidl Polska network (Pic. 3) introduced multi-use bags for fruits and vegetables, made in 100% from polyester (polyester is also plastic). The price for the set consisting of two bags is 2.99 PLN. When searching for solutions, being more favourable for the environment, Lidl company has commenced sale of 'multi-bag' (in Polish: "wielokrotka") (Pic. 4), that is, multi-use shopping bag made from a thick polyethylene film, marked with German certificate Blue Angel (confirming the suitability for recycling and the content of raw materials coming from recycling). Multi-use bags for fruits and vegetables made completely from polyester were also introduced by shop network Stokrotka (Pic. 5).

NEONET, the network of electro-markets, has introduced another solution. They offer compostable bags, made from biodegradable biopolymer, produced from potato starch



PIC. 4. MULTI-USE BAGS MADE FROM THICK POLYETHYLENE FILM

[[HTTPS://WWW.BANKIER.PL/WIADOMOSC/LIDL-WPROWADZA-EKOTORBY-WIELOKROTKI](https://www.bankier.pl/wiadomosc/lidl-wprowadza-ekotorby-wielokrotki)]



PIC. 5. POLYESTER BAGS IN STOKROTKA TRADE NETWORK

[[HTTPS://WWW.WIADOMOSCIHANDLOWE.PL/ARTYKUL/STOKROTKA-WPROWADZA-EKOLOGICZNE-TORBY-I-REZYGNUJE-Z-KOLPORTAZU-GAZETEK](https://www.wiadomoscihandlowe.pl/artykul/stokrotka-wprowadza-ekologiczne-torby-i-rezygnuje-z-kolportazu-gazetek)]

NEONET

LET'S SPEAK ABOUT GOOD OFFERS.

I AM MADE FROM POTATO.

Our ecological bags are produced from potato starch granulate owing to almost cosmic technology

Procesy produkcji i pakowania zgodne z normami EN 13432:2002

100% biodegradowalne i kompostowalne

1. ziemniak → 2. mączka ziemniaczana → 3. granulacja → 4. torba kompostowalna → 5. torba gotowa do użycia → 6. torba gotowa do użycia

100% BPA bezwzględnie wolny, nie zawiera nikotyny, wolny od CO2 (zobacz pkt. 5), w 100% z wody i energii

HOME OK COMPOST TÜV AUSTRIA

5 708422 160008 7

PIC. 6. COMPOSTABLE BAGS

[[HTTPS://WWW.WIRTUALMEDIA.PL/ARTYKUL/NEONET-TORBY-ZE-SKROBII-I-ZIEMNIACZANEJ-CENA-RADOISLAW-BACZKOWSKI](https://www.wirtualmedia.pl/artykul/neonet-torby-ze-skrobie-i-ziemniaczanej-cena-radoislaw-baczkowski)]

(Pic. 6). The mentioned bags possess *OK compost HOME* certificate what means that they may be subjected to composting under the conditions of home composter.

DESIGNING THE PLASTIC PACKAGES WITH THE CONSIDERATION OF RECYCLING

Within the frames of closed packaging management model, the systems of recycling play a very significant role; therefore, it is important when designing single-use plastic packaging to bear in mind recycling, especially in the context of the targets obligatory in the years 2025-2030.

The usability of post-use plastic packaging for the reprocessing is limited by diversity of polymers/copolymers and type of packaging. On the one hand, the diversity of plastic (PE, PP, PET, PVC, PS, PA, copolymers and combinations of the mentioned plastic) is a very positive phenomenon as it enables choice of the appropriate properties for requirements of the packaged product. From the perspective of counteracting the waste production, it may be, however, a considerable obstacle in running the selective collection and then, reprocessing. Undoubtedly, the collection of plastic is connected with greater problems than in the case of other packaging materials such as glass, metal, paper or cardboard. The post-use packaging as being collected in the yellow container requires the additional specialized segregation which raises the price of the secondary raw material. The identification of polymer (or polymers) itself in packaging is not easy. To obtain the secondary material with the satisfying quality parameters, the uniform material is required. The most favourable (for recycling) variant includes performance of packaging from non-coloured, uniform polymer and the application of additional elements and components (such as labels, closure, glue, barrier layers in laminates, overprint) which do not constitute barriers in processing technology and allow obtaining the valuable material. We should pay attention to the basic principles concerning material recycling:

- The use of homogeneous polymers, plastics (monoplastics), limitation of types of polymers, application of approvable combinations of polymers
- Elements made from plastic of different density (flotation segregation)

- Limitation of colour intensity, preferred non-pigmented material
- Easy-to-remove closures; after taking off, they should be suitable for recycling
- Easy-to-remove labels (below 60% of surface), optimization of glues for fitting the labels
- In the case of label in a form of sleeves, avoiding full sleeves; they should be easy to remove
- Barrier layers in laminates which do not cause barriers in recycling
- Limitation of the surfaces of overprints
- Application of signs on the label which may facilitate the processes connected with recycling (identification of polymers, sign of suitability for recycling)
- Application of raw materials from recycling.

SUMMING UP

Plastics are an important material in packaging sector; they ensure food safety and reduce its wastage. Production of single-use plastic packaging requires, however, activities aiming at the appropriate waste management and reduction of contamination, caused by such packaging. Although the

packaging market occurred to be extremely resistant to turbulences connected with pandemics, producers and users of certain single-use polymer packaging will have to prepare to restrictions, connected with the introduced legal regulations and higher manufacturing costs, associated with the extended responsibility of the producer. It refers mainly to the cups for drinks, packaging for foodstuffs intended for direct consumption, packages/bags and wrappings made from flexible film, containing food intended for direct consumption without any further treatment, commercial bags, etc.

Certain packaging will be completely eliminated from the market due to the ban on their use and production (packaging made from oxydegradable plastics, dishes, packaging made from foamed polystyrene: containers for foods and drinks and cups). Single-use polymer packaging should consider, to a greater degree, the principles of designing in connection with recycling. Bio-plastics are still in an early stage of development and create a small market niche. Their further development will be connected with the improvement of the properties, availability and reduction in price as well as with the introduction of organic waste collection system for composting.

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COMPARATIVE ANALYSIS OF LABELS PERFORMED BY FLEXOGRAPHIC AND ELECTROGRAPHIC MACHINES

ABSTRACT: In the present paper, the issues connected with two printing technologies in aspect of label printing, were discussed. The main aim of the studies was to compare the copies, obtained from the flexographic machine and from digital machine, utilizing the phenomenon of electrophotography. The comparative analysis was based, first of all, upon the colouristic aspects but other parameters concerning the final copies and the process of their production was considered.

To perform the prints, the following machines were used: Digital Pro 3 and flexographic Performance Series 5 by Mark Andy company. As substrate, the standard self-sticking paper MC FSC S2000NG-BG40BR was used; it is one of the most popular substrates employed in production of labels. The assessment of the copies was carried out on the basis of a special printing test, using spectrophotometer X-Rite eXact.

The digital and flexographic copies were subjected to visual evaluation as well as spectrophotometric and densitometric measurements. For the produced copies, the following parameters were determined: optical density, reproduction of colours, gamut, balance of greyness, relative contrast, trapping, reproduction of small elements, and errors of the process.

On the grounds of the obtained data, the diagrams were prepared and the respective calculations were carried out. The analysis of the measurement results allows concluding that the digital machine, which employs the phenomenon of electrophotography as well as flexographic equipment are very well adapted to label printing. The both discussed devices possess certain defects and advantages; therefore, the choice of machine for printing should be carried out in relation to the defined work and in accordance to the expectations. In summing up, the criteria of the choice were determined and the comparison of the employed techniques was carried out.

Key words: digital printing, flexography, optical density, gamut, printing quality, paper

STRESZCZENIE: W niniejszym artykule poruszane są zagadnienia związane z dwiema technologiami drukowania w odniesieniu do produkcji etykiet. Głównym celem badań jest porównanie odbitek uzyskanych za pomocą maszyny fleksograficznej oraz cyfrowej wykorzystującej zjawisko elektrofotografii. Analiza porównawcza opiera się przede wszystkim na aspektach kolorystycznych, ale rozpatrywane są również inne parametry dotyczące gotowych wydruków, jak i procesu ich produkcji.

Do wykonania wydruków zastosowano maszyny: cyfrową Digital Pro 3 oraz fleksograficzną Performance Series P5 firmy Mark Andy. Jako podłoże użyto papieru standardowego samoprzylepnego MC FSC S2000NG-BG40BR, który jest jednym z najpopularniejszych podłoży wykorzystywanych do produkcji etykiet. Oceny odbitek dokonano na podstawie specjalnego testu druku przy użyciu spektrofotometru X-Rite eXact.

Wydruki cyfrowe i fleksograficzne zostały poddane ocenie wizualnej jak również pomiarom spektrofotometrycznym i densytometrycznym. Dla wykonanych odbitek zbadano następujące parametry: gęstość optyczna, odwzorowanie barw, gamut, balans szarości, kontrast względny, trapping, odwzorowanie drobnych elementów, błędy procesu.

Na podstawie uzyskanych danych utworzono wykresy i dokonano odpowiednich obliczeń. Po analizie wyników pomiarów wywnioskowano, że zarówno maszyna cyfrowa wykorzystująca zjawisko elektrofotografii jak i fleksograficzna są bardzo dobrze przystosowane do drukowania etykiet. Oba urządzenia posiadają pewne wady i zalety, dlatego wyboru maszyny do drukowania należy dokonywać dla konkretnej pracy oraz w zależności od oczekiwań. W podsumowaniu określono kryteria wyboru i dokonano porównania wykorzystanych technik.

Słowa kluczowe: druk cyfrowy, fleksografia, gęstość optyczna, gamut, jakość drukowania, papier

INTRODUCTION

Sector of labels has currently become one of the most rapidly developing and growing sectors of economy [1]. The producers are constantly improving labelling of the products with the aim to attract constantly the attention of potential consumers what, in consequence, means higher sale.

Nowadays, the labels may be produced practically by any printing technique (see: Fig.1). One of the most popular methods of creating the label includes flexography and digital technologies, including electrography. The choice of the appropriate printing technology is very important aspect of production planning. It requires analysis of many factors and

variables. Depending on the order, we should make the assessment of available printing methods in respect of *inter alia*, type of the material to be printed, durability of print on a given substrate, the employed improvements or colour expectations.

At present, printing sector in segment of labels and packaging is found at the beginning of digital revolution. The number of installations of digital machines for printing of labels and flexible packaging during the recent years has become higher than the quantity of installations of traditional equipment. Also, the application of hybrid printing machines which combine few printing techniques has been very popular. At such situation, we may combine some classical methods or traditional printing and digital technologies in one device [2].

THE AIM OF THE STUDIES

The aim of the studies was to compare the copies, obtained from flexographic machine and digital machine, utilizing the phenomenon of electrophotography. The comparative analysis is based, first of all, upon the colouristic aspects but other parameters concerning the ready prints and the process of their production are taken into consideration, as well.

To perform the prints, the following machines were used: Digital Pro 3 and flexographic Performance Series 5 by Mark Andy company. As substrate (background), standard self-sticking paper MC FSC S2000NG-BG40BR was used; it is one of the

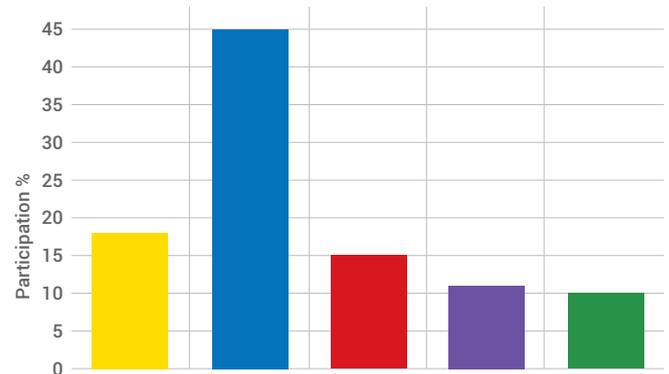


FIG. 1. PARTICIPATION OF CLASSICAL

PRINTING TECHNOLOGIES IN LABEL PRODUCTION

■ OFFSET ■ FLEXOGRAPHY
 ■ LETTERSET ■ ROTOGRAVURE ■ SCREEN PRINTING

most popular substrates employed in production of labels. The assessment of the copies was carried out on the basis of special printing test, using spectrophotometer X-Rite eXact.

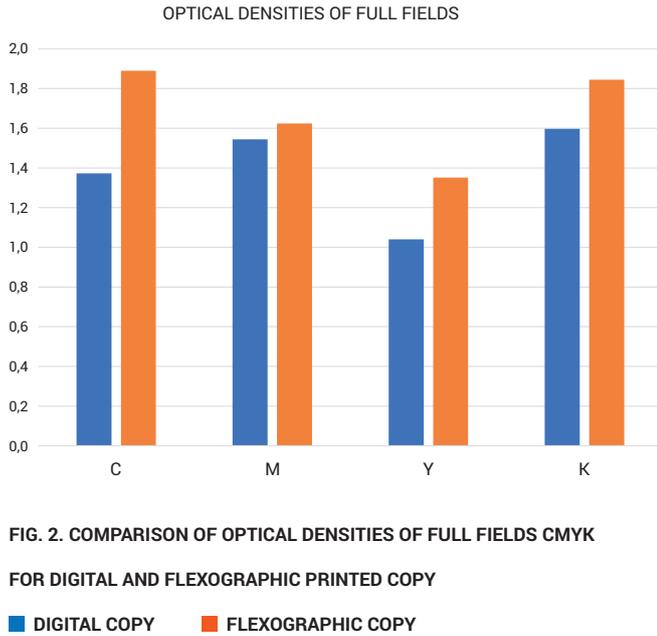
OPTICAL DENSITY

Optical density on the copy is closely connected with the amount of laid ink and is dependent on many factors during printing process. [3].

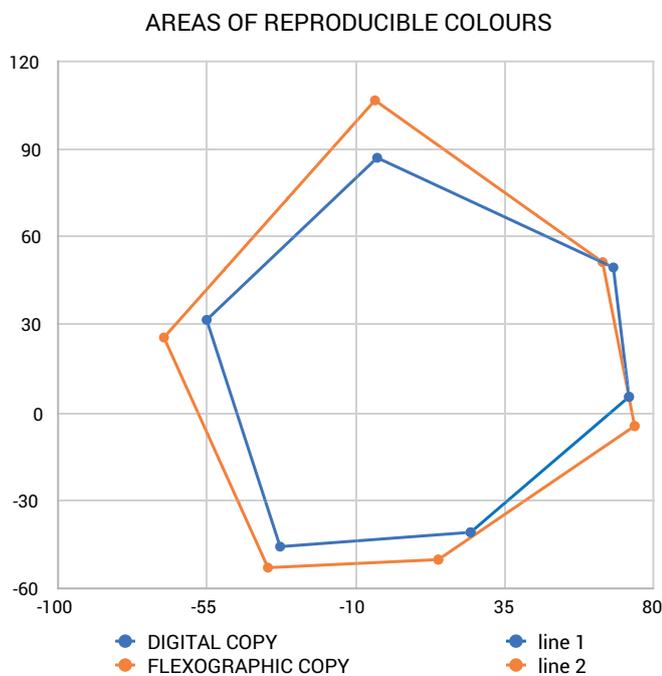
The measurement of optical density of the colour range CMYK was performed using field no 1 of the first page of the test. Then, standard deviation of the obtained results was calculated. The measured values of optical densities of full fields are higher in the case of flexographic copy for all primary colours what

TAB. 1. OPTICAL DENSITIES OF FULL FIELDS CMYK ON THE GROUNDS OF MEASUREMENT OF FIELD NO 1 AT P.1 OF THE TEST

Copy	DIGITAL COPY				FLEXOGRAPHIC COPY			
	C	M	Y	K	C	M	Y	K
Optical density values	1,37	1,56	1,04	1,56	1,89	1,64	1,36	1,85
	1,36	1,50	1,03	1,61	1,89	1,60	1,35	1,86
	1,36	1,51	1,03	1,60	1,90	1,62	1,35	1,83
	1,38	1,56	1,04	1,56	1,90	1,65	1,36	1,82
	1,34	1,58	1,05	1,59	1,85	1,60	1,35	1,86
	1,41	1,53	1,05	1,66	1,89	1,64	1,34	1,84
	1,39	1,57	1,04	1,60	1,91	1,62	1,35	1,85
Mean	1,37	1,54	1,04	1,60	1,89	1,62	1,35	1,84
Deviation	±0,02	±0,03	±0,01	±0,03	±0,02	±0,02	±0,01	±0,02



may be noticed in Fig.2. The lowest values of optical density were found for the fields printed with yellow colour for digital as well as for flexographic copy. Standard deviations are low for all CMYL colours. The lowest value of standard deviation



was demonstrated by yellow colour for the both digital and flexographic copy.

REPRODUCTION OF COLOURS

The quality of colour reproduction on the copy may be evaluated using coordinates $L^*a^*b^*$, creating three-dimensional space of colours CIE Lab. The coordinate L^* means brightness of colour. The coordinate a^* characterizes participation of colours from green to red whereas the coordinate b^* determines the colour from blue to yellow [4].

Each background of CMYK and RGB colours was measured in three sites alongside the printing direction (see; Tab. 3)

The data contained in Tab. 3 indicate the stability of printing process in the digital as well as in the flexographic machine. The measurements for the both mentioned technologies are coherent for all colours CMYK and RGB.

On the grounds of the measured coordinates, the difference in colours for the particular colours between the digital and flexographic copy was calculated with the application of the following formula: $\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$

The results are given in Tab. 4.

The colour differences between the digital and flexographic copy are high. The greatest difference occurs in the case of componential Y and colour G which contains this componential. It affected, first of all, by the coordinate b^* of yellow colour which is considerably higher in flexographic copy. It means that for printing in flexographic machine, the mentioned colour is more yellow whereas in the case of digital machine, it makes the impression of lightly blue. On the other hand, for componential C and M, parameter b^* is higher for digital copy. In the case of componential K, it has a higher componential L^* on digital print, i.e. greater brightness.

The measurements of coordinates $L^*a^*b^*$ served for determination of the areas of reproducible colours of the machines, the so-called gamut (the complete subset of colours).

The mentioned areas have a shape of hexagons the tops of which are created by marking – in system a^*b^* – the values for the particular colours in sequence MRYGCB. Black colour is omitted as it is dependent only on the coordinate L^* , meaning brightness.

TAB. 2. COORDINATES L*A*B* OF THE OVERPRINTED SUBSTRATE

Measured values			Values according to standard (norm)			Difference of colour	
L	a	b	L	a	b	ΔE	Mean
91,98	0,80	-1,45	93,00 \pm 3,00	0,00 \pm 2,00	-3,00 \pm 2,00	2,02	2,12
92,14	0,67	-1,22				2,09	
92,08	0,77	-1,37				2,02	
92,44	0,62	-1,07				2,10	
92,51	0,60	-0,82				2,31	
92,49	0,59	-0,93				2,21	
92,59	0,65	-1,08				2,07	

TAB.3. COORDINATES L*A*B* OF FIELDS CMYK AND RGB FOR DIGITAL AND FLEXOGRAPHIC COPY ON THE BASIS OF PAGE 2 OF THE TEST

Copy	DIGITAL COPY			FLEXOGRAPHIC COPY		
Values	L	a	b	L	a	b
C	51,51	-31,73	-45,62	50,70	-36,79	-52,13
	50,33	-32,81	-45,80	49,42	-36,95	-52,15
	51,47	-31,78	-44,46	49,42	-36,48	-52,98
M	43,92	72,42	5,36	46,66	74,03	-4,66
	43,22	72,16	4,10	45,92	72,67	-4,87
	2,84	71,80	4,50	46,69	74,11	-4,61
Y	84,25	-3,53	87,00	86,99	-4,57	105,51
	84,36	-4,08	86,82	86,81	-4,33	106,27
	84,03	-3,84	86,53	86,74	-4,20	106,61
K	19,11	-0,43	-0,33	10,10	0,75	1,74
	19,94	-0,44	-0,57	9,37	0,64	1,41
	19,39	-0,42	-0,37	9,48	0,70	1,35
R	43,73	66,45	47,55	47,33	64,47	51,35
	42,51	65,85	47,25	47,34	64,48	51,29
	43,02	67,70	49,54	47,52	64,66	49,33
G	50,73	-54,00	31,12	42,39	-67,85	25,63
	50,20	-54,51	31,37	42,14	-67,20	23,15
	50,62	-54,97	31,65	42,60	-67,12	21,99
B	25,08	24,05	-39,33	19,14	14,90	-50,23
	23,23	24,45	-39,82	19,03	14,55	-50,07
	24,64	24,65	-40,91	19,92	13,72	-49,52

TAB. 4. COLOUR DIFFERENCES CMYL AND RGB FOR DIGITAL AND FLEXOGRAPHIC COPY

Colour	Difference of parameters						Difference of colours	
	ΔL	Mean	Δa	Mean	Δb	Mean	ΔE	Mean
C	0,81	1,26	5,06	4,63	6,51	7,13	8,28	8,62
	0,91		4,14		6,35		7,63	
	2,05		4,70		8,52		9,94	
M	2,74	3,10	1,61	1,48	10,02	9,37	10,51	10,02
	2,70		0,51		8,97		9,38	
	3,85		2,31		9,11		10,16	
Y	2,74	2,63	1,04	0,55	18,51	19,35	18,74	19,54
	2,45		0,25		19,45		19,61	
	2,71		0,36		20,08		20,27	
K	9,01	9,83	1,18	1,13	2,07	1,92	9,32	10,08
	10,57		1,08		1,98		10,81	
	9,91		1,12		1,72		10,12	
R	3,60	4,31	1,98	2,13	3,80	2,68	5,60	5,83
	4,83		1,37		4,04		6,44	
	4,50		3,04		0,21		5,43	
G	8,34	8,14	13,85	12,90	5,49	7,79	17,07	17,23
	8,06		12,69		8,22		17,13	
	8,02		12,15		9,66		17,47	
B	5,94	4,95	9,15	9,99	10,90	9,92	15,42	14,99
	4,20		9,90		10,25		14,86	
	4,72		10,93		8,61		14,69	

Flexographic copy is characterized by greater area of reproducible colours as compared to digital copy. As regards red colour, curves for the both copies are similar. For the remaining areas, the tops of the hexagon, limiting the range of the reproducible colours of flexographic machine are more distant from the middle of coordinates' system. It means that yellow, green and blue colours are more differentiated in the case of flexographic copy.

BALANCE OF GREYNESS

The name of the greyness balance is defined as combination of componential elements CMY which create a colour on a copy that is mostly approximate to greyness resulting due to the application of solely black paint with a given degree of coverage. To this end, there were measured the coordinates $L^*a^*b^*$ for

chromatic fields, simulating printing with the black ink at the level of 25%, 50% and 75%. The obtained values have been presented in Tab.6.

The flexographic copy shows greater chromaticity of greyness fields. Coordinate b^* is considerably more deviated from zero as compared to digital copy. The measured data indicate that the greyness fields of flexographic copy have a yellow shade what is suggested by high values of coordinate b^* . The digital copy is characterized by a colour more approximate to achromatic overprint as coordinates a^* and b^* are near zero. For field of 75% coverage, the flexographic copy shows low negative values of coordinate a^* , i.e. it acquires green shade. There was determined the difference of colours for the greyness fields in the case of digital and flexographic copy (Tab.7).

The differences of colours for all fields are equal to ca. 10. It is a relatively high value what is affected by, first of all, difference in b* coordinates. Brightness of greyness fields is similar for the both copies.

The quality of greyness balance was also visually assessed: in the case of digital copy, the greyscale, created from CMY colours resemble more grey, generated from the black colour. The chromaticity of greyness is more visible for flexographic copy; it is true especially for field of 25% coverage for which yellow colour is dominating, and for field of 75% coverage where the colour makes the impression of being slightly blue.

TAB. 5. THE SELECTED COORDINATES A* AND B* FOR DIGITAL AND FLEXOGRAPHIC COPY

Copy	DIGITAL COPY		FLEXOGRAPHIC COPY	
	a	b	a	b
M	72,42	5,36	74,11	-4,61
R	67,70	49,54	64,47	51,35
Y	-3,53	87,00	-4,20	106,61
G	-54,97	31,65	-67,85	25,63
C	-32,81	-45,80	-36,48	-52,98
B	24,65	-40,91	14,90	-50,23

TAB. 6. COORDINATES L*A*B* OF GREYNESS FIELDS FOR DIGITAL AND FLEXOGRAPHIC COPY

K	DIGITAL COPY			FLEXOGRAPHIC COPY		
	L	a	b	L	a	b
25%	71,58	0,69	-4,05	74,53	0,94	7,04
	71,59	0,63	-3,88	73,94	0,84	7,62
	71,45	0,18	-3,59	74,76	0,85	6,81
50%	55,69	1,59	-1,71	57,34	-0,69	8,24
	55,88	1,38	-0,74	57,62	-0,74	9,41
	55,58	0,72	-1,01	57,40	-0,81	7,74
75%	38,34	0,29	0,15	37,46	-6,33	8,57
	38,52	0,04	1,02	37,62	-7,14	10,26
	37,80	-0,33	0,26	37,82	-7,37	9,66

TAB. 7. DIFFERENCE OF COLOURS OF GREYNESS FIELDS IN THE CASE OF DIGITAL AND FLEXOGRAPHIC COPY

Colour	Difference of parameters						Difference of colours	
	ΔL	Mean	Δa	Mean	Δb	Mean	ΔE	Mean
25%	2,95	2,87	0,25	0,38	11,09	11,00	11,48	11,38
	2,35		0,21		11,50		11,74	
	3,31		0,67		10,40		10,93	
50%	1,65	1,74	2,28	1,98	9,95	9,62	10,34	9,97
	1,74		2,12		10,15		10,51	
	1,82		1,53		8,75		9,07	
75%	0,88	0,60	6,62	6,95	8,42	9,02	10,75	11,41
	0,90		7,18		9,24		11,74	
	0,02		7,04		9,40		11,74	

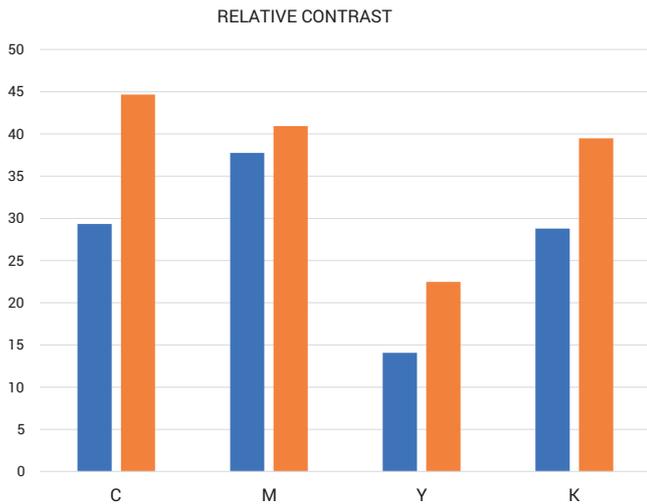


FIG.4. COMPARISON OF RELATIVE CONTRAST

FOR DIGITAL AND FLEXOGRAPHIC COPY

■ DIGITAL COPY ■ FLEXOGRAPHIC COPY

THE RELATIVE CONTRAST

The relative contrast is characterized by the reproduction of small elements in the shades for a defined colour. The optimum value of the relative contrast is estimated at more than 30%. It may be calculated using the following formula:

$$K_{WZ} = \frac{D_{100} - D_{75}}{D_{100}} \cdot 100\%$$

where:

D_{100} is the optical density of the field with 100% coverage,
 D_{75} is the optical density of the field with 75% coverage [5].

Values are given in Tab.8.

All the CMYK colours are characterized by a greater relative contrast in the case of flexographic copy what may be noticed

TAB. 8. VALUES OF RELATIVE CONTRAST OF CMYK FIELDS FOR DIGITAL AND FLEXOGRAPHIC COPY

Copy Colour	DIGITAL COPY			FLEXOGRAPHIC COPY		
	Value	Contrast	Mean	Value	Contrast	Mean
C	1,35	29,30		1,97	52,90	
	1,34	28,60	29.33	1,96	51,90	44.67
	1,39	30,10		1,32	29,20	
M	1,50	36,60		1,50	42,30	
	1,51	38,40	37.77	1,49	42,30	40.93
	1,55	38,30		1,52	38,20	
Y	1,02	14,70		1,29	27,90	
	1,02	13,40	14.07	1,30	26,00	22.47
	1,05	14,10		1,02	13,50	
K	1,51	27,60		1,86	45,20	
	1,55	29,30	28.80	1,89	44,10	39.47
	1,55	29,50		1,54	29,10	

TAB. 9. TRAPPING VALUES FOR DIGITAL COPY

Copy Colour	DIGITAL COPY								
	Y	M	Trapping	Y	C	Trapping	M	C	Trapping
Values	0,96	1,44	88,40	0,96	1,24	77,50	1,44	1,24	69,90
	0,96	1,45	87,00	0,97	1,26	78,90	1,44	1,27	70,50
	0,96	1,46	87,00	0,96	1,24	77,60	1,44	1,25	69,30
Mean			87.47			78.00			69.90

in Fig.4. The smallest relative contrast both for the digital and flexographic copy was found for yellow colour. The remaining fields show the optimum relative contrast, therefore, the reproduction of details of the image on the both copies in shades may be defined as good.

TRAPPING

The conception of trapping is referred to printed sites where ink is laid down on the other. Trapping determines the ability of receiving the ink, transferred on the copy by the layer of ink which is already found on the substratum at the same site [3]. When determining trapping, the sequence of overprinted colours is significant. In printing on digital as well as flexographic machine, the colours were laid on the band in sequence from the brightest to the darkest, i.e. YMCK. The ink with Y colour is first overprinted on the substrate. Application of ink in M colour on the mentioned above colour, causes generation of R colour

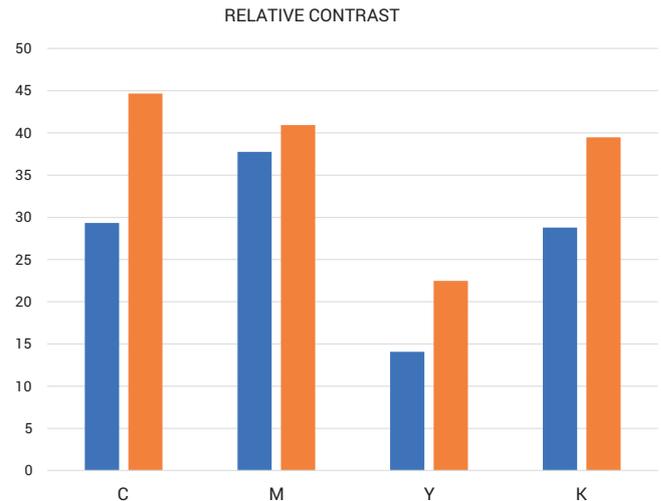


FIG. 5. COMPARISON OF TRAPPING IN DIGITAL AND FLEXOGRAPHIC COPY

■ DIGITAL COPY ■ FLEXOGRAPHIC COPY

TAB. 10. TRAPPING VALUES FOR DIGITAL COPY ON THE GROUNDS OF FIELD NO 9 AT PAGE 3 OF THE TEST

Copy	FLEXOGRAPHIC COPY								
	Y	M	Trapping	Y	C	Trapping	M	C	Trapping
Values	1,25	1,39	78,80	1,24	1,85	83,10	1,39	1,85	82,80
	1,24	1,39	78,70	1,24	1,86	82,50	1,39	1,85	82,60
	1,24	1,39	79,10	1,24	1,85	83,40	1,38	1,85	82,30
Mean			78.87			83.00			82.57

TAB. 11. VALUE OF TRAPPING FOR DIGITAL COPY

Copy	DIGITAL COPY								
	Y	M	Trapping	Y	C	Trapping	M	C	Trapping
Values	0,96	1,44	88,10	0,95	1,26	77,20	1,43	1,28	67,70
	0,96	1,45	85,60	0,95	1,32	73,20	1,45	1,31	66,00
	0,93	1,42	85,40	0,96	1,32	73,30	1,47	1,33	67,50
	0,97	1,49	85,60	0,94	1,24	77,60	1,48	1,33	65,60
	0,94	1,47	86,40	0,96	1,34	72,80	1,50	1,34	66,40
	0,96	1,49	87,90	0,96	1,32	74,60	1,46	1,24	71,70
	0,96	1,48	84,90	0,97	1,33	73,20	1,47	1,29	67,20
Mean			86.27			74.56			67.44

TAB. 12. VALUE OF TRAPPING FOR DIGITAL COPY

Copy	FLEXOGRAPHIC COPY								
	Y	M	Trapping	Y	C	Trapping	M	C	Trapping
Values	1,23	1,37	83,20	1,23	1,79	86,80	1,38	1,85	83,60
	1,25	1,38	81,90	1,25	1,81	87,00	1,38	1,80	84,40
	1,22	1,36	82,90	1,27	1,84	83,90	1,38	1,81	83,30
	1,25	1,39	81,10	1,22	1,86	84,40	1,35	1,82	82,40
	1,26	1,38	81,70	1,23	1,84	85,40	1,38	1,78	85,00
	1,25	1,39	80,40	1,24	1,77	87,50	1,38	1,79	85,60
	1,23	1,37	83,00	1,25	1,80	85,60	1,38	1,82	84,20
Mean			82.03			85.80			84.07

whereas overprinting C on Y results in obtaining G colour. Colour B is obtained via application of ink in C colour on M layer.

Trapping was determined for secondary colours RGB, resulting from overlapping of two componential CMYK elements (Tab.9 and 10).

The measured values of trapping are relatively high what means that the employed inks indicate a good capability of accepting another ink. For colour R, trapping is greater in the digital copy. G and B Colours show a greater percentage value of trapping in the flexographic copy (see: Tab.11 and 12).

In the case of digital copy, values of trapping are more differentiated for the individual RGB colours. In the flexographic

copy, trapping is similar for all secondary colours. The acceptance of ink by another ink in the both discussed types of copies is relatively constant alongside the printing direction (see; Fig.6 and 7). The variations of the mentioned parameter are found within the limits ca. 5%.

REPRODUCTION OF SMALL ELEMENTS

We may observe a low quality of reproduction of small elements in the digital copy for resolution of 2 400 dpi and 4 800 dpi. The mentioned fields acquire a uniform grey colour. In turn, flexographic copy reproduces well the smallest elements. Very small details are noticeable even by eye for all examined resolutions.

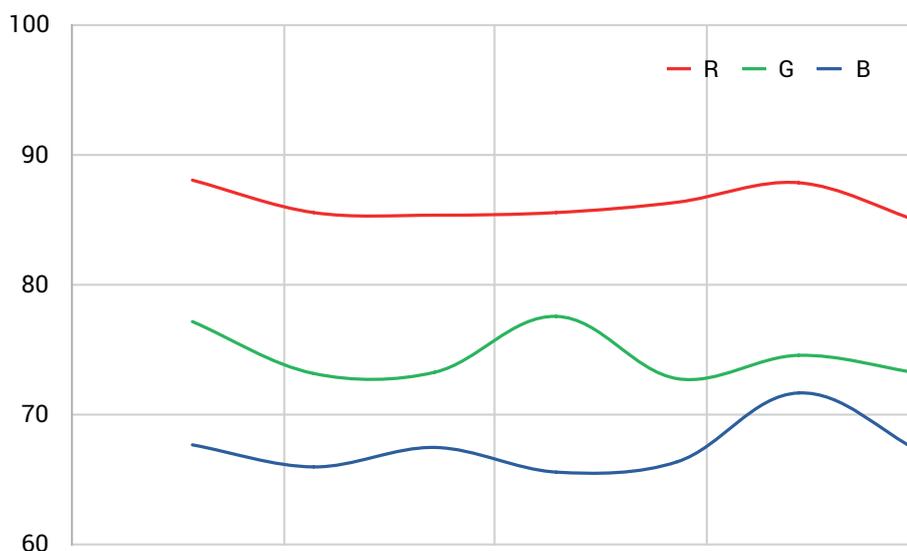


FIG. 6. RUN OF TRAPPING FOR DIGITAL COPY

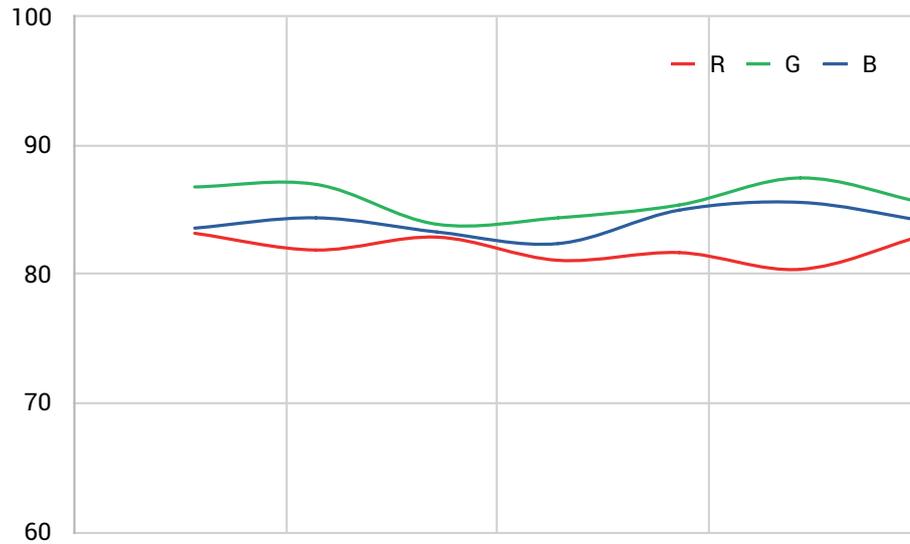


FIG. 7. RUN OF TRAPPING FOR FLEXOGRAPHIC COPY

TAB. 13. THE COMPARISON OF MACHINES: DIGITAL PRO 3 (DIGITAL) AND PERFORMANCE SERIES P5 (FLEXOGRAPHIC)

PROPERTY / MACHINE	DIGITAL	FLEXOGRAPHIC
Greater area of reproducible colours		+
Better reproduction of small elements		+
Better reproduction of greyness balance	+	
More „vivid” pictures	+	
Higher optical densities of full fields		+
Greater relative contrast		+
Greater trapping	It depends on the componential	It depends on the componential
Better reproduction of colours	It depends on the componential	It depends on the componential
Shorter preparation of materials to printing	+	
Shorter tool of machine	+	
More types of substrate		+
Greater number of improvement in machine		+
Possibility of slitting in machine	+	
Possibility of punching in machine	+	
Greater amount of spot colours		+
Higher speed of printing		+
Lower costs for small volume	+	
Lower costs for big volume		+
Possibility of printing on wider web		+
Possibility of printing on narrower web	+	

For digital copy, the dashes (bars) creating the figures become "ragged" at the level of 0.04 mm. For thickness of bars from 0.01 mm to 0.03 mm, they make the impression of having the equal thickness. On the other hand, in the case of the flexographic copy, the differences in the thickness are visible even for the thinnest dashes.

For the digital copy, the text of the size of 2 p becomes little readable. For 2 p, on the white background and for 3 p on the black background, the serif typeface is deprived of details. Already for 4 p, the difference in the thickness of the bars, forming the letters and figures is unnoticeable. The white text on the black background with the size of 1 p is impossible to be read out. In the case of flexographic copy, the text of the size of 1 p is possible to be read out under the magnifying glass both on the white and black background. In the case of the white text on the black background, the letters and figures of Times type of the size of 1 p, do not have any details.

THE ERRORS OF THE PROCESS

In the case of flexographic copy, the bright spots appear on the elements produced from componential K. Initially, it was believed that it was caused by contamination of printing mould. Cleaning of the mould has not eliminated the problem. It may mean that the reason for occurring printing mistakes is incorrectly exposed printing mould for the black colour.

The lines for yellow colour in the digital copy acquire undesired shapes. For the remaining colours at the level of 300 dpi, the errors in reproduction of the middle of circle and bright lines are found. It may indicate the smaller resolution of digital printing as compared to the flexographic printing.

CONCLUSIONS

The digital machine, which employs the phenomenon of electrophotography as well as the flexographic equipment are very well adapted to printing of labels. The both discussed devices possess certain defects and advantages, therefore the choice of machine for printing should be carried out for a defined work and according to the expectations. The basis criteria of the choice may be as follows:

- colouristic expectations,

- print volume ,
- format of work,
- number of colours,
- substrate,
- durability of print
- employed improvements.

On the grounds of the conducted studies, the comparison of the electrophotographic and flexographic technologies in relation to the employed machines has been carried out. The results have been given in Tab.13.

The conclusions coming from the coloristic aspects of the copies cannot be generalised and refer directly to the electrophotographic and flexographic technologies. The comparison concerns the defined machines, in which the printing was performed. Additionally, the results of the measurements were affected by many factors such as processes of preparation to printing, setting the machines, and also, properties of the employed materials. In the case of printing on flexographic machine, the reproduction of colour is dependent, inter alia, on the application or transfer curve. For flexographic copy, the "supporting" of minimal point was also performed what could affect the improvement of the print quality and better reproduction of small elements.

BIBLIOGRAPHY

- [1] <https://etyfol.pl/funkcje-etykiet/> (data dostępu: 18.10.2021) (available: at 18.10. 2021)
- [2] Svitlana Khadzhyanova, *Klasyczne i cyfrowe metody drukowania w produkcji etykiet i opakowań giętkich*, Świat druku, 2017 (In English: Traditional and digital methods of printing in production of labels and flexible packaging, World of Printing, 2017)
- [3] Jan Kowalczyk, *Technologia drukowania*, Oficyna Wydawnicza Politechniki Warszawskiej, 2019 (In English: Printing Technology, published by Warsaw University of technology, 2019)
- [4] <https://www.sony.pl/electronics/support/about-color-management> (data dostępu: 01.05.2022) (Available at 01.05. 2022)
- [5] Marcin Wroniak, *Badanie parametrów jakościowych odbitek drukarskich uzyskanych metodami cyfrowymi*, Politechnika Warszawska, Wydział Geodezji i Kartografii, Warszawa 2006 (In English: *The studies on the quality parameters of printed copies, obtained by digital methods*, Warsaw University of Technology, Faculty of Geodesy and Cartography, Warsaw, 2006).

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EVERYTHING ABOUT PACKAGING

– 14TH EDITION OF PACKAGING INNOVATIONS FAIRS



The time during the Fairs runs quicker – it is one of the most frequently repeated sentences during the 14th International Fairs Packaging Innovations which were held on 31.05 – 1.06 2022 in EXPO XXI in Warsaw. The cited above words do not surprise as the program of the discussed event was very comprehensive. Apart from the fair exhibition, it included many workshops and presentations in the zone workShops, meetings with the young designers in Student zone and the accompanying conference Packaging [R]evolution.

SUCCESS BEGINS FROM MEETINGS

During the Fairs, the visitors were familiarized with the offer of almost 80 most important exhibitors from the following sectors: food, cosmetics, chemistry, pharmaceuticals, motorization, electronics, transport and industry. They represented services

in as many as 10 thematic zones: PACKAGING, LABELLING, ECO, E-COMMERCE, MACHINES, COMPONENTS, PRINT FINISHING, POS&DISPLAYS, LUXPACK AND SERVICES. From among the exhibitors, there were the companies which had been present for many years during the Fair Packaging Innovations as well as those companies which participated the first time in the Fairs. *For us, it is the relation-creating event, so we cannot imagine we are absent here. It is not a secret that many customers with whom the contact is difficult, come directly to the Fairs and then, we may establish the cooperation with them. We treat the Fairs as the important, strong event as far as acquisition of the new customers is concerned. We are the producer of ecological components for packaging; our main production includes paper shavings for filling of parcels and all types of boxes, tissue papers – everything that is connected with pro-ecological packaging. We are never bored at our fair stand,*



something happens all the time – Patrycja Bylak from Packaging Centre of RBECO summed up. The company participated the third time in the Packaging Innovations.

Apart from the exhibitors with a long history of participation in Packaging Innovations, there were also many companies which were present for the first time in the event. *As the exhibitor, we are the first time at Packaging Innovations whereas we know the event as itself; we arrived here earlier as visitors. Our stand enjoys a great interest of the visitors; yesterday we could even observe long queues to our stand. We wanted to show here our possibilities – and they are really comprehensive – from packaging made from corrugated cardboard to poly mailers and bags. Actually, we are able to produce whatever the customer wishes, so we wanted to show the whole range of our possibilities and to talk with the customers because it is not always all visible at our Web page. We are very glad that we could present ourselves, especially among so many known and magnificent companies; we appreciate our participation very well – Agnieszka Hutkowska, business partner manager of Packhelp company* said.

Barbara Rodek, sales manager of E-packing company has the same opinion: *We are the first time present at the Packaging Innovations Fairs and our aim was to show the solutions concerning*

packaging. We are Polish producer and we wanted to boast our solutions and, additionally, to gain new customers and distributors of our products. I think that our target will be implemented as our stand and our products enjoy a great interest among the potential clients due to the fact that we offer the products which are pro-ecological, innovative and constitute the alternative solution to plastic filling.

STRONG SHAKING HANDS

Packaging Innovations Fairs have proved once again that direct meetings have a great power. *For us, the participation in stationary fairs has a big value because we may meet with our current customers in vivo and additionally get familiarized with our potential clients and show personally our solutions. I think that it is the best way of presentation of our products when the customer may touch the product or try to pack the given articles personally – Barbara Rodek* noticed.

In business relations, the confidence plays a key role what was stressed by **Bolesław Jasinowicz, Vice-President of FANO company**: *Direct relation increase undoubtedly the mutual confidence of the both meeting sides and it is very important. When we may sit down at the one table and talk and get mutually familiarized, the mentioned cooperation becomes finally much*

DURING THE FAIRS, THE VISITORS WERE FAMILIARIZED WITH THE OFFER OF ALMOST 80 MOST IMPORTANT EXHIBITORS FROM THE FOLLOWING SECTORS: FOOD, COSMETICS, CHEMISTRY, PHARMACEUTICS, MOTORIZATION, ELECTRONICS, TRANSPORT AND INDUSTRY



better. I think, therefore, that it is meaningful during the meetings at the fairs as well as during direct meetings when we visit our customers or the customers pay a visit to our company.

Pandemic has undoubtedly affected strongly the packaging sector. After the months of lockdown, remote work and lack of the possibility of business trips, everything however comes back to the appropriate route. *It is our debut at the fairs. We collect experience; we learn, observe and draw the conclusions for the future. We are nicely surprised as we had quite a lot of visitors and we hope it will be continued in the future. We appreciate face-to-face contacts. We may get know each other and talk directly. The persons, who visited us at the stand, were also longing for a direct contact. The people want to meet; talk and get know each other. It is not the same as e-mail, telephone or camera. I also like direct contacts very much* – **Piotr Modzelewski, Commercial Director of Printing Plant "Ekorol"** said. The power of meeting was also appreciated by **Justyna Kierzkowska-Grzyb, Manager of Marketing Department in Aniflex company**: *We experienced online versions, organized various webinars but in my opinion, nothing can replace direct meetings when you may see a given product and touch it. We promote strongly the eco-solutions and it is difficult to sell pro-ecological solutions, containing different elements from recycling when not demonstrating them in the products. It is probably the greatest value of stationary meetings – when we may not only tell the customer about something but simply to show it to him.*



CHANGES, CHALLENGES AND COMING TRENDS

"The change" was the key of the past edition of the fair. The role of the fairs is changing, and the expectations of the consumers in respect of packaging are changing as well. In the both cases, the choice becomes more and more informed. As it was noticed by the exhibitors, the fairs are presently attended by more specific visitors who search for the new solutions. The similar situation is in the case of packaging from which we expect ... more than only attractive design. Pandemic and geopolitical situation has a very strong impact on the market. The new challenges appeared before the producers and distributors of packaging. Rise of the prices of raw materials, problems with logistics, the EU regulations, Single Use Plastics (SUP) Directive (2019/904/EU) – all this situation was clearly demonstrated at the Packaging Innovations Fairs. They have showed what the problems of the sector are. *Pandemic caused that the way of communication has changed. For example, when considering cosmetics, we had trade galleries and shops and now we can see the change in the way of ordering the products by the customers. Once, the standard at the Far East consisted in the situation when the shop played a role of the exhibition and the products were ordered directly by internet. Nowadays, we are faced, more and more frequently, with the mentioned situation in Europe: we can see the change in distribution and perhaps ordering by our customers. As regards our situation, the inflow of materials from recycled raw materials has been generally changed. The mentioned trend was commenced before pandemic and not it is continued. The problem has not disappeared*



and we will not stop the discussed change – said **Tomasz Rathman, managing director of Berry Global company** department in Otwock. According to **Robert Rogalski, the main specialist of sales in Arexim company**: *The challenge before which the packaging sector has been faced for a certain time, is logistics – the increase of transport prices, lack of container availability, or even lack of drivers. Sometimes, it is difficult to find transport to carry some goods in Europe or in Poland; in my opinion, it makes the greatest troubles to our customers as well as our suppliers, who struggle with the problem of punctual deliveries, appropriate quality products and at reasonable price.* The opinion of Boleslaw Jasinowicz from FANO as regards the mentioned above problems was as follows: *Ecology, regulations and rules, imposed by the European Union, lack of raw materials and their prices. The sector is in a difficult post-pandemic situation, during the war in Ukraine. Certain earlier indicated trends, in the light of the current situation, have been disturbed and the supply chains broken. We are found in the completely different reality.*

YOUNG CREATORS AND THE NEW IDEAS

Every year, the Zone of Student causes a great interest among the visitors. The same situation occurred during the 11th edition of the competition, the aim of which was to give a chance to the young designers who begin their professional career. On the first day, we got to know the Laureates.

- Category **“Graphic appearance”** – the First Place for Małgorzata Kosicka from Bydgoszcz University of Technology, for design of packaging and label of handcraft-made beer / Bydgoszcz Plant of Architectonic Beer
- Category **“Functionality and form”** – the First Place for Milena Bruska from Bydgoszcz University of Technology, for design of packaging of educational toy
- Category **“Impression”** – the first Place for Wojciech Zabel from Bydgoszcz University of Technology for design of Case Island/packaging of school set for children

THE SUCCESSIVE, 15TH EDITION

OF THE INTERNATIONAL FAIRS PACKAGING INNOVATIONS

WILL BE HELD ON SEPTEMBER 20-21, 2023 IN EXPO KRAKÓW

Additionally, the distinction was awarded to Natalia Stanisławska from University of technology in Cracow for design of starch-chitosan foil with curcumin/intelligent biodegradable packaging.

FANO company was the sponsor of the award. *It is the second consecutive year when we are the sponsor of the Student Zone. In my opinion, the young creators should receive a support and we are just trying to do it. My attention was paid to the fact that at the present trend, imposing the presence of many colours on the packaging, those presented at the fairs were toned-down and thoughtful as regards ecology. Two or three colours were enough to implement the package* – Boleslaw Jasinowicz stressed.

The Fairs mean impressions, emotions and talks but also, the requiring labour of all who participate in the event. *The time runs quicker at the fairs, 8 hours at the event are decisively more exhausting than 8 hours at the traditional work; nevertheless that's the point that it is intensive and interesting and giving the possibility to talk with the people* – Piotr Modzelewski from Ekorol company emphasized. The pockets full of visiting cards which gradually with the time will be transformed into new contracts may become the award for the hard work.

The successive, 15th edition of the International Fairs Packaging Innovations will be held on September 20-21, 2023 in EXPO KRAKÓW.



ANNA NARUSZKO, MSC, EDITOR OF THE PACKAGING REVIEW

TRANSITION IN PACKAGING AT FACHPACK 2022



From 27 to 29 September 2022, it will once again be time for FACHPACK, the trade fair for packaging, technology and processes, to open its doors at Exhibition Centre Nuremberg. Under the banner “Transition in Packaging”, more than 1,100 exhibitors will present their innovative products and solutions for the packaging of the future in nine exhibition halls.

FACHPACK is the European trade fair for packaging, technology, and processes, where exhibitors showcase their products for the packaging process chain for industrial and consumer goods. On display will be packaging materials, packaging and accessories, bottling and packaging machinery, labelling, marking and identification technology, machines and equipment for the packaging periphery, packaging printing and finishing systems, palletising technology, intra-logistics and services.

With its new slogan: „We create the future”, FACHPACK 2022 will be devoted to the trending topic of „Transition in Packaging”. As the No. 1 gathering for the European packaging market, FACHPACK attracts trade visitors from all packaging-intensive sectors like food/beverages/luxury food, pharmaceuticals/cosmetics/chemicals/health care, non-food/pet food/other consumer goods as well as automotive/technical articles/medical technology and other industrial goods.

FACHPACK sees itself as a trailblazer and source of inspiration for the industry. As such, it is once again organising an extensive programme of presentations to complement the exhibition. The PACKBOX forum (Hall 9), TECHBOX forum (Halle 3C) and exhibitor forum INNOVATIONBOX (Hall 5) will all feature interesting topics and speakers.

The FACHPACK forums are always a crowd puller: Last year, the PACKBOX and TECHBOX forums attracted around 9,500



**FACHPACK IS THE EUROPEAN
TRADE FAIR FOR PACKAGING, TECHNOLOGY,
AND PROCESSES, WHERE EXHIBITORS
SHOWCASE THEIR PRODUCTS FOR THE
PACKAGING PROCESS CHAIN FOR INDUSTRIAL
AND CONSUMER GOODS.**

THE FORUMS WILL ADDRESS TOPICAL INDUSTRY ISSUES LIKE SUSTAINABILITY, DIGITALISATION, THE SHORTAGE OF SKILLED PERSONNEL, SUPPLY CHAIN BOTTLENECKS, THE ENERGY CRISIS, SUPPLY CHAIN MANAGEMENT, RAW MATERIAL PRICES, AND A WHOLE LOT MORE.



participants. What is special about the forums is that the programme is designed by prestigious partners from the packaging sector that invite participants not just to listen to the presentations but to get actively involved in the discussions as well. The forums will address topical industry issues like sustainability, digitalisation, the shortage of skilled personnel, supply chain bottlenecks, the energy crisis, supply chain management, raw material prices, and a whole lot more.

DIFFERENT FOCUS EVERY DAY

Each day, the PACKBOX and TECHBOX forums focus on a different topic. In PACKBOX, which is all about packaging, packaging printing and finishing, these topics are „Market Experience and Expectations“ (27.9.), „Sustainable Design & Material“ (28.9.) and „Packaging: digital & smart“ (29.9.).

PACKBOX partners include: bayern design, Berndt + Partner, German Packaging Institute (dvi), DFTA Flexodruck Fachverband, EPDA (European Brand & Packaging Design Association), FFI (German Folding Carton Association/ProCarton (European Association of Carton and Cartonboard Manufacturers), FuturePackLab/ popular packaging, Horváth & Partners, IK (German Association for Plastics Packaging), K&A Brand-Research, Packaging Europe Ltd., Packaging Journal, PAHNKE, taste, WPO (World Packaging Organisation) and Zukunftsinstitut (futurology institute).

In the TECHBOX forum, which focuses on packaging technology and logistics, the themes are „Innovation & Climate Strategy“

(27.9.), „NEW WORK: future working models in packaging (28.9.) and „Efficiency & Digitalisation“ (29.9.). This forum is hosted and organised by: AIM-D e. V., BayStartup, BGH Consulting, German Association of Packaging Engineers (bdvi), Deutsche Bank AG | Research / Economics, FNR (Agency for Sustainable Resources), University of Applied Sciences Vienna Campus, Fraunhofer Institute for Material Flow and Logistics (IML), Fraunhofer Institute for Process Engineering and Packaging (IVV), Institut für Generationenforschung (generational research institute), Logistik heute / Huss Verlag, neue verpackung / Hüthig Verlag, Packaging Journal, Packaging Valley Germany, TILISCO, TU Dresden, and VVL (Association for the Promotion of Innovative Logistics Solutions). The PACKBOX and TECHBOX forums are accompanied by the exhibitor forum INNOVATION-BOX in Hall 5, where registered exhibitors can introduce their innovations and product highlights to trade visitors in live, 30-minute presentations.

FRESH THOUGHTS ON THE SUPPLY CHAIN

It all kicks off at 10 a. m. on the first day in the PACKBOX Breakfast Club with a keynote by Gunhard Keil from the renowned Zukunftsinstitut (futurology institute). The Viennese entrepreneur and longstanding advisor to the packaging industry reveals „Fresh thoughts on the future of the supply chain“ in his presentation „Structure follows strategy or customer follows packaging?“ He sees conurbations like New York, Beijing or Frankfurt as the raw material centres of the

future, for example. And as with transport packaging, there are going to be a lot of changes in the future in the field of logistics and freight transport.

NEW WORK: THE BRAVE NEW WORLD OF WORK

In the TECHBOX forum, the second day of the fair (28.9.2022) is devoted entirely to the topic of „New Work“. In the „war for talent“, the increasingly fierce competition for the best talent, companies need to offer attractive working models. Between 10 a. m. and 5 p. m., seven presentation slots look at the issue from various perspectives.

For example, futurologist Hartwin Maas from the Institut für Generationenforschung (generational research institute) compares baby boomers with digital natives and explains the skills and technological capabilities that will be in demand in the new world of work (12:00-13:00). Richard Clemens, Managing Director VDMA Food Processing and Packaging Machinery Division, explores the question: „Between digitalization and sustainability: contradictory area or challenge for young talents?“ (16:00-17:00). The round table hosted by BGH-Consulting (14:00-15:00) will discuss the advantages and disadvantages of new versus existing methods for winning and retaining skilled personnel, as well as the special role played by interim management. Packaging Valley Germany will present successful examples of personnel recruitment under the



title „NEW WORK fully on the move! The valley of career opportunities for top talent – how companies in Packaging Valley are already winning over the skilled workforce of the future!“ (10:00-11:00).

TURNING POINT IN PACKAGING

The title of the hard-hitting and unsparing presentation by Eric Heymann from Deutsche Bank in the TECHBOX forum on the last day of the fair (29 September from 13: 00–13: 30) has the title: „The turning point and its challenges for the world and for packaging“. The Deutsche Bank director and senior economist takes a macroeconomic look into the crystal ball and explores the question of what the new realities about energy, supply bottlenecks and the shortage of skilled personnel will mean for developments in the coming years.

LIVE STREAMING OF PRESENTATIONS VIA MYFACHPACK

This year too, the digital add-on myFACHPACK for matchmaking and knowledge transfer between exhibitors, partners, speakers and visitors will extend the on-site event into the virtual environment. Ahead of the fair, from 16 September, the new tool for visitors will give them the opportunity to network with exhibitors, partners and presenters. During the event, the PACKBOX, TECHBOX and INNOVATIONBOX forums will be live streamed on myFACHPACK and can also be accessed there afterwards.

In 2022, POWTECH, the leading international trade fair for powder, granule and bulk solids technologies, will take place at Exhibition Centre Nuremberg at the same time as FACHPACK. This will create additional synergies in the processing and packaging segment.

ON DISPLAY WILL BE PACKAGING MATERIALS, PACKAGING AND ACCESSORIES, BOTTLING AND PACKAGING MACHINERY, LABELLING, MARKING AND IDENTIFICATION TECHNOLOGY, MACHINES AND EQUIPMENT FOR THE PACKAGING PERIPHERY, PACKAGING PRINTING AND FINISHING SYSTEMS, PALLETISING TECHNOLOGY, INTRA-LOGISTICS AND SERVICES.

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