

Current state and production characteristics of the Polish tanning industry: A case study

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ABSTRACT

This article presents the results of a study on the current state and evaluation of the Polish tanning industry, focusing on its production characteristics. The research sample included 220 companies that were contacted to gather information about their operations. Some of these companies have been suspended, liquidated, or have changed their business profiles. Approximately 30 % confirmed that they are still active in leather manufacturing, indicating that the Polish tanning industry is experiencing a process of deindustrialization. Surveys conducted in 20 companies revealed that Polish tanneries operate on national, European, and global scales. Most of them are micro or small enterprises with annual revenues of up to PLN 5 million. The primary factor defining their competitiveness is the high quality of the products and services they offer. They mainly process calfskin and cowhides sourced from Poland and abroad, primarily for the footwear sector. Polish tanneries are aware of global trends, including the industry's shift towards ecological practices, the adoption of modern technologies, and the introduction of innovations. Given the current challenges facing the Polish tanning industry, it is essential to take action to improve the health of this sector of the economy.

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1. Introduction

Leather is a valuable raw material used in the production of a variety of products that are considered luxury by consumers and have been eagerly purchased for years, regardless of the prevailing fashion. Leather manufacturing has a long history and tradition. However, over the years, the tannery sector has changed due to technological progress, innovative solutions, and, above all, the introduction of new regulations or the modification of existing ones. It estimates that the European tanning sector consists of almost 1,600 companies, over 34,000 employees, and generates a turnover of up to €7.4 billion. In recent years, a gradual concentration has been observed. As recently as 2000, tanneries employed an average of 24 workers, today it is 21. European tanneries range from small and medium-sized enterprises, continuing long family traditions, to large companies operating internationally [1]. The modern leather industry in Europe is a strategic area of the manufacturing sector, resulting from a combination of tradition and con-

tinuous innovation. What is more the European market of the leather sector leads, among others, in terms of quality, technology, innovation, and sustainable development [2].

Three countries were identified as the largest producers of leather in 2022, i.e. Brazil, the United States, and Turkey. Their combined share of global production is 33 %. Countries playing a significant role in global leather export include Italy, Brazil, and China [3]. According to estimates by the Food and Agriculture Organization of the United Nations (FAO), more than 50 % of the leather produced worldwide is used in the clothing industry. Only about one-fifth is produced in European tanneries, which have high environmental and safety standards, and require sustainable processes and chemicals. The result is a high-quality, strength material whose intricate production steps justify calling it a luxury product [4]. It is used to produce various goods also referred to as luxury [5]. Analysing the destination of leathers supplied by European tanneries, this raw material is mainly used in footwear (41 %), leather goods/accessories (19 %), and furniture (17 %), but also automotive industry (13 %) and clothing (8 %) [6].

Data from the report *Global Leather Goods Market – Industry Trends and Forecast to 2030* [7] confirms the ever-increasing demand for leather goods, projecting that the global market for these products will continue to grow in the coming years, reaching USD 699,906.77 million by 2030. Premium and high-quality luxury products made from natural leather are expected to be popular. New and innovative solutions are expected from the global leather industry in terms of raw material properties and design. However, the sector may be challenged by, inter alia, problems with technology, equipment, and the lack of adequate leather processing skills. Among the factors that may have a negative impact on the development of the global leather market are problems with the availability of raw materials or competition from other materials that are synthetic substitutes for natural leather. An important aspect, according to Cafasso [8], is to educate consumers about the origin of the leather products they use, the methods and ways in which they are produced, and the associated environmental impact. It is worth mentioning that many researchers concerned the ecology issues and the various aspects of sustainability for example according to the footwear industry [9-11], which is closely associated with the tanning/leather sector.

The Polish economy is currently undergoing the process of reindustrialization and is the 7th largest industrial country in the European Union and 21st in the world, supplying many important products. However, when it comes to the leather industry, the decline of this industry is observed in Poland. Data from the Central Statistical Office show that the structure of sold production of the clothing, textile, and leather industries in Poland in 2020 decreased by about 9 percentage points compared to 1985 and amounted to 2 % [12]. In the case of the leather and leather products industry, the sales value for 2021 was PLN 3,836.2 million [13]. In recent years, there has been a gradual decline in employment in the sector, but a positive trend is an increase in wages [14]. The most recent data shows that in Poland at the end of December 2023, there were 310 leather manufacturing and tanning-related entities (PKD 15.11.Z), as well as 2623 footwear manufacturers (PKD 15.20.Z) and 1558 manufacturers of bag and saddlery products (PKD 15.12.Z) [15]. The Polish leather-footwear industry uses mainly domestic raw materials for production. Entrepreneurs operating in this sector cooperate closely with the vocational education system. This is because the work done in their factories is a combination of traditional craftsmanship, the art of design and construction, as well as the ability to operate increasingly advanced production machinery [16]. Even though demand for leather products remains high and, as mentioned above, a further increase in the value of the global leather market is predicted, more and more tanneries are closing down in Poland.

This study aimed to present the current state and make an assessment of the Polish tanning industry, taking into consideration the characteristics of the production process carried out in tanneries located in Poland. Once a database of domestic tanneries had been established, a survey questionnaire was designed and sent to companies via email. Respondents were also allowed to take part in the survey by answering it during a telephone interview. This allowed the verification of the previously developed database of tanneries, the selection of companies that are still active in production, and the extraction of information regarding their leather manufac-

turing processes. The following research questions were formulated and verified in the course of the study:

- RQ1: What is the current overall state of the tanning industry in Poland?
- RQ2: What most determines competitiveness in the tanning industry in Poland?
- RQ3: Do the tanneries in Poland know current global business trends concerning their sector of the economy?
- RQ4: What raw materials are processed in tanneries in Poland, using what tanning methods, and what goods are produced from Polish leather?

The remainder of this article is organized as follows. The second section describes the research procedure and method used for data collection. This is followed by the presentation of the results of the research obtained with elements of discussion. The research was then summarized and conclusions were drawn while answering the research questions posed. The final part of the article includes the formulation of recommendations for further research along with a discussion of the limitations encountered due to the specifics of the research topic and methods adopted.

2. Research methodology

2.1 Procedure of the research

The research procedure to achieve the objective of the study is presented in Fig. 1. The research was conducted in three phases:

- (1) **RESEARCH PREPARATION PHASE:** Following the procedure, the study started by formulating the research problem in the form of a general question: What is the current state of the tanning industry in Poland and what are the characteristics of the production process carried out in Polish tanneries? Then, to define the scope of the study, an attempt was made to analyse scientific texts on the issue under investigation. A search for information and materials on scientific studies carried out on the Polish tanning industry has resulted in the conclusion that there is a research gap in this area. Based on the information collected, research questions were formulated, as mentioned in the Introduction.
- (2) **RESEARCH EXECUTION PHASE:** A survey approach was selected and used to collect data to enable further analysis and answers to the research questions. The characteristics of the research tool are described in detail in section 2.2. The survey was sent to tanneries located all over Poland. The data collected through the questionnaire was analysed.
- (3) **RESEARCH SUMMARY PHASE:** Based on the interpretation of the research results obtained, the research questions were answered and conclusions were drawn. In addition, recommendations were formulated in connection with the study.

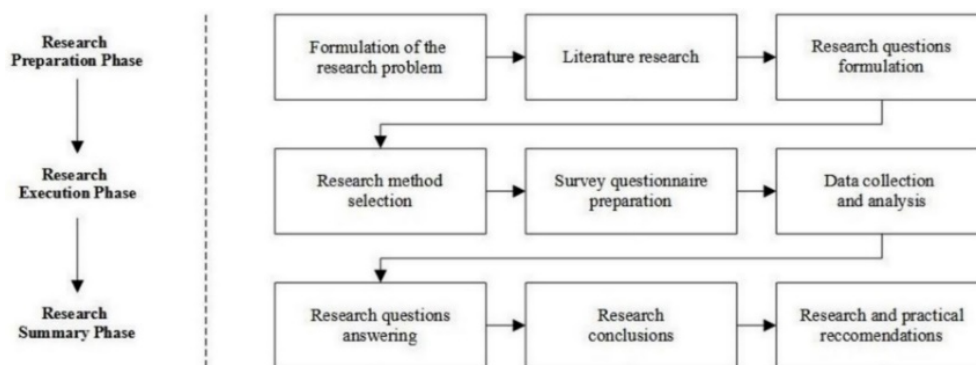


Fig. 1 Diagram showing the procedure for the research process (Source: Own elaboration)

The authors declare that the research was conducted in accordance with ethical principles. The article presents non-interventional studies. All interviewees gave informed consent to participate in the survey.

2.2 Survey questionnaire design

Based on the review of current industry literature, the operationalization of the research problem, and having regard to the formulated research questions, a survey questionnaire was designed. In the authors' opinion, a survey was the most appropriate tool for substantive and organizational reasons. The survey questionnaire used in the study was created in the Microsoft Forms application.

The survey questionnaire was divided into three sections: formal, substantive, and final. The formal section was the introduction to the survey. It included a return to the addressees of the survey, an introduction to the research problem, a presentation of the aim and authors of the research, assurances of the anonymity of the answers provided, and information on how the data collected in the research will be used. The substantive part is the part that includes questions to respondents on the issues of the research problem. The final part of the questionnaire was devoted to thanking for participation in the research and information regarding the possibility of obtaining the research report.

The questionnaire of the survey consisted of 23 questions, which took the form of both closed and open questions. The order of questions in the substantive part of the questionnaire was related to the division of variables into the following categories: company characteristics, market position, information on the production process, and management information. This publication presents the data obtained through the respondents' answers to questions 1 to 14, i.e. those relating to the characteristics of the company, its market position, and the production process it follows. Of the 14 questions analysed, 3 were open-ended – respondents were asked to provide their own answers. The remaining 11 questions were closed: 6 single-choice questions, 4 multiple-choice questions, and 1 question for putting the given answers in the right order. The information gathered through the respondents' answers to the remaining 9 of the 24 questions of the survey will be included by the authors in the next article, which will focus on management in Polish tanneries.

2.3 Development of a database of Polish tanneries and data collection

To present the current state and characteristics of the Polish tanning industry, a database of tanneries was developed. The initial list of tanneries was drawn up in cooperation with the Polish Chamber of Shoe and Leather Industry [17], an industry organization that has been active in the leather industry since 1989 and whose mission is to create an economically and organizationally strong leather industry in Poland and to support its activities internationally. The list was further supplemented with additional tanneries, based on information obtained from 8 online company and/or service search facilities shown in Table 1.

Table 1 Websites used in the development of the tannery database (Source: Own elaboration)

No.	Website name	Website address
1	Az-Polska.com	https://www.az-polska.com/
2	Baza firm pkt.pl	https://www.pkt.pl/
3	BiznesFinder.pl	https://www.biznesfinder.pl/
4	Cylex Szukaj Lokalnie Polska	https://www.cylex-polska.pl/
5	Firmy.net	https://www.firmy.net/
6	Ohmycraft.pl	https://ohmycraft.pl/
7	Panorama Firm	https://panoramafirm.pl/
8	Polski Katalog Firm	https://pkf.org.pl/

To gather information on Polish tanneries, the following search terms were entered into search engines on the websites listed in Table 1: '*tanning*', '*tannery*', and '*leather manufacturing*'. The result of applying the described search method was the creation of a database containing, for most companies, data such as company name, postal address (in some cases with exact territorial location shown on a map of the country), contact phone number(s), email address, web address.

Data collection in the study of the state and production process characteristics in Polish tanneries was carried out using:

- an online survey to which a link was sent via email – this was completed by a representative of the tannery, or
- a telephone survey in which a representative of the tannery answered questions in an online survey, the answers being marked by an interviewer.

The timeframe for the development of the tannery database and survey data collection is shown in Fig. 2. The list of tanneries located in Poland created at the end of 2022 based on information obtained from the Polish Chamber of the Footwear and Leather Industry and company search engines, included 220 companies. The email address provided online was held by 139 of them, so in the first instance, an email was sent to these enterprises in January 2023 with information about the survey, a link to the survey, and a request to complete it. Of the companies reached via email, only 5 chose to complete the survey questionnaire in the first quarter of 2023.

The database developed contained between 1 and 3 contact numbers (landline and/or mobile) for 219 companies. As a next step, a telephone contact was therefore attempted, which proved successful for 89 companies. From the information obtained from the callers, it appeared that 2 of the 89 companies had changed their business profile, while 67 tanneries (about 30 % of the 220) confirmed that their core business is related to leather manufacturing. However, 7 of the 67 companies indicated that they were currently in the process of reducing production and phasing out. A few respondents also indicated that the enterprises they represent are small, 1- or 2-person businesses. During the interviews, it became apparent that 20 companies (about 9 % of the 220) were no longer engaged in leather manufacturing, had suspended or liquidated, or were in liquidation bankruptcy. The remaining 130 companies (about 59 % of the 220), with which it was not possible to establish telephone contact despite three attempts made over six months (April to September 2023), are likely in a similar situation. After dialling the telephone numbers to these tanneries, found in the companies' online directories, the voicemail turned on or the answering machine said *"The number dialled does not exist"*, *"There is no such number"* or *"The number dialled is not answering at the moment"*, or even though the call tone could be heard in the handset, no one answered the phone.

During a telephone interview with 67 tanneries that confirmed their active leather production, several respondents requested that we resend an email containing a link to the survey. Notably, nine callers provided alternative email addresses—either company or personal—different from those listed in our database. Email addresses were also obtained for 4 enterprises where contact via this route had previously been impossible, due to the lack of availability of an electronic address on the Internet. Only 4 of the 67 individuals representing actively operating tanneries were willing to complete the survey during the telephone interview, while 21 callers definitively refused to participate in the survey, either by telephone or email. In the end, 20 completed survey questionnaires were obtained.

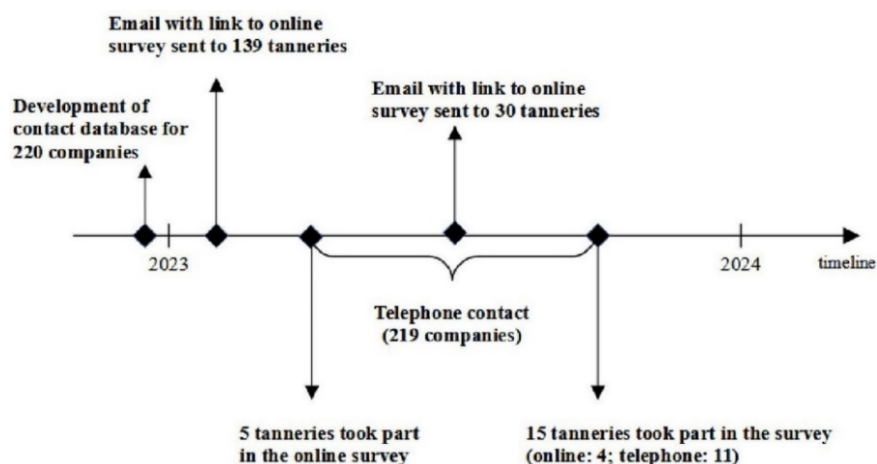


Fig. 2 Timeline of the tannery database development and survey data collection (Source: Own elaboration)

2.4 Evaluation of the manoeuvrability in the conducted studies

To assess the research methodology used and the quality of the results obtained, in the context of their representativeness, return rates were determined (Table 2). According to Kopyś [18], their estimation allows, among other things, to verify the effectiveness of the applied data collection methodology and informs whether the sample was properly selected.

Table 2 Return rates in the survey (Source: Own elaboration based on Kopyś [18])

Rates	Equation (%)	Equation components	Values of components	Values of rates (%)
Total return (r_o)	$r_o = \frac{p}{n} \times 100$	p - number of fully completed questionnaires received	$p = 20$	9
Return rate of all questionnaires (r_w)	$r_w = \frac{p+c}{n} \times 100$			9
Actual return of questionnaires (r_r)	$r_r = \frac{p}{n-z} \times 100$	n - number of entities in the sample	$n = 220$	30
Rate of survey participation (r_u)	$r_u = \frac{p}{k} \times 100$	c - number of partially completed questionnaires received	$z = 153$	30
		z - number of outdated addresses	$k = 67$	
Rate of refusal (r_x)	$r_x = \frac{o}{k} \times 100$	k - number of entities contacted	$o = 21$	31
		o - number of entities that refused to participate in the survey	$c = 0$	

The total return rate (r_o), i.e. the rate indicating the percentage of respondents who answered taking into account all selected respondents, was estimated at around 9 %. Such a low total return rate is because in the case of 20 companies, information about their liquidation was obtained, while the vast majority (131 companies) could not be contacted in general, despite repeated attempts, which may also indicate that their activities have ceased. Another indicator estimated was the return rate of all questionnaires (r_w), reporting the percentage of completed questionnaires obtained, regardless of whether respondents answered all the questions in the questionnaire. As each of the questionnaires returned by respondents was filled in its entirety, the return rate of all questionnaires equalled the total return rate, i.e. 9 %. This demonstrates, among other things, the good quality of the survey questionnaire that was designed, as respondents wanted to answer the questions asked and had no trouble doing so.

Taking into account outdated addresses, the actual return of questionnaires rate (r_r) allowed for a more meaningful estimate of the answers to the surveys. Outdated addresses were considered to be 131 companies that could not be contacted in general (neither by email nor by telephone), 20 tanneries that confirmed that they had ceased operations, and 2 companies that reported a change in their business profile. The actual return rate was approximately 30 %. The rate of survey participation (r_u), taking into account the number of actively operating tanneries that could be contacted by telephone, was approximately 30 %. It allowed to show a relationship between the number of enterprises contacted with no answer. The rate of refusal (r_x), was around 31 %. Its estimation allowed to obtain information on respondents who were explicitly unwilling to participate in the surveys. This could have been due to, among other things, a lack of interest in the research topic, concerns about sharing company data, or other factors.

3. Results and findings

3.1 General characteristics of Polish tanneries using 20 companies as examples

Of the 20 tanneries that took part in the survey, 10 (50 %) are located in the Mazowieckie Voivodship and 5 (25 %) are located in the Małopolskie Voivodship. One company from the Dolnośląskie Voivodship, Lubelskie Voivodship, Lubuskie Voivodship, Pomorskie Voivodship,

and Śląskie Voivodship (5 % respectively) also decided to complete the survey. The territorial distribution of these tanneries is shown in Fig. 3. Considering the settlement units, the majority—14 tanneries (70 %)—are located in rural areas, while the remaining 6 are situated in smaller or larger cities (4 tanneries, or 20 %, in cities with up to 50,000 inhabitants, and 2 tanneries, or 10 %, in cities with 51,000 to 100,000 inhabitants).

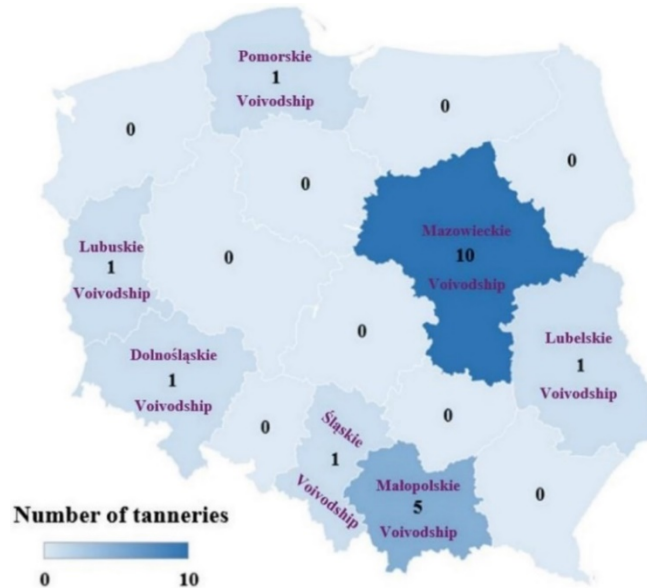


Fig. 3 Territorial location of the tanneries that took part in the study
(Source: Own elaboration using Bing © GeoNames, Microsoft, TomTom)

When characterising the geographical range of their activities, only 5 % of the tanneries indicated a local range (village/town area), while 15 % a regional range (voivodship area). The companies in question mainly operate nationally and internationally within Europe (45 % and 35 % respectively), with a select few (about 1/3) also indicating a global reach. Seven of the 20 (35 %) tanneries that participated in the study are micro-enterprises with less than 10 employees. The largest number, i.e. 9 (45 %), are small enterprises employing between 10 and 49 people. 15 % of those surveyed (3 companies), with a workforce of 50-249, are classified as medium-sized enterprises. One of the tanneries surveyed is a large company with more than 250 employees. This confirms the information contained in the *Social & Environmental Report 2020: The European Leather Industry* [1], according to which European tanneries are mainly small and medium-sized enterprises, but also large companies with an international reach. Taking into consideration the average annual net turnover of the last 10 years, in the case of 6 (30 %) tanneries it was up to PLN 1 million, while 8 companies (40 %) admitted that it was in the range of PLN 1-5 million. A revenue structure of 5-10 million PLN was achieved by 2 (10 %) tanneries, while large profits, exceeding an annual average of 10 million PLN, were indicated by 4 (20 %) of the companies participating in the study.

When asked about their market position, about 2/3 (65 %) of the tanneries considered themselves to be one of the many leather production companies in Poland. The remaining 7 companies (35 %) position themselves as a leader in the tanning sector on the domestic market. The vast majority, i.e. 14 (70 %) of the surveyed companies claim that the most important factor defining their competitiveness is the high quality of the products and/or services they offer (Fig. 4). According to a few (20 %) tanneries, their advantage is mainly determined by the price of products and/or services. One of the companies indicated an option related to technological innovation, and one also admitted that it relies on modern product design (5 % of the respondents respectively).

A lot of interesting information was obtained in the answers to an open question, in which the companies surveyed were asked to identify the most important global business trends in the tanning industry. To clarify and ensure the correct interpretation of the question, the questionnaire included an explanation that business trends are understood as, among other things, activ-

ities related to management, brand promotion, and networking. Responses to the question indicated were varied, with broad and precise answers in the case of 3 tanneries:

- *'Western markets and access to them through green certifications (origin of raw materials, eco-friendly, low-carbon, etc.). First and foremost LWG certification. Promotion of leather to consumers as a renewable, natural and strength, and therefore ecological material, which is a recycled waste from the meat industry and an answer to the 'fast-fashion' trend dominated by oil-based cheap synthetic materials. In addition, automation is an answer to the lack of skilled labor. Reduction of energy consumption in processing'*,
- *'wide-ranging certification of the enterprise and products, modern technologies (also ecological), modern machinery, promotion on the world market, cooperation with other companies of the leather industry in terms of new trends of innovative products'*,
- *'as of today, the most important business trend is to manage production in the most economically viable way in order not to lose financial liquidity due to the constantly increasing costs of services and semi-finished products used in production. Current increases in the chemicals used in production are up to 70 % by 2021. In such turmoil and stress, it is difficult to find funds for brand promotion.'*

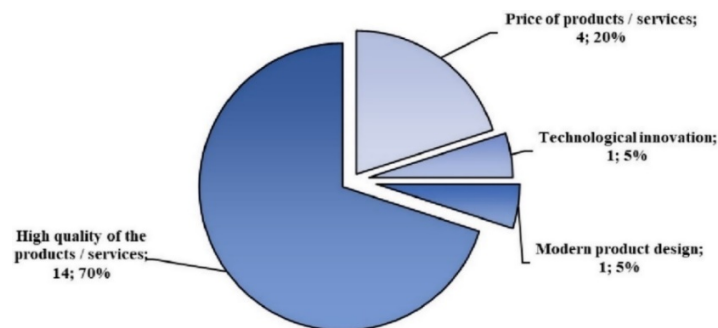


Fig. 4 Determinants of competitiveness in Polish tanneries (Source: Own elaboration)

The majority of respondents to the question on business trends gave a short, slogan-like answer, i.e. *'brand promotion'*, *'brand promotion, quality, customer acquisition'*, *'price, product promotion'*, *'price and quality play the most important role'*, *'constant contact with customers'*, *'social media'*, *'cooperation with the environment'*, *'establishing cooperation'*, *'creation of new products'*, *'innovation, availability of high-quality products'*. One of the tanneries indicated that *'it is necessary to re-brand, production of wellingtons, corrugated packaging, certainly not diversification of production'*.

3.2 Analysis of issues related to leather production carried out in Polish tanneries

As shown in Fig. 5, the raw materials most frequently processed in Polish tanneries are calfskin and cowhide. These hides are processed in 17 (85 %) of the 20 companies surveyed. In addition, tanneries located in Poland also use, but to a lesser extent, sheep, goat, and pig skins (options indicated by 5 of the tanneries respectively, 25 % each). 2 (10 %) of the enterprises surveyed chose the answer *'other skins'*. These data are in line with European statistics, according to which tanneries located in this part of the world mainly produce bovine leather, with a share of more than 80 % [2]. This is because this type of leather can be used to manufacture a wide variety of products [19].

Continuing on the theme of raw material characteristics, respondents in the next two open questions were asked to indicate the countries of origin of the skin/hides processed in their tanneries (when enterprises source raw material from more than one country, average percentages had to be added) and to indicate the average number of tonnes of raw material processed per year. The responses obtained are shown in Table 3. Approximately half (45 %) of the tanneries surveyed purchase their raw material exclusively in Poland. Skin and hides processed in the remaining tanneries are sourced from domestic suppliers and imported from both European and non-European countries. The countries of origin of skin and hides mentioned by the respondents

are shown in Fig. 6. The country from which Polish tanneries most often import skins and hides is Germany. Analysing the responses regarding the average number of tonnes of raw material processed per year by Polish tanneries, a significant discrepancy was found between the companies. 5 (25 %) of the 20 tanneries surveyed process less than 100 tons of skin/hides per year, while 10 (50 %) process between 100 and 1000 tons. 5 (25 %) are producing on a much larger scale, i.e. processing 20,000 tonnes or more of raw material per year.

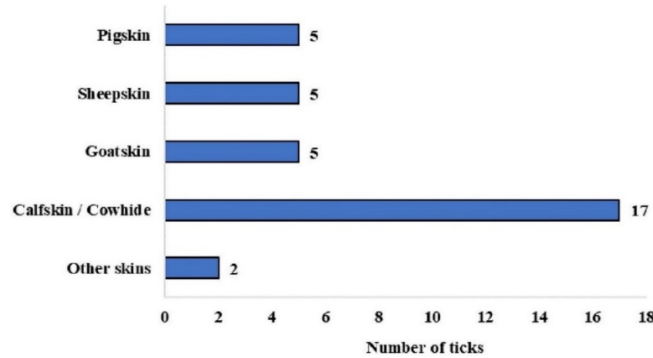


Fig. 5 Type of raw material processed in Polish tanneries (Source: Own elaboration)

Table 3 Countries of origin and volume of raw material processed in Polish tanneries (Source: Own elaboration)

Tannery no.	Countries of origin of the skins/hides	Average share (%)	The average number of tonnes of raw material processed per year
1	Poland	50	350
	Greece	15	
	Bulgaria	15	
	Ukraine	5	
	Bangladesh, India, Brazil, Italy, Germany	15	
2	Poland	100	150
3	Poland	65-70	20 000
	Germany, USA, Canada, other countries	30-35	
4	Poland	100	1
5	Poland	40	700
	Bulgaria	60	
6	Poland	100	180
7	Poland	30	1 000
	Germany	30	
	other countries	40	
8	Poland	100	50
9	Iceland	90	9
	Germany	10	
10	Poland	100	1 700 000
11	Poland	100	100
12	Poland	100	220 000
13	the whole world, from Paraguay to Nepal	100	30
14	Poland	50	3 300 000
	Germany	50	
15	Poland	80	200
	France	20	
16	Poland	100	1
17	Finland	30	500
	Israel, Greece, France, Serbia, Germany	70	
18	Poland	30	115
	Slovakia	50	
	Czech Republic	20	
19	Germany	60	30 000
	England	20	
	USA	10	
	other countries	10	
20	Poland	100	300

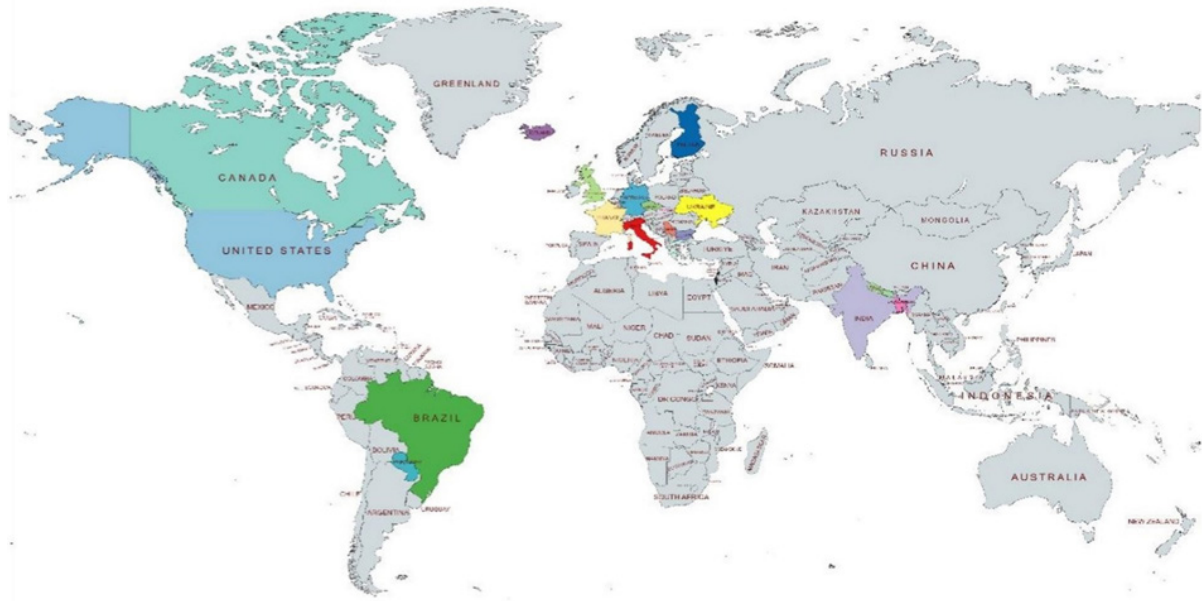


Fig. 6 Countries from which raw material processed in Polish tanneries is imported
(Source: Own elaboration using mapchart.net)

Most (65 %) of the tanneries surveyed carry out a full 3-stage leather manufacturing process [20], i.e., they carry out the phase of 1) preparing the skins/hides for tanning (beamhouse), 2) proper tanning, and 3) finishing. The tanning itself (phase 2) is carried out by 1 (5 %) of the enterprises, while 3 (15 %) only carry out the final phase, i.e. finishing the material they previously acquired in the form of a tanned semi-finished product. One (5 %) of the tanneries is engaged in preparing the skins/hides for tanning (phase 1) and proper tanning (phase 2), with no further finishing. Two of the companies purchase skins/hides prepared to receive tanning, known as pelt, and subject it to tanning (phase 2) and finishing (phase 3).

The tanning method carried out in the 17 tanneries surveyed is shown in Table 4. Tanning with trivalent chromium (Cr^{3+}) salts is carried out in 13 (65 %) enterprises. This method is widely used in leather production worldwide, as the most popular tanning method, allowing to obtain soft leathers, characterised by high strength and good elasticity useful for the production of, among others, footwear, clothing, furniture, and automotive upholstery [21]. According to estimates, about 75 % of leather made today, is produced using this tanning method [22]. Eight (40 %) of the tanneries surveyed use vegetable tannins. This the oldest tanning method makes it possible to obtain hard and resistant leathers, which are used in the production of shoe soles, bags, belts, furnishings components [23], or saddlery products such as saddles and harnesses [24]. As can be seen from Table 4, other tanning methods are also used in tanneries located in Poland, in addition to the two mentioned. It should be noted that 10 of the tanneries that completed the survey rely on a one tanning method, 5 tanneries use two tanning methods, while the remaining 2 enterprises use at least three different types of tanning agents to obtain leather with specific properties desired by the customer.

In the last question, respondents were asked to indicate the destination of the leather produced at the tanneries they represent. When completing the questionnaire, the sample types of goods given (footwear, gallantry, clothing, upholstery, etc.) had to be ranked in descending order of production volume (from the largest to the smallest share). The majority of the respondents, i.e. 12 (60 %) of the tanneries indicated that they primarily produce leather for the footwear industry. This is in line with European statistics, according to which most of the leather supplied by tanneries located in Europe is used for footwear production [6]. Two enterprises (10 % each, respectively) produce leather primarily for clothing and gallantry, while 1 (5 %) tannery oriented its production primarily for upholstery leather. Three (15 %) of the 20 companies surveyed primarily produce leather for uses other than those previously mentioned.

Table 4 Types of tanning method carried out in Polish tanneries (Source: Own elaboration)

Tannery no.	Tanning methods		
	chrome	vegetable	other
1*			
2	x		
3	x		x
4	x		
5	x	x	
6		x	
7*			
8	x		
9		x	
10	x		
11	x		
12*			
13			x
14	x		
15	x	x	
16		x	
17	x	x	x
18	x		x
19	x	x	x
20	x	x	
Total	13	8	5

*/ Tanneries where the tanning process is not carried out.

4. Discussion

According to the information obtained at the beginning of the study, approximately 220 tanneries have been located in Poland in recent years. As part of the ongoing research, the compiled database of tanneries was updated. In the process of data collection, it was confirmed that 20 companies with this profile (about 9 %) have been suspended or liquidated, or the enterprises are in liquidation bankruptcy. Another 130 companies (about 59 %) are likely to be in a similar situation and have not been contacted via email and/or telephone, despite several attempts. Additionally, 67 tanneries (about 30 %) confirmed that they are still actively engaged in leather manufacturing, but 7 of them admitted that they are currently in the process of reducing production and phasing out. Two of the 220 companies, which until recently were tanneries, have changed their business profile. This indicates that the tanning industry in Poland has undergone a process of deindustrialization in recent years, especially during the COVID-19 pandemic, which is the answer to research question RQ1.

The characterisation of the production process carried out in Polish tanneries was based on the example of 20 tanneries that participated in the survey. These enterprises are primarily located in villages and small towns (with populations up to 50,000) within the Mazowieckie and Małopolskie Voivodships. They operate not only domestically but also in Europe, with some indicating a global reach for their activities. The surveyed tanneries are usually micro or small enterprises with up to 49 employees and annual revenues of up to PLN 5 million net. About 2/3 (65 %) of the companies indicated that they were one of many leather producers in the domestic market, while the others placed themselves in a leadership role. According to the majority of the surveyed tanneries, the most important factor defining their competitiveness in the market is the high quality of the products and services they offer. This answers the research question RQ2.

Polish tanneries are aware of the relevance of global trends related to the industry's transformation towards ecology and sustainability. They point out, among other things, the need to reduce energy consumption in processing, the introduction of modern, environmentally friendly production technologies, and the need for certification confirming that their operations are environmentally focused. Current business trends for Polish tanneries also include automation of production and investment in modern machinery. An important aspect is brand promotion in domestic and global markets, contact with customers, including using social media, and cooperation with the environment. The tanneries point to the need to develop customer-appealing, in-

novative products, characterized by good quality and affordable prices. This answers the research question RQ3.

Regarding production characteristics, information was obtained that the surveyed Polish tanneries process mainly calfskin and cowhides, purchased domestically and/or imported from various European and non-European countries, in quantities ranging from 1 to as much as 3300000 tons per year. In most enterprises, a full 3-stage process of leather manufacturing is carried out, i.e. preparation of skins/hides for tanning, proper tanning, and finishing. Selected companies limit production to one or two of these stages. The most common tanning method used in the surveyed enterprises is chrome tanning; vegetable tanning is used less frequently. Polish tanneries are mainly oriented toward the production of raw material for the footwear industry, and to a lesser extent for clothing or gallantry. This answers the research question RQ4.

Skins and hides, which are a major by-product of the food industry, will be supplied to markets as long as meat and dairy products are consumed. The most appropriate management of them is related to the use of technological processes, thanks to which a natural material is obtained—a raw material with unique properties that cannot be replaced by any synthetic substitute [25]. Given this, as well as because of the current situation of the Polish tanning industry, it is necessary to take measures to improve the condition of this sector of the economy.

According to the authors, entrepreneurs in the tanning industry in Poland should consciously analyse and adapt to the most important global trends in the sector, which, according to the survey results, are well known to them. To increase the competitiveness of the Polish tanning industry, action should be taken aimed at improving production processes in tanneries, with the transformation of the industry towards more ecological and sustainable production. The focus should be on eco-friendly tanning methods, recycling of waste and used leather goods, and thus minimizing the negative environmental impact. What is more, it is necessary to track and adapt new technologies, consumer patterns, and changes in their preferences. Action should focus on finding alternative sources of skins and hides obtaining and manufacturing leather with new and/or better properties to increase the flexibility and diversity of offerings.

The state and characteristics of the Polish tanning industry, as presented in the article, are issues that have not been subjected to wider analysis and studies by researchers for years. This undoubtedly demonstrates the existing research gap in this area. Thus, the scientific research designed and carried out made it possible to obtain up-to-date knowledge regarding the situation of this important branch of the national industry, the directions of its changes and the most important problem, which is the progressive deindustrialization of the industry. Similar topics have also not been addressed in the current literature with regard to other European and non-European countries. Therefore, the studies presented in the article may inspire to perform similar analyses with regard to other countries. Based on such studies, it would be possible to draw broader conclusions and assess the situation of the European and global tanning industry, point out the challenges and problems it faces, and propose concrete solutions to them.

5. Research recommendations and limitations

Further research into the structural changes and needs of the Polish tanning industry in the context of the deindustrialization process is recommended. The research should include an analysis of the causes and consequences of this transformation and the search for new development opportunities in this sector. In addition, the authors also suggest research into the development of leather manufacturing technologies in a more environmentally friendly direction to create sustainable products with better properties and higher quality. An example is the research that has been carried out for several years, also in Poland, on the use of natural biocides - essential oils in the production of leather for the internal parts of footwear, to obtain raw material with antimicrobial properties [26, 27]. In the context of the development of the tanning industry, not only in Poland, but around the world, it would also be worth noting the possibility of applying machine learning solutions. Support in this regard could contribute, among other things, to increasing production efficiency, reducing costs, improving product quality and reducing the negative impact of the industry in question on the environment. The application of machine learning in

manufacturing processes and beyond is a topical and frequently addressed issue in publications that have appeared in recent years [28-29].

When planning further research, the limitations encountered by the article's authors should be borne in mind. Conducting survey research may face various constraints, both general and specific to the research topic. Limitations when conducting survey research to assess the current state of the tanning industry in Poland and characteristics of the production process include several aspects:

- For survey results to be reliable, the sample should be representative of the entire population surveyed. In the case of a survey on the state of the tanning industry, difficulties may arise, for example, from not having access to a complete list of all companies in the sector.
- Another limitation proves to be the low response rate to the survey and the low involvement of respondents. This may affect the representativeness of the sample and the reliability of the results. Some information about the tanning industry in Poland may be confidential or protected by law, which may make it difficult to collect a complete picture.
- It is also worth bearing in mind the subjectivity of responses. Respondents may have opinions on the state of the tanning industry that may be formed by their own experiences or prejudices. This can result in the introduction of errors or distortion of results.

To effectively carry out further research in the area of the Polish tanning industry, it is recommended to increase the motivation of respondents. In addition, the authors of the study recommend making study visits to tanneries and conducting in-depth interviews with tannery entrepreneurs.

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