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Theobroma Cacao: Processing Into Products, and Economic Impact

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Abstract

The Food of the Gods, *Theobroma cacao*, provides the raw material for multibillion dollar chocolate industry and other cocoa-based products processing industries. It is also the world's primary source of revenue for millions of smallholder farmers, helping in the alleviation of poverty in most cocoa producing regions. This review focuses on the transformation of cocoa into various products such as chocolate, cocoa powder and cocoa butter, as well as the utilisation of cocoa by-products for useful gains. It also highlights the global economic impacts of cacao and its derivatives, right from production, through harvesting, post-harvest treatments, exportation and importation, industrial processing, till it reaches the consumer.

Keywords: *Theobroma cacao*, cocoa processing, cocoa products, cocoa by-products, economics of cocoa.

1. Introduction

Theobroma cacao, commonly known as cocoa is one of the most important, if not the most important economical agricultural commodity for the survival of millions of people in the world. The lives of more than 40 million people are solely dependent on cocoa [1, 2]. It is generally known that, the majority of the world cocoa production (80%-90%) comes from smallholder farmers or farms up to 5 hectares [3]. This is not far from the situation in Ghana, making cocoa a vital agricultural produce for alleviating poverty especially in cocoa growing regions. According to the 48th Annual Report and Financial Statements of Ghana Cocoa Board (COCOBOD) of 30th September, 2017, the world cocoa production was evaluated at 4.6 million tons as reported by the International Cocoa Organization (ICCO) in 2016/2017, seeing a 15% increase from the previous year. Of this total, West Africa Sub-region accounted for about 74% of global cocoa supply with Cote d'Ivoire and Ghana dominating as usual, as the leading producers of cocoa globally. In the aforementioned report, global consumption of cocoa beans, as measured by grindings, was estimated at 4.24 million tons in 2016/2017, which saw a 2.12% increase from the previous year. Among the cocoa-producing nations, Ghana is estimated to have contributed 850,000 tons to global production in 2019/2020 (Table 1). This gives an indication that, cocoa is still the most vital and one of the most important economic agricultural commodities for the nation and the globe respectively.

Table 1 World cocoa production by country from 2018/2019-2019/2020 (in 1000 metric tons)

Cocoa production Ranking	Country	2018/2019	2019/2020	Population (2020)
1	Cote d'Ivoire	2154	2180	26,378,274
2	Ghana	812	850	31,072,940
3	Ecuador	322	325	17,643,054
4	Cameroon	280	290	26,545,863
5	Nigeria	250	250	206,139,589
6	Indonesia	200	200	273,523,615
7	Brazil	176	190	212,559,417
8	Papua New Guinea	40	35	8,947,024

Source: (Statista, 2020)

Cocoa beans or cocoa almonds remain the primary source of raw material for as many chocolate producing, as well as other cocoa products producing industries that exist. Switzerland is tagged to be the country the country with the highest consumption. Chocolate is known to be one of the commonly processed products from cocoa, and it is one of the most widely known foods and confectionery. Nevertheless, products such as cocoa liquor, natural cocoa butter, cocoa cake, cocoa syrup, cocoa powder, etc are obtained from cocoa. The final quality of the cocoa products in terms of aroma and taste especially, is determined by the various processing stages. Post-harvest processing (fermentation, drying, and roasting) is always required for the development of aroma and flavour precursors [4, 5, 6, 7]. Complete stages in cocoa processing are shown in fig. 1 below.

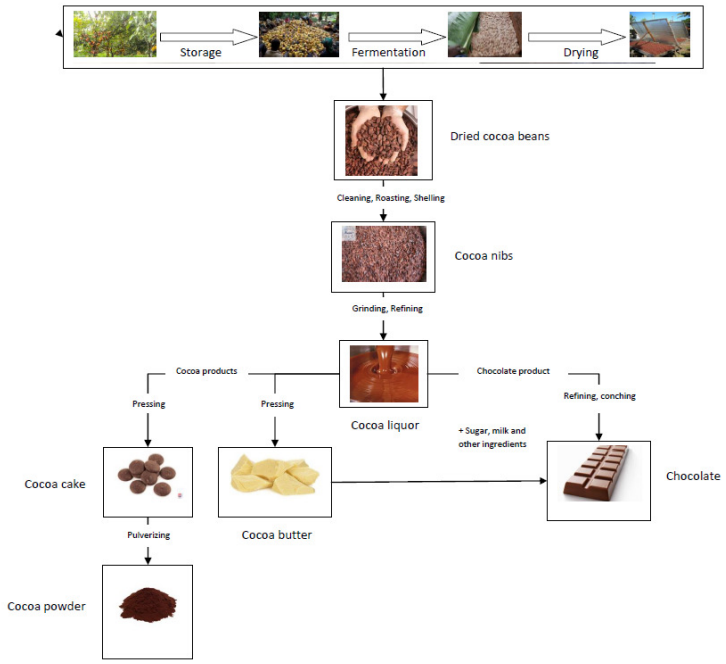

Fig 1: General scheme of cocoa bean production and manufacturing processes.

The cocoa beans, which is the main raw material for chocolate production, constitutes only 10% of the total cocoa fruit weight, while the remaining 90% is designated as waste or by-products (8, 9). Most of these so called by-products are also being exploited in diverse beneficial means. Cocoa pod husks can be used as animal feed, production of soft drinks and alcohol, potash for soft soap and fertilizer. Cocoa bean shells are also used as mulch in gardens and farms, and are utilized by industries as a biofuel and absorbent [10, 11, 12].

This article, which is the outcome of mainly review of other articles, is organized into four sections. Section 1, which is the introductory part, emphasizes on the economic importance of cocoa with a little emphasis on the economy of Ghana. It also throws light on the processing of cocoa and products that could be obtained from it. Section 2 gives further elaborations on how to process cocoa, taking into consideration the three main products (chocolate, cocoa powder, and cocoa butter) we can derive from it. Moreover, fertilizer, mulch, alcoholic beverages, activated charcoal etc, can be obtained from cocoa shell and pulp as by-products, and section 3 throws more light on that. The final section talks about the economic impacts of cocoa and its derivatives. This section also pinpoints the factors involved in economic loss to cocoa producers, from farming to exportation factors.

2. Cocoa Processing and Products.

The final quality of the cocoa products in terms of aroma and taste especially, is determined by the various processing stages [13]. Post-harvest processing (curing, fermentation, drying, and roasting) is always required for the development of aroma and flavour precursors [4, 5, 6, 7]. The purpose for curing cocoa fruits (for 5-7 days under shade) is to enhance uniform maturity as well as promoting the ease of releasing seeds from the fruits. Cocoa beans produce distinct brown color and flavor during the curing process, which have an impact on the final product [14]. The cocoa fruit is broken open to remove the beans for fermentation.

Fermentation of the beans pulp, which can last for 5 to10 days, is an important step for the development of seed color traits, flavor and taste since it produces aroma precursors [15]. Nevertheless, chemical processes that happen during fermentation remains unclear and needs investigating further. Fermentation can be carried out in two ways: we have the natural means known as the spontaneous fermentation where fermentation is solely dependent on microorganisms in the natural biota, and we also have controlled fermentation where microbial starter cultures are employed. When fermentation is too short or incomplete, it results in grainy and gray texture. On the other hand, when fermentation process takes too long, it results in fragile and moldy seeds. In both cases, the quality of the seeds is reduced. During fermentation, combination of endogenous and microbial enzymatic activities, along with the rise of temperature to about 50°C, and the diffusion of metabolites into and out of the cotyledons, allow polyphenols to polymerize and react with proteins and peptides to generate brown color [16].

The next step is to stop the fermentation process, where cocoa seeds are then soaked and washed to do away with residual fermentation mucus that inhibits or slows drying process. After drying of the cocoa beans using heating method, the moisture content reduces to about 7.5% (w/w) [17]. Drying process is where water, volatile compounds, and low-boiling acidic compounds are extremely reduced; producing cocoa beans with bitter and astringent taste [13]. When drying takes place at a very high rate, acids such as acitic acid, which impede flavor production, are produced excessively. On the other hand, when the process occurs at a slower rate than required, it results in reduced pH, enhances the growth of molds as well as absence of characteristic color of cocoa beans [17, 18, 19]. In order to obtain a quality dried cocoa beans is dependent on the drying approach such as conventional hot air drying and sun drying, that is employed. Natural sun drying is still the commonly used approach in West Africa. Hii *et al*. demonstrated that step-up-dried beans gave a very high level flavor profile, which also showed a reduced sour taste, bitterness and acidity [20].

The fermentation stage can be skipped for some cocoa beans, and can only be washed and dried using sunlight. However, Schwan and Wheals in 2004 reported that, the resulting cocoa beans may have weak characteristic brown aroma, and the seeds become a lot bitter [21]. Once cocoa beans are dried, the formation of the distinctive color, aroma, taste, and texture are further enhanced through Maillard's reaction by roasting process [22].

2.1 Chocolate from Cacao.

Chocolate is one of the most widely eaten foods, both as confectionery and as a flavor of other foods. Naturally, chocolate has a bitter and astringent taste, but due to the addition of sugar during production, it usually assumes a sweet taste. Commercially, chocolate can be in the form of solid, liquid, pasta or powder, and the worldwide popularity of chocolate has made it a part of many traditions and cultures. [23]. There are three main recognised genetic varieties of cocoa used for the manufacture of chocolate: Forastero, Criollo, and Trinitario; a fourth variety which was recently discovered in Peru (2011) and grows in Ecuador as well, goes by the name Nacional [24, 25]. Criollo is the finest of all the four cocoa varieties [26]. Forastero is leading the world's production of cocoa, with Criollo contributing a smaller number, about 5 percent [27]. The most noteworthy characteristic of the commercially approved cocoa bean is its fragrance, which also defines its consistency. The scent is produced by volatile compounds with smell receptors from the olfactory tissue of the nasal cavity detected by the cephalic system [28]. On the basis of their aroma, two commercial cocoa classifications are carried out: bulk / ordinary cocoa (Forastero) and fine-aroma cocoa (Criollo and Trinitario) [6, 29]. During the roasting of the bean, the volatile compounds of the cocoa aroma and chocolate are created, transforming the molecules known as aroma precursors that are produced through proteolysis of the proteins stored inside the bean during fermentation [30]. For the optimal development of aromatic volatile compounds, adequate quantities and proportions of the formed precursors are crucial [27].

There is a multistep process involved in chocolate production (fig 1). Cocoa fruit generally contains about 30–40 seeds covered by a mucilaginous pulp removed by bacteria and yeast during fermentation, which is a key step for the development of the chocolate flavor, since it produces aroma precursors. After fermentation, drying is done to reduce the water content to 5–7%; this ensures product stability before further processing. Dried cocoa beans or nibs (i.e., beans without the outer shell) are then roasted to further develop the chocolate flavor. The next step in chocolate production involves nib grinding to convert the solid nibs into a liquid paste (liquor). In the production of dark chocolate, the basic ingredients are cocoa liquor, sugar, cocoa butter, and emulsifiers. Milk and other ingredients may be added, mixed and then refined to reduce the particle sizes of solids. After refining, conching operation, which consists of the agitation of the chocolate mass at high temperatures, and finally tempering, which involves heating, cooling and mixing process, is required for the development of the final texture and flavor. For the production of dark chocolate, the basic ingredients are cocoa liquor, sugar, cocoa butter, and emulsifiers. Milk and other ingredients may be added, mixed and then refined to reduce the particle sizes of solids [31].

After refining, the conching operation, which consists of the agitation of the chocolate mass at high temperatures, and finally tempering, which consists in a heating, cooling and mixing process, is required for the development of the final texture and flavor [31]. Milk chocolate on the other hand normally contains 10% and 12% of chocolate liquor and whole milk solids respectively. Due to the reduced bitter chocolate liquor, it is lighter in color and

sweeter in taste. Chocolate making only differs from confectionery coatings in that, in confectionery coatings, part or all of the chocolate liquor is supplemented with the same amount of cocoa powder, and other vegetable fats of the same or higher melting points are used instead of adding cocoa butter, with a melting point of around 32-33 ° C (90-92 ° F) [32].

2.2 Cocoa Powder from Cacao

In the production of cocoa powder, cocoa nibs are ground, roasted, and milled to first obtain cocoa liquor. A pressing method is then used to separate the liquor into cocoa powder and cocoa butter [33]. Natural-process cocoa powders and chocolate liquors do not go through any alkali treatment. Cocoa beans naturally are slightly acidic (pH of 5.2–5.8). A pH of that range is able to produce sharp pleasant flavors which are able to blend well in many foods and confections [32].

For the purpose of producing alkalized cocoa powder, the powders and chocolate liquors are treated at the nib, liquor, or powder stage. This treatment is frequently called “Dutching” where a food-grade alkali solution is employed to partially neutralize the natural cocoa acids, (mostly acetic acid); or it may be applied to give a strictly alkaline product (pH as high as 8.0). The mostly used alkalizer is potassium carbonate. Nevertheless, other alkalies such as sodium carbonate may be used [32].

Dutch-process, first devised by Coenraad Johannes van Houten in the 19th century, is mostly used to enhance cocoa powder solubility, partially remove acetic acid produced during fermentation, as well as develop a darker color and characteristic taste. Milk□based beverages are mainly supplemented with cocoa powder for confectionery reasons [34]. Previous literature have shown that a number of researches have been carried out on cocoa alkalization and roasting process. However, the changes of the flavor compounds of cocoa occurring at various stages of the cocoa powder production have not been understood yet. The two major steps in the processing of cacao beans that can influence the final taste of the cocoa powder are alkalization and roasting [21]. According to researchers, the percentage of aromatic materials can be changed by altering the amount of sodium or potassium carbonate used during the alkalization process [35].

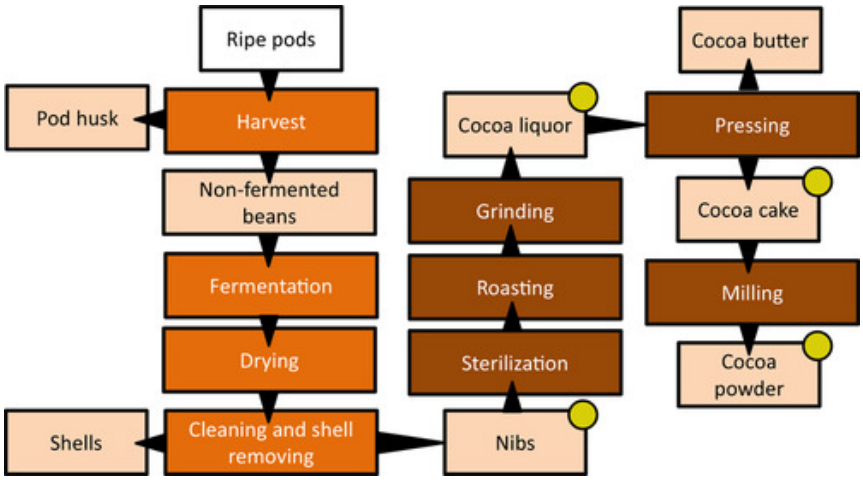

Fig 2: General flowchart of natural cocoa powder production. Primary process (dark orange), secondary process (brown), products (light orange). Yellow circles indicate the products that can be alkalized. **Source:** (García et al, 2020)

Cocoa powders are produced by milling or pulverizing cocoa cakes. This is carried out by submitting the chocolate liquor of about 55% cocoa butter content to hydraulic pressing to eliminate a pre-established quantity of cocoa butter. Not all the cocoa butter content are removed however, but the remaining in the powder may range from 8% to 36%, with the most common commercial grades in the United States containing 11, 17, or 22 percent cocoa butter. In the United Kingdom, cocoa sold for beverage use must contain a minimum of 20% butter [32].

2.3 Cocoa Butter from Cacao

Cocoa butter is an edible natural fat that is primarily contained in dark chocolate derived from Theobroma cocoa seeds [36]. It is a rich source of monounsaturated and saturated fatty acids, consisting primarily of around 33% oleic acid, 25% palmitic acid and 33% stearic acid [37], but not of caffeine or theobromine. Fat cocoa solids have a lower phenolic content than non-fat cocoa solids, like cocoa butter, but may contain some polyphenols of various flavonoid structures with antioxidant properties [38]. Cocoa butter is used in chocolate and other food products and can also be found in skin items that are over-the-counter, such as lotions, creams, and bars designed to preserve skin softness. Although cocoa butter has skin hydrating properties, it has not been shown to decrease the risk of striae gravidarum, commonly referred to as stretch marks, forming [39]. Still, it is a common active ingredient for prevention of skin dryness in cosmetic and skincare products.

The lipid-lowering effects of cocoa butter have been studied and investigated, as fatty acid constituents of cocoa butter are known to exhibit lipid-lowering properties. Dyslipidemia is characterised by elevated plasma triglyceride and low-density lipoprotein (VLDL) cholesterol levels due to the overproduction of large VLDL

cholesterol particles enriched with triglycerides [37]. In animal studies, cocoa butter has been shown to lower VLDL cholesterol levels, indicating its potential use for lipid disorders.

Cocoa butter consists of saturated fatty acids which have a neutral cholesterol reaction in humans [40]. Stearic acid is a non-atherogenic source of dietary saturated fat that is one of the main constituents of cocoa butter [36]. Stearic acid from plant sources such as cocoa, although it is a saturated fatty acid known to elevate plasma lipids and lipoproteins, varies from animal sources of stearic acid [40]. Stearic acid, in addition to its lipid-lowering actions, can also mediate hemostasis and thrombosis actions that remain uncertain. Cocoa butter can also contain flavonoids that evoke antioxidant, anti-platelet, anti-inflammatory effects, as well as HDL rises, blood pressure decreases and endothelial function improves [36].

3. By-products from Cocoa

The cocoa shell is the primary by-product of cocoa and chocolate production, accounting for 8 percent to 10 percent of the weight of raw cocoa beans. In the cracking and fanning, or winnowing process, the shells are blown off and used for manure, mulch, activated carbon and fuel [31]. Cocoa pod husks can be used as animal feed, production of soft drinks and alcohol, potash for soft soap [10, 11, 12].

3.1 Cocoa Pulp as an Adjunct for Beer Production

Cocoa pulp is a rich substrate and can be used in processing processes to produce by-products [41, 21, 42]. A collection of mucilaginous spongy cells containing water, fructose, glucose, sucrose, citric acid, and a variety of inorganic salts make up the pulp [43]. Cocoa pulp has a complex and variable microbiota, and spontaneous fermentation in the food industry is a common method [21, 43, 44, 45]. In studies conducted with cocoa pulp, it was found that it can be used as a substrate for the growth of various microorganisms, with a higher prevalence of fungi than bacteria, and that there is a propensity for *Saccharomyces cerevisiae* to stand out among this diversity [44]. The research seeks to obtain pulp for juice, jam, compotes, fermented beverages and other processed products, providing unique and attractive flavours [46]. Yeasts such as *S. cerevisiae* can readily ferment cocoa pulp to produce an alcoholic beverage. According to the first historical accounts of beer and wine production, this yeast has long been used in fermentation processes [47, 48, 49, 50, 51, 52, 53, 54]. For beer production, the composition of the wort is very important because it ensures the consistency of the finished product and is a means of developing the yeast. Several environmental factors affect the development of metabolites and the survival of yeast during industrial fermentation. In the case of beer processing with the use of an adjunct, temperature, pH and sugar concentration are the key influences, as well as the properties of the pulp [55, 56, 57, 58]. Cocoa pulp is a rather favorable raw material for alcoholic fermentation for the manufacture of beverages since it is high in carbohydrates, has low acidity and contains essential organic acids [46, 59, 60, 61, 62].

The method for production of beer from the cocoa pulp begins with obtaining and storing the cocoa pulp [63]. For chemical analysis, the selected clean and disinfected fruits are broken, pulped, fractionated, packed in flexible polyethylene bags and frozen at around 18 ° C. Processing the wort is the next step. Wort can be produced in accordance with traditional beer processing techniques. Malt is milled with a bench mill to reduce the grain size and promote hydrolysis catalyzed by enzymes during the processing of wort, and the milled malt is merged with water at 35 ° C (temperature ranges from 35 ° C to 76 ° C). The initial pH is changed to 5.4 by adding lactic acid and adjusted to 1.26 g / kg of malt with $CaCl_2$ [63]. The grade of wort production used has been adapted from Carvalho and Zambiazi [64]. Before being added as an adjunct to the brewing wort, the cocoa pulp is first enzymatically handled to minimize viscosity. The pulp is then applied to the wort after the boiling point, at the beginning of fermentation, according to Carvalho *et al*. [65]. This fermentation is accompanied by frequent measurements of the apparent consumption of extracts and the output of ethanol at regular intervals until the apparent attenuation is approximately 70–75 per cent. After reaching the end of fermentation, the beer, considered to be green, matures at 12 ° C for 14 days plus 2 days at 0 ° C to increase clarity and maturation. The addition of cocoa pulp as an adjunct is intended to increase the concentration of major fermentation products and to create a beer with distinct organoleptic traits [63].

3.2 Cocoa Shell as an Adsorbent

Agricultural waste products are used for the adsorption process as natural or modified products via the activation process [66]. The grafting of aryl diazonium salt on cocoa shells has been investigated by Fioresi *et al* [67]. The manufacture of cocoa shell powder free from heavy metals was patented by Bernaet & Ruysscher [68]. The cocoa shells have strong potential for the treatment of waste water from the agro-industry. They are less effective than the polyethylene material used as a bacterial support in eliminating organic pollutants. Sludge residues (made up of a mixture of cocoa shells and biomass) containing high quantities of nutrients such as nitrogen have been produced by the treatment of cocoa shells and can possibly be reused as compost in agriculture [69].

The conversion of waste into activated carbon is one way of elevating the importance of cocoa by-products. It is proposed as an opportunity to replace activated carbon based on industrial coal, as it is an eco-friendly commodity [70]. A few different studies on this subject have been published by Ahmad *et al*. [71, 72, 73], Kalaivani *et al*. [74], Ribas *et al*. [75], Saucier *et al*. [76], and Plaza-Recobert *et al*. [77]. Ahmad *et al*. [71, 72, 73] showed that activated carbons based on cocoa shell have the ability to be used as an adsorbent for 4-nitrophenol and methylene blue (MB) dye in water or wastewater treatments, and that higher temperature and higher acid concentration acid treatment resulted in the creation of a new cocoa shell-based activated carbon structure that removed carbonates and higher acid concentrations. Activated cocoa shell carbon (TCAC1 and TCAC2) prepared at two different temperatures (30 and 350 ° C) has been documented [74] to show significant potential for the removal of Ni(II) ions from an aqueous solution.

The thermal treatment of the adsorbent has resulted in a smaller particle size and a larger surface area and, as a result of an improvement in adsorption power, Ni (II) removal efficiency is almost 62 percent higher compared to TCAC1.

The implementation of microwave-assisted activated carbon from cocoa shells as an adsorbent to remove sodium diclofenac and nimesulide from aqueous effluents has been studied by Saucier *et al*. [76]. In a medium with a high salinity and sugar content, approximately 95 percent of the mixture of different organic compounds has been effectively removed. Plaza-Recobert *et al*. [77] investigated the cocoa bean husk preparation of binderless activated carbon monoliths. The findings show that an appropriate combination of cocoa bean husk macromolecular components (lignocellulosic molecules, pectin, gums and fats) along with a laminate macromolecular microstructure has made it more suitable than other lignocellulosic precursors for obtaining binderless carbon monoliths. Activation of these carbon monoliths, with greater micropore volume and good mechanical performance, provides activated carbon [78].

4. Economics of Cocoa

4.1 Production

Cocoa is mainly generated by hand and has never undergone widespread machinery of its production [79, 80, 81]. Despite this constraint, about 4 million tonnes of cocoa beans have been generated since 2010 annually worldwide [82]. To produce chocolate, cosmetics and a number of foodstuffs, the beans are first converted into cocoa liquor and then into cocoa butter or cocoa powder [83].

A significant source of livelihoods is the cocoa sector, which produced revenues for 40 to 50 million people in 2012, mostly in developing countries, including 16 Low Human Development Countries (LHDCs) [84, 85]. An estimated 5 million farming households depend on cocoa as a cash crop, and 70% of cocoa is grown by smallholders who live on less than USD 2 a day and earn 60 to 90% of their income from cocoa [84].

Fig 3: World's biggest cocoa bean producers

4.2 Exportation and Importation

Either whole or cracked, raw or roasted, exported cocoa beans had a total value of USD 8.6 billion in 2017 [86, 87]. The global market for cocoa beans is expected to grow to reach USD 16.32 billion at a compound annual growth rate (CAGR) of 7.3 percent from 2019 to 2025 [88]. The retail market value of the chocolate industry, which consumed 43% of all cocoa in 2017, was USD 106.19 billion in 2017 and is expected to grow to USD 189.89 billion by 2026 [87, 89].

In importing countries, where cocoa beans are mostly exported for processing and selling to end users, the cocoa and chocolate industries also generate jobs. It sponsored about 2,000 companies in the European Union and 650 companies in the United States in 2011 and employed a total of 70,000 people [84].

Fig 4: World's biggest cocoa importers

Côte d'Ivoire (USD 3.9 billion) was the biggest exporter of cocoa beans in 2016, followed by Ghana (USD 2.5 billion) and Nigeria (USD 0.8 billion). The Netherlands (USD 2.6 billion), Germany (USD 1.5 billion) and the United States (USD 1.3 billion) were the main importers [90].

4.3 Economic Threats

4.3.1 Market Price Volatility

While the cocoa industry is expected to experience a Compound Annual Growth Rate (CAGR) of 7.3 percent from 2019 to 2025, there are serious challenges on the supply side of cocoa that can restrict this possible expansion [88]. Historically, market price volatility has been a major challenge for cocoa growers, which has recently been intensified by the confusion over the timing and terms of Brexit, considering the value of the United Kingdom in cocoa trading [91, 92]. Future cocoa prices fell sharply from USD 3,422 per tonne at the end of 2015 to USD 1,769 per tonne at mid-2017, impacting the price charged to the farmer for cocoa beans (farm-gate price) [93].

4.3.2 Income disparity

The income inequality across the value chain, coupled with market instability, remains a constant challenge in the sector. For example, despite providing chocolate bars with the main ingredient, cocoa farmers in Cote d'Ivoire and Ghana earn only 3 to 6 percent of the retail market value of chocolate bars [94].

The majority of the world cocoa production (80%-90%) comes from smallholder farmers in Africa [3]. However, most of these smallholder farmers and their families are still wallowing in poverty. The situation reported in Indonesia revealed that, the economic value of cocoa is small because the original export of cocoa is more as compared to the processed cocoa products [22]. This is no different from the situation across cocoa producing countries in Africa, and within cocoa growing regions in the world as a whole.

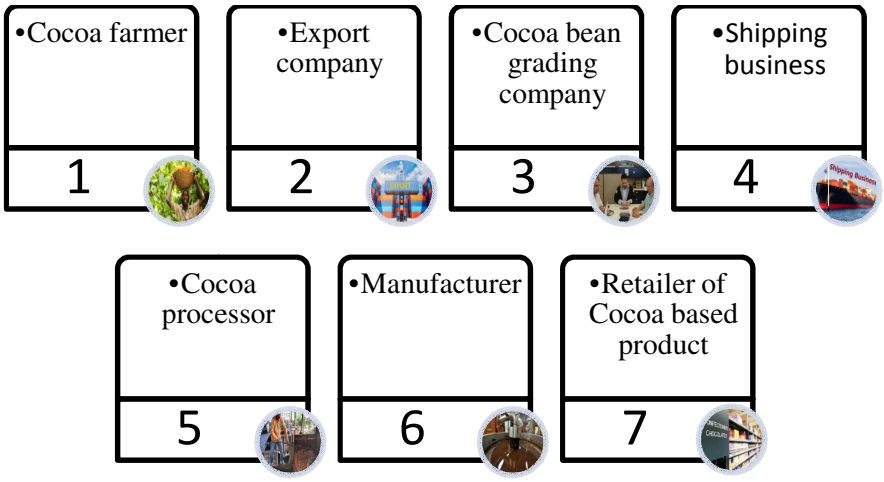

Fig 5: Cocoa supply chain; from cocoa farm to the consumer.

Figure 6 shows the African continent languishing at the bottom with the lowest percentage in terms of global cocoa been processing (added value to raw cocoa beans), with only 18.6% . Europe on the other hand which is the lowest producer of cocoa sits at the top with the highest processing capacity of 38.9%. It is very important that the world largest producers of cocoa such as Ghana, Cote d'Ivoire and Indonesia also climb up the value chain of manufacturing, marketing and sales. This will have a positive economic impact on such countries by generating more income, and boosts their involvement in the chocolate industry [95].

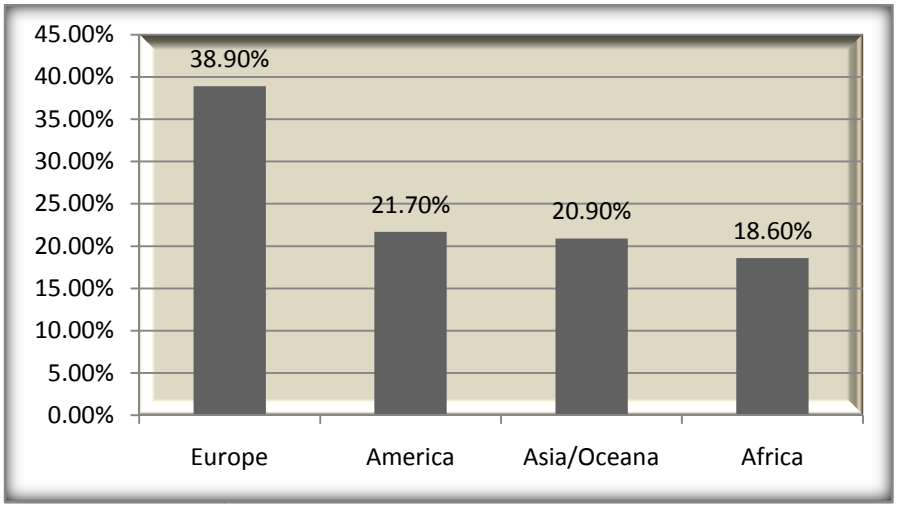

Fig 6: Distribution of global cocoa bean processing in 2012/2013, by region. Europe leads in cocoa processing where the greatest value addition takes place (Modified figure from Statista, 2015).

4.3.3 Ageing and Climate change

Global food production is likely to be impacted by climate change [96, 97, 98]. Agriculture is endangered by extreme weather events, such as droughts or climate change-enhanced floods [99]. Cocoa is known as vulnerable to drought [100], but few field studies have been conducted on the impact of drought on cocoa.

Major challenges in meeting growing demand include the ageing of cocoa trees, leading to a significant decline in yields; the impact of rising temperatures in major West African producing countries, which could weaken output levels and promote changes in production sites and could lead to more deforestation [101]; and systemic poverty, impacting the vast majority of cocoa farmers [102].

In order to ensure that the benefits of the continued growth in cocoa demand are equitably spread across the value chain, these challenges need to be addressed through joint efforts between industry actors, including governments, standard setting bodies, development organizations and private companies [83].

5. Conclusions and Recommendations

Theobroma cacao has been proved to be one of the most important agricultural commodities, which has a very significant global economic impact. It serves as a source of livelihood to millions of people in the world. It provides jobs and income to farmers, exporters and importers, grading companies, as well as processors. Cacao beans have been exploited in diverse ways, being the primary source of raw material which feeds the chocolate-producing industries, as well as other cocoa-based products such cocoa powder, cocoa butter and cocoa syrup. Apart from the cacao beans which are the main material from the cacao fruit, other materials such as the pod husks, cacao pulp and the shells,

which are considered as waste or by-products, are being utilized in the production of alcoholic beverages, activated carbon, fertilizers/manure, and other beneficial products.

Africa remains the world bank of cacao, feeding the world with about 74% of cacao production, with Cote d'Ivoire leading, followed by Ghana. In spite of this, Africa and other cocoa producing regions like Indonesia are the worst when it comes to global cocoa processing or adding value to the cacao beans. In order to close the vast economic gap between the producers and processors, Africa and the rest of the cacao producing regions need to think in the direction of industrialization to climb up the value chain of manufacturing, marketing and sales. This will have positive economic effects by generating more income, and boosting their involvement in the processing industry.

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