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DETERMINATION OF FACTORS INFLUENCING THE SUPPLY OF COCOA BEANS

Abstract. Cocoa cultivation is only possible in tropical climate with special treatment, such as providing enough shadow for the trees. Harvesting, fermenting and drying processes provide beans that are a mass commodity, mainly used to produce chocolate and cocoa powder. Throughout the years, the demand for cocoa has grown, mostly because of the sensory attractiveness of cocoa-based products. It is continuously growing, posing numerous challenges for manufacturers and distributors. The purpose of this study was to determine the factors influencing cocoa beans supply by analyzing data retrieved mostly from ScienceDirect and Central Statistical Office databases. The most important factors are climate changes and weather anomalies in the countries producing cocoa beans. The climate-related problems tend to deteriorate, and may become overbearing by 2050. There are other significant factors that influence cocoa supply, related to the countries producing majority of the product. The most important one is the unstable political situation in key cocoa producing regions. Solutions for such challenges must be sought after in order to be able to supply enough product to meet demand. Should there be no effective strategy, chocolate and other cocoa-based products' prices will increase significantly, even to the level that these products could be considered luxurious.

Keywords: cocoa beans, cocoa supply, climate change

INTRODUCTION

Climate change is often mentioned among the many factors which affect agriculture and are responsible for the vegetation and yields of plants. The subject of global climate change is discussed by various scientific groups, especially in the context of these changes being more often caused by human activity. In this case, the blame is mainly attributed to the burning of fossil fuels and the emission of increased amounts of greenhouse gases into the atmosphere, which can be directly responsible for raising the global temperature. The effects of climate change are analyzed taking into account three aspects of these changes: economic, social and environmental (Michalak, 2016). Different scenarios predict how climate change will affect agriculture and food security in the world. According to the current research, the sum of atmospheric precipitation is much higher in South America and Asia than in Africa (Bański and Błażejczyk, 2005). Such a situation affects agricultural production and the acquisition of many plant materials in Africa, including cocoa.

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The demand for cocoa beans has been constantly growing in the recent years all over the world. Cocoa bean products are used in the production of foodstuffs, cosmetics, dietary supplements and medicinal products.

Also, cocoa cultivation is influenced by political and economic factors. Cocoa farming regions, in particular West Africa, are pervaded by strong political conflicts leading to armed clashes and tribal feuds. As a consequence, agricultural land becomes dilapidated (Skarżyński, 2015). The political situation and the climate change influence the yields of cocoa, which in turn determine the price of cocoa in the global market (International Cocoa Organization, 2012). Additional factors influencing the supply of cocoa are social problems, workforce exploitation and illegal employment of children (Fromm et al., 2013).

The purpose of this paper is to indicate various factors that affect global cocoa bean production, especially in West Africa. This problem is gradually becoming more critical in the context of the growing demand for cocoa beans and, apart from the climate change, sociopolitical changes. This paper is a review. The methodology employed is based on using statistical data, information from the International Cocoa Organization (ICCO) and scientific publications available in databases. The paper also seeks answers to questions about the quality of chocolate and chocolate products because of the declining global production of cocoa and fraudulent practices of producers that lead to the counterfeiting of chocolate and chocolate products (Kowalska et al., 2008; Quelal-Vásconeza et al., 2019; Acierno et al., 2016; de Oliveira et al., 2018; Śmiechowska, 2013; Śmiechowska, 2014)

COCOA BEAN PRODUCTION

Cocoa beans are obtained from the seeds of an evergreen tropical tree *Theobroma cacao L.* from the *Malvaceae* family. The plant comes in several varieties. *Criollo* is considered the most noble cocoa variety and has a mild flavor. Cocoa trees of this variety grow in Mexico, Central America and Venezuela. The most common variety, *Forastero*, is grown both on small farms and on plantations in West Africa and Brazil. The third form, *Trinitario*, is considered a hybrid of the two former types and is cultivated in South and Central America, Africa, Indonesia and Sri Lanka. The fourth type, *National*, is grown only in Ecuador and probably comes from the country's Amazonian area (Świechowski, 2000; Kania-Lentes, 2005; Beckett, 2009).

Fruits can be harvested all year round, but it is usually done twice a year. After harvesting, cocoa beans are fermented, dried and sorted. Such pre-processed cocoa beans become a mass commodity traded globally. Cocoa beans are the basic raw material used in the production of food and cosmetics. The most common cocoa-containing foods are chocolate and chocolate-based products and cocoa powder.

The largest cocoa producers in the world are West African countries, with a cultivation area of ca. 6 million hectares. Ivory Coast, Ghana, Nigeria and Cameroon provide nearly 64% of the total world production, in which Ivory Coast accounts for almost 32% (Table 1) (Beg et al., 2017; Wessel and Foluke Quist-Wessel, 2015).

The production of cocoa beans in Ivory Coast (IC) grew significantly in the 1980s. This was influenced by

Table 1. Main cocoa producers in the world

Country	2000	2005	2010	2011	2012	2013	2013
	thous. t						overall %
World	3 373	4 044	4 341	4 627	4 646	4 586	100.00
Brazil	197	209	235	249	253	256	5.59
Ecuador	100	94	132	224	133	128	2.80
Ghana	437	740	632	700	879	835	18.22
Indonesia	421	749	845	712	741	778	16.96
Cameroon	123	140	264	240	269	275	6.00
Nigeria	338	441	399	391	383	367	8.00
Côte d'Ivoire (Ivory Coast)	1 401	1 286	1 301	1 511	1 486	1 449	31.60

Source: own elaboration based on the Central Statistical Office database.

the governmental policy of stimulating cocoa cultivation through incentives of financial support for the development of arable land, and by large migration of labor force from the north of the country in search of work. Cocoa production in Ghana is systematically growing. According to Asante-Poku and Angelucci (2013), the main factors that contributed to the growth of cocoa production in Ghana are the support measures of the COCOBOD[1] government agency. The agency's tasks are: ensuring safety of purchase prices; marketing activities; disease control programs; and delivery of free pesticides. In Nigeria and Cameroon, cocoa production has almost doubled in the last twenty years. In these countries, support from governmental organizations is much smaller than in Ivory Coast or Ghana. The west coast of Africa faces problems with the growing and harvesting of cocoa beans to meet the ever greater global demand. Cocoa, often next to coffee, is still one of the most important sources of income for these countries.

PROCESSING AND CONSUMPTION OF COCOA BEANS

A number of problems associated with the production of cocoa stem from the fact that this fruit, like coffee, is produced in poor countries for consumers in rich countries and developing economies. The largest amounts of cocoa beans and semi-finished products derived from it, such as cocoa liquor and cocoa butter, are used in the production of chocolate. Chocolate is a product made from cocoa mass or butter, milk, cream or white chocolate mass, optionally with filling or other additives such as nuts, fruits, seeds etc. (Bruinsma et al., 1999; Coady, 2008).

The recipients of cocoa beans exported from the producing countries are large western chocolate manufacturers, such as Barry Callebaut, Ferrero Group, Mars, Nestlé, Kraft Foods etc., which dominate the global chocolate market. These corporations contribute most to demand for cocoa raw material in the world, thus making the demand stable[2]. The largest clusters of chocolate producers in the US are located on the Middle East coast, i.e. in the regions of New York, New Jersey and Philadelphia. Another large cluster can be found in Michigan, Ohio and Illinois. Chocolate producers are also clustered in western parts of the US and Canada (Mroczkowska and Bohdan, 2011).

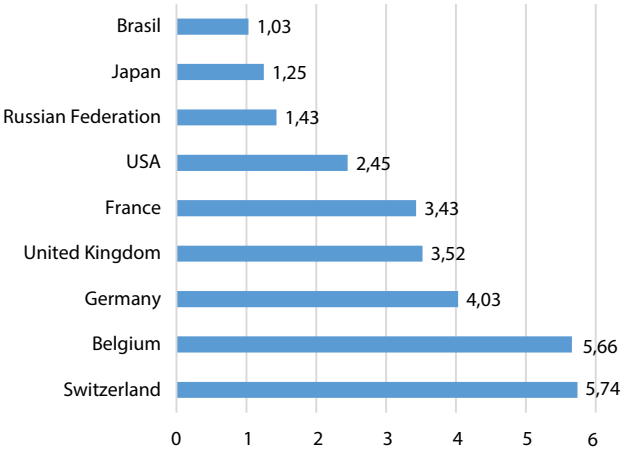

Fig. 1. Cocoa consumption in the world
Source: own elaboration based on The World Cocoa Economy: Current Status, Challenges and Prospects.

The largest group of consumers of cocoa and its products reside in Switzerland, Belgium, Germany, the United States, United Kingdom, Indonesia and Japan (Fig. 1). Increased consumer awareness – caused by factors which include the impact of cocoa and chocolate on human health – has caused a rapid increase of demand for these products.

COCOA AND CHOCOLATE VS. HUMAN HEALTH

Cocoa beans contain ingredients with varying effects, including fats, protein, fiber, alkaloids, polyphenols, minerals and vitamins (Crozier et al., 2011; Kłobukowski et al., 2016; Konar et al., 2016; McFarlin et al., 2015; Śmiechowska and Kłobukowski, 2012). Nutritional properties of cocoa are primarily used in the feeding of children and undernourished or convalescent people. However, many publications indicate that the impact on body weight is due not only to the high fat content of cocoa beans but above all to the addition of sugar, honey and other carbohydrate additives (Ackroff et al., 2007) Cocoa is also characterized by a high content of polyphenolic compounds that have antioxidant, anti-inflammatory, cardioprotective and chemopreventive properties in cancer (Dasgupta and Klein, 2014; Di Castelnuovo et al., 2012; Martin et al., 2013; Ramiro-Puig and Castell, 2009). The studies also showed the

[1] www.cocobod.gh/ (access: 05.06.2018)
[2] www.bossafx.pl (access: 20.11.2016).

importance of cocoa powder and bioactive cocoa ingredients in the prevention of obesity and in stimulating metabolism (Rabadan-Chávez et al., 2016; Strat et al., 2016; Yamashita et al., 2012). The level of polyphenols in cocoa is higher than in tea, wine or acai and other fruits; this is especially true for flavanols and procyanidins (Crozier et al., 2011; Martin et al., 2017).

IMPACT OF SOCIAL, POLITICAL AND ECONOMIC FACTORS ON COCOA PRODUCTION

West Africa was and still is affected by strong political and military conflicts that have numerous implications, including the division of Ivory Coast into two parts. The northern part is under the influence of the rebels while the southern part is controlled by the government. These conflicts have a negative impact on agriculture, the environment and society. Ivory Coast is the area most affected by conflicts. The country witnesses mass migrations of people, declining incomes, losses in agriculture, losses of cattle, numerous victims etc. Ivory Coast is a major producer of coffee and cocoa which contribute 20% to gross national income. The central western part of the country is home to a protected forest complex, Haut-Sassandra. During the conflict, the northern part of the forest reserve was located in an area controlled by the rebel groups, and the southern part in an area controlled by UN forces and the French army. Due to this situation, the reserve was exposed to significant infiltration by local populations and immigrants who penetrated the forest to obtain timber (Barima et al., 2016). Forest complexes in Ivory Coast were subject to strong anthropic pressure which led to deforestation and fragmentation due to forest robbery and loss of biodiversity. In addition, most African countries rely on the same method of cocoa cultivation which is based on traditional cutting and removal of stumps by firing. Similar uncontrolled tree felling practices takes place in Benin and Madagascar. These actions lead to lower cocoa yields and a decreased amount of cocoa beans.

Other factors diagnosed as contributing to the decline in cocoa production in Africa include: the ageing of cocoa farms; low level of farming culture in the field of cocoa cultivation; lack of modern methods of plant cultivation and protection; and lack of shadow management, which is extremely important in the cultivation of cocoa trees. Factors that inhibit growth of cocoa production include the low creditworthiness of farmers and the fact that small farms are not associated in unions and cooperatives which can support farmers in crop improvement systems, such as the joint purchase of new plant seedlings, protection measures, equipment etc. Figure 2 shows the main reasons behind the decreasing productivity in cocoa cultivation (Wessell and Foluke Quist-Wessel, 2015).

In Ivory Coast, cocoa cultivation is a business worth billions of dollars a year. The export of cocoa accounts for ca. 15% of GDP and gives employment to about 5 million people. Cocoa plantations also employ workers from neighboring countries. Unfortunately, children are also exploited on plantations. According to the estimates of the US Department of State, about 100,000 juveniles work in Ivory Coast alone. Although nine countries in Western Africa signed the Harkin–Engel

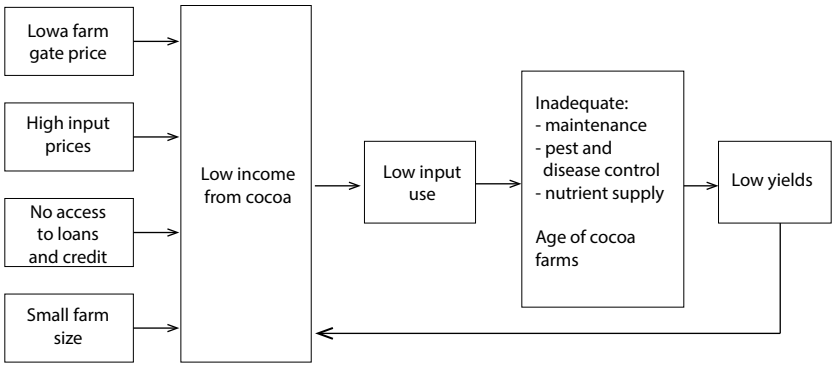

Fig. 2. Causes of low yields in cocoa farming in West Africa
Source: Wessell and Foluke Quist-Wessel, 2015.

Table 2. Factors influencing cocoa bean prices in 1976–2013

Years	Approximate cocoa bean prices (USD/t)	
	price	causes
1976–1977	above 3500	heavy raining in Brasil pestilence low quality and quantity yield in Africa wrong analytics forecasts speculations logistics problems in Ghana
1981–1985	1700–2500	unstable politics in Ghana wrong yield forecasts speculations
2001–2003	965–2230	rebel at Ivory Coast, leading to fights being held at the plantations cocoa trees being cut down by the rebels after cease-fire landmines blocked the trade passages
2007–2008	to 3000	speculations – cocoa purchased by hedge funds
2009–2010	to 3500	higher demand was considered as a response to the world economic crisis
2010/2011	to 3800	political conflict at the Ivory Coast

Source: Skarżyński, 2015.

Protocol in 2001, pledging to halve the number of children working on cocoa plantations, it is virtually unclear to what extent this decision has been implemented. The lack of visible effects in the eradication of child labor on cocoa plantations has prompted the Nestlé concern to state that if Ivory Coast does not take decisive actions, Indonesia will take over the place of African suppliers (Skarżyński, 2015).

There are many factors influencing the supply and fluctuations of prices of cocoa beans in the global market. Skarżyński (2015) conducted an analysis of aspects affecting the prices of cocoa beans in 1976–2013. He concluded that among the many factors, the most important are weather conditions, the ageing of the cocoa plantations and the political situation in Africa (Table 2).

Cocoa trees bear fruit after 4–6 years from planting, for a maximum of 25 years. The destruction of cocoa plantations may inhibit production in a given area for several years. Therefore, in order to maintain the supply of cocoa, new plantations should be planned. In the case of cultivations located in the equatorial belt of Africa, an important element determining the supply and (at the same time) the price is the unstable political, economic and social situation. It poses a real threat of reduced harvests and inefficient logistics, and thus hinders the management of the supply chain of cocoa beans from producers to recipients.

IMPACT OF ENVIRONMENTAL FACTORS ON COCOA PRODUCTION

Predatory forest management conducted in West Africa results from the simplest methods of gaining a livelihood. Thus, new areas for cultivation (including cocoa cultivation) are mainly cleared by burning primary forests. Such areas are exploited until crop yields decline. The main causes of low yields are: the high occurrence of pests and diseases; the aging of cocoa farms; and the lack of nutrients in the soil. Concerns about the decline in production due to aging and diseased trees have prompted the governments of Ivory Coast and Ghana to launch large rehabilitation programs that will provide farmers with better planting material, plant protection products and fertilizers. Due to the fact that the owners of small farms do not get enough income from growing cocoa, they switch to alternative cultivation of oil palm. Cocoa trees grow best and yield in the shade of tall trees. However, growing in full sun is becoming more and more popular, which leads to the degradation of forests, loss of biodiversity and deterioration of soil quality. The final

results are low yields, food insecurity and greenhouse gas emissions (Tondoh et al., 2015).

As the research results indicate, the implementation of unsustainable agriculture in West Africa, in particular on cocoa farms, leads to a reduction of organic matter and basic mineral content in soil and the loss of biological life. Biological life changes as a result of the depletion of nutrients from bedding in agroforestry systems (Tondoh et al., 2015).

As part of the reclamation of areas damaged by growing cocoa trees in full sun, it is recommended to plant trees that provide farmers with additional sources of income. These can be fruit trees, flower trees with medicinal properties or legumes like *Gliricidia sepium*. As an example of such plants, *Leucaena leucocephala* is used for various purposes, such as firewood, fiber and fodder for farm animals. The chances of success for this scenario may be high, although not all studies prove such actions to be viable (Wessell and Foluke Quist-Wessel, 2015).

Agroforestry is often promoted as a sustainable agricultural practice that can counteract the causes of productivity decline (such as soil degradation). However, despite the widely claimed potential of agroforestry, quantitative data on the benefits of shady forests is limited to relatively few cultivation systems (especially corn and coffee). Agroforest crops are not cost-free, and their benefits may be insufficient to outweigh these costs in certain farming systems or environments. Research carried out in Ghana by Blaser et al. (2017) showed that agroforestry did not improve soil fertility in the plantation surveyed. Cocoa growth was even slightly lower in individual tree stands, and decreased with the increase of tree stand coverage on the plantation. Moreover, cocoa yields also decreased with the increase of shading. It is difficult to unequivocally evaluate this research. Other elements of this study are missing, such as the assessment of water retention in forest root systems. However, it is impossible to overestimate the other qualities of agroforest crops, such as the preservation of biodiversity or the beauty of landscape.

Other causes of poor yields of cocoa plantations are pests and diseases of trees. Cocoa Swollen Shoot Virus Disease (CSSVD) is present in the entire cocoa growing area in West Africa. The disease affected crops primarily in Ghana, but recently viral outbreaks have occurred in Ivory Coast. The plague is combated by cutting sick trees or planting CSSVD-resistant hybrid varieties. It is also proposed to separate cocoa trees with citrus fruits in order to stop the viral infection (Dzahini-Obiatey et al., 2010; Kouakou et al., 2012). Dangerous pests on cocoa plantations include the mirids *Distantiella theobroma* and *Sahlbergella singularis*. They cause crop losses of around 25% in Ghana and of 30–40% in Ivory Coast. Studies have shown that due to the high costs of spray equipment, chemicals and labor, most farmers do not practice insect control (Wessell and Foluke Quist-Wessel, 2015). Serious losses in cocoa crops are also caused by diseases spread by Phytophthora fungi. Phytophthora Pod Rot (PPR) is a disease caused by two species of pathogens, *P. palmivora* and *P. megakarya*. These species cause an average annual loss of ca. 40% of pods in Ghana and Ivory Coast. The highest incidence of PPR is found in shady cocoa crops in Cameroon. The removal of infected pods and the reduction of shading (and thus lower humidity) can reduce the loss of pods to some degree. However, usually, chemical control (regularly spraying with fungicides) is also necessary. Alas, most farmers are unable to adopt this technology due to high costs of fungicides and application problems (Opoku et al., 2000; Wessell and Foluke Quist-Wessel, 2015).

The second half of the 20th century witnessed a sharp increase in demand for cocoa beans and its products. The answer to growing demand consisted in extending the area of cultivation, mainly at the cost of cutting down and burning the forest cover. Changes in cocoa cultivation through felling and burning, and thus the disappearance of primary forest cover, is confirmed by the decrease in the amount of earthworms in the soil. Low quality of bedding in cocoa plantations, as evidenced by a high C:N ratio varying in the range of 32.7±1.2 to 33.1±2.9 (combined with low nitrogen content) probably explains the negative impact on the diversity of earthworms (Guéi and Tondoh, 2012).

IMPACT OF CLIMATIC FACTORS ON COCOA PRODUCTION

Climate forecasts until 2050 indicate the possibility of violent climate turbulence in the west coast of Africa. Several climate change scenarios are adopted based on temperature increase, reduction of precipitation and progressing drought. However, sudden precipitation and flooding cannot be ruled out.

The main weather hazards for growing, harvesting and shaping the quality of cocoa are harmattan and El

Niño winds. Harmattan is a strong north-easterly wind usually blowing at the beginning of the year, in the dry season, from the Sahara to the coast of the Gulf of Guinea, and also to the west coast of North Africa, which affects the production of cocoa in Ivory Coast, Ghana, Nigeria and Cameroon. In turn, El Niño brings drought to Southeast Asia, affecting the size of crops (e.g. in Indonesia) and causing hurricane rains in some areas of Latin America which destroy plantations in Ecuador (Skarżyński, 2015).

Long-term conversion of forests into cocoa plantations in full sun can cause agro-ecological problems. In addition to such risks as forest degradation, loss of biodiversity, soil quality disturbance associated with low yields and lack of food security, there are also increased emissions of greenhouse gases (Gockowski and Sonwa, 2011; Tondoh et al., 2015).

The agricultural sector related to the cultivation of cocoa is exposed to climate-related shocks that require mitigation and adaptation strategies. From an economic point of view, it is suggested that one of the solutions to this problem be to insure the farmers against the consequences of climate change and weather anomalies. Unfortunately, farmers' poverty, uncertainty and poor functioning of institutions that fail to take into account the realities are the reason for the lack of interest in this form of insurance (Kimengsi and Azibo, 2015).

In the second half of the twentieth century, Western Africa experienced drought which led to a decrease in annual rainfall by 30% and affected the forest zone. As a result, important areas of cocoa production in the eastern forest belt of Ivory Coast basically ceased to be suitable for growing in the 1960s, and especially for replanting cocoa in the 1990s. There is growing concern that the projected global rise in temperature and in water demand may cause increasing stress in the dry season and further deterioration of climatic conditions for cocoa cultivation (Ruf et al., 2015; Schroth et al., 2016).

SUMMARY AND CONCLUSIONS

Many papers confirm the cardioprotective activity of cocoa, its benefits in anti-diabetic diets and in prevention of obesity (Martin et al., 2013; Hill, 2015; Kłobukowski et al., 2016; Konar et al., 2016). The demand for chocolate products containing more than 70% of pure cocoa is increasing. However, there is not enough response from cocoa producers to these growing needs of the industry. Research conducted in producer countries points to a number of factors affecting the growth of crops. An attempt to diagnose these factors was conducted based on studies of various papers about cocoa producing countries in West Africa which provide about 70% of cocoa beans. The forefront are the political and economic factors that cause the increase of other threats such as social conflicts, farm poverty, forest felling, migration of people in search of work and better living conditions and, last but not least, child labor in plantation works. The situation could be improved if cocoa beans were at least partially processed in producer countries, especially those with a political situation stable enough to create opportunities for the inflow of investment capital.

Predatory forest management in West Africa leads to environmental degradation, depletion of nutrients from soil and desertification. In addition, climate changes in the form of persistent drought result in decreased cocoa bean production volumes and, as some researchers believe, are responsible for the development of diseases and for an increased number of pests, which further reduce yields. In West Africa, cocoa farms are mostly based on the model of short-term opportunistic cycles. Similar trends were found in cocoa plantations in Ghana, Nigeria and Cameroon. This does not guarantee sustainable development (Tscharntke et al., 2011).

Various solutions are suggested, such as the selection of pest- and drought-resistant varieties. In place of cut-down trees, the planting of legumes and fruit trees can be increased, which will create shadow for cocoa trees and provide additional products of great importance to the food economy. It would be beneficial for small growers to associate in order to reduce production costs through joint purchase of tree seedlings and productive inputs in the form of plant protection products and fertilizers. Various forms of producer activation efforts can be observed, but in the absence of political and economic security, as well as social order, it is difficult to expect quick results.

This analysis leads ultimately to the following conclusions:

1. The economic situation could be improved if cocoa beans were at least partially processed in the producing countries, especially those that are politically stable enough to allow for an influx of investment capital.

2. Cocoa raw material should be better managed, both in producing countries and globally. Wastage of beans should be reduced; more care should be given to

the quality of goods produced by implementing an authenticity and traceability system for products.

3. The processing industry should definitely introduce better technologies leading to more efficient utilization of cocoa beans and husks. The scientific research in this area gives reason to hope that every component of the bean could be used to obtain attractive novel food products, cosmetics and medicines.

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OKREŚLENIE CZYNNIKÓW WPŁYWAJĄCYCH NA PODAŻ ZIARNA KAKAOWEGO

Abstrakt. Uprawa kakao jest możliwa tylko w klimacie tropikalnym przy specjalnym traktowaniu, takim jak zapewnienie wystarczającej ilości cienia drzewom kakaowym. Zbiór, fermentacja i suszenie dostarczają ziarna, które jest podstawowym surowcem wykorzystywanym głównie do produkcji czekolady i kakao w proszku. Przez lata zapotrzebowanie na kakao rosło, głównie ze względu na atrakcyjność sensoryczną produktów na bazie kakao oraz wartości zdrowotne i stale rośnie, co staje się wyzwaniem dla producentów i dystrybutorów. Celem badania było określenie czynników wpływających na podaż ziarna kakaowego poprzez analizę danych zawartych głównie w bazach danych Science Direct i GUS. Najważniejsze czynniki to zmiany klimatu i anomalie pogodowe w krajach produkujących ziarno kakaowe. Problemy związane z klimatem mają tendencję do pogarszania się i mogą ulegać intensyfikacji do roku 2050. Istnieją inne znaczące czynniki, które wpływają na podaż kakao i są związane z krajami produkującymi ziarno. Najważniejszy z nich to niestabilna sytuacja polityczna w regionach produkujących większość ziaren kakaowych. Należy szukać rozwiązań, aby móc dostarczyć wystarczającą ilość surowca oraz zaspokoić popyt. W przypadku braku skutecznej strategii ceny czekolady i innych produktów na bazie kakao znacznie wzrosną, nawet do poziomu, kiedy będzie je można uznać za produkty luksusowe.

Słowa kluczowe: ziarno kakaowe, dostawa kakao, zmiana klimatu