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A REVIEW ON SUSTAINABILITY IN COCOA AND CHOCOLATE PROCESSING: A FOCUS ON WEST AFRICA

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ABSTRACT: *Cocoa is traded internationally and is highly significant to most economies. The majority of cocoa beans are sourced from West Africa, exporting over 70 % of cocoa globally. Despite this, West Africa makes minimal profits as compared to the consumer countries controlling the chocolate industry. A lot of sustainability interventions have been rolled out to ensure the continuous production of the crop. Europe and other international organizations have invested largely in cocoa sustainability. Some interventions have been in the form of certification standards, sensitization and awareness programs, training and empowering farmers, particularly in the West African region. Ghana and Cote d'Ivoire have benefitted from a lot of sustainability programs as the world's largest cocoa producers. This review delves into several sustainability initiatives implemented in Ghana and Cote d'Ivoire through Voluntary Sustainability Standards, local government regulations, and international organizations. It also highlights the importance of sustainability in ensuring a consistent supply of high-quality cocoa beans for processors and highlights its associated health benefits.*

KEYWORDS: Sustainability, West Africa, Certifications, Voluntary Sustainability Standards, Cocoa Industry, Bean Quality.

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INTRODUCTION

Cocoa is an important cash crop globally. A very critical commodity whose impact on the economies of developing countries has been significant. Cocoa trees are typically grown in limited areas in Africa, Asia, and Central and South America. These areas offer conducive climate conditions for cocoa cultivation. Over 70% of cocoa beans worldwide come from West African countries: Ivory Coast, Ghana, Nigeria, and Cameroon. With Côte D'Ivoire and Ghana exporting over 50–60% of it (Wessel & Quist-Wessel, 2015). Most cocoa farms are owned in small portions by individual families. A report from Barry Callebaut (2024) indicated that an estimated 2 million local cocoa farmers from the two largest exporters in Africa are responsible for the manual cultivation and harvesting of cocoa fruits on small scales. There is a gap in cocoa bean tonnage production and bean processing in these West African regions. Europe has the largest cocoa processing economy. Cocoa beans are processed into semi-finished products (cocoa liquor, butter, and powder) and further processed into confectionery products around the globe. Cocoa products are enjoyed by many individuals aside from its sensory qualities.

A study by Vyas et. al. (2024) shows that cocoa powder with at least 72% cocoa improves cognition and may lower the risk of heart disease. The United Nations defines sustainability as ensuring the needs of the present are met without compromising those of future generations. Cocoa sustainability ensures that each process in the chain works to improve the livelihood of cocoa farmers, and mitigations to ensure the continuous production of quality cocoa beans and processing, according to the World Cocoa Foundation. Key sustainability issues identified by Barry Callebaut among local cocoa farmers in the West African region include poor productivity, farmer poverty, child labour, deforestation, and climate change. A 2021 study in Ghana and Côte d'Ivoire indicated that 30–58% of farming households earned a gross income below the extreme poverty line set by the World Bank while 73–90% of study participants did not earn a living income (Van Vliet et al., 2021).

COCOA PROCESSING: THE QUALITY, NUTRITION, AND HEALTH DIMENSION

Sustainability seeks to address and ensure the continuous availability of high-quality cocoa beans in abundance. Cocoa bean quality is graded on several indicators including bean size and count, fatty acid content, and bean colour, with high significance given to the quality of flavours due to its importance in the chocolate industry. Cocoa bean flavour quality is dependent on the genotype of beans, the environment, the de-pulping process, storage of pod, fermentation and drying methods, and roasting during bean processing (Kongor et al., 2016). An extensive study (Crafack et. al. 2014) provides data on the identification of over 600 flavour compounds associated with both cocoa beans and products. Sensory evaluation in the cocoa industry has become very key in ensuring the continuous research and identification of distinct flavour combinations for savory taste in the manufacturing of chocolate and other cocoa confectionaries.

Each variant of cocoa and its origin is characterized by its distinct flavour composition (Afoakwa et al., 2008). The fresh cocoa bean has an approximate composition of 32–39% water, 30–32% fat, 10–15% proteins, 5–6% polyphenols, 4–6% starch, 4–6% pentosans, 2–3% cellulose, 2–3% sucrose, 1–2% theobromine, 1% acids, and 1% caffeine (Bertazzo et al., 2011; Kongor et.al., 2016). The genetic makeup (storage polysaccharides, proteins, and polyphenols) of each cocoa fruit type impacts its flavour. Forastero hybrids originating from Ghana are characterized by strong chocolate flavour composition. Forastero cocoa type from Cote

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d'Ivoire is noted for its low bitterness, low acidity, and fruity and nutty flavour profile whereas Forastero grown in Brazil has a bitter, acidic, and no nutty characteristic as its flavour type (Kongor et al., 2016). The various cocoa types show differences in overall bean yield, ability to resist pests and diseases, pod appearance, and distinct flavour composition. These properties significant in cultivation have resulted in growing three common cocoa types: Forastero, Criollo, and Trinitario (Afoakwa et al., 2008). The constituents of each cocoa bean type determine the outcome of the flavour type, aroma, and intensity during the fermentation and drying process.

Handling post-harvest activities involving pulp-conditioning, fermentation, and drying cocoa beans are highly critical in the overall flavour of the final dried beans. Bad post-harvest process treatment results are in the production of poorly flavoured dried beans, irrespective of satisfying other factors that determine overall bean flavour. Pulp-conditioning creates conducive properties to allow beans to undergo a good fermentation process. The cocoa pulp serves as a substrate for microbial metabolism during fermentation, resulting in the production of acids by lactic and acetic acid bacteria. The pulp contains high volumes of sugars that can be fermented into acids. To minimize cocoa bean acidity and polyphenolic content, studies have shown that reducing bean pulp quantity is ideal (Kongor et al., 2016). Pulp conditioning can be done in three ways: de-pulping (mechanical and enzymatic method), pod storage, and bean spreading. The mechanical method of de-pulping involves using presses, centrifuges or manually spreading beans directly onto a surface for several hours before fermentation to reduce moisture content and general pulp volume. The type of de-pulping removes approximately 10–30% of cocoa pulp from the total cocoa bean and pulp weight (Afoakwa et al, 2011). Enzymatic depulping requires the inclusion of the pectinase enzyme in the cocoa bean pulp mass to break down pectin which results in low volumes of pulp in the mass. The de-pulping process also helps reduce fermentation time. Lastly, the pod storage method requires that the harvested cocoa pods are stored over a set period before being opened for fermentation. Afoakwa et al. (2011) study showed that ample storage of cocoa pods significantly impacted the quality of the fermentation process of Ghanaian cocoa beans and reduced their acidity.

The colour of the cocoa bean is an indicator in assessing cocoa bean quality and for developing chocolate flavour precursors. The cut test is done during bean sourcing to verify the effectiveness of the fermentation process. (Hartuti et al., 2019). After fermentation, dried cocoa beans should change from purple (moist and unfermented beans) to brown. The purple cocoa bean is an indication of a poor fermentation process which affects the flavour of the beans. (Hartuti et al., 2019). With fermentation, the cocoa beans are subjected to specific conditions that allow a microbial reaction to take place to induce flavor development. It is a natural process involving microorganisms, yeast, lactic acid bacteria, and acetic acid bacteria with spore-forming bacilli and filamentous fungi taking part in the microbial action. This process modifies the cocoa bean, gets rid of the pulp mucilage, and sets it up for a reaction that will modify the bean's color, taste, and smell (Guzman-Alvarez et al., 2021). The process is two-phased: aerobic and anaerobic. The first stage of the fermentation process is anaerobic. The wet cocoa is stored in wooden boxes with perforations beneath and covered with banana leaves during this stage. The pulp surrounding the beans creates an anaerobic environment for the process. The pulp consists of water, sugars, acids, and enzymes. The sugar-acid combinations are conducive to microbial function. The yeasts convert sugars into carbon dioxide, ethanol, and energy. Lactic acid bacteria convert acid and glucose into lactic acid. Carbon dioxide release

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results in the formation of bubbles on the cocoa surface. Pulp enzymes also help in the degradation of pulp around the cocoa beans, converting them into free liquid (Guzman-Alavarez et al., 2021). The breakdown of the pulp allows airflow through the process. The citric acid generated through the degradation is broken down, therefore increasing the overall pH of the fermentation process. These factors (air and high pH) serve as precursors for the aerobic phase (Guzman-Alvarez et al., 2021). In the aerobic stage, there is oxidation of ethanol and acid to produce acetic acid by acetic acid bacteria. Oxygen further breaks down acetic acid into carbon dioxide and water. Heat is released during ethanol breakdown, resulting in high temperatures of the cocoa. The cocoa beans are continuously turned to reduce the temperature at marked time intervals in the aerobic process. This phase breaks down cell walls due to the reaction between heat, acid, and ethanol. The research conducted by Calvo et al. (2021) indicates that temperature and pH are key controllers for assessing bean quality during fermentation. The type of fermentation will depend on the type of beans cultivated. Forastero and Trinitario bean types undergo fermentation between 5–7 days whereas Criollo requires 2 to 3 days. The entire fermentation process results in the production of free amino acids, peptides, reducing sugars, and volatile compounds (esters, alcohols, aldehydes, and organic acids). These give cocoa beans their distinctive aroma and flavour (Kongor et al., 2016). The fermented beans are dried directly in the sun to lower the moisture for storage. Drying usually takes five to ten days. For a good drying process, spread beans onto flat surfaces raised 1 meter above ground level. Also, bean layers should not be crowded and thick, and not greater than six centimetres. Regularly stir beans to ensure uniformity in drying (Zulkarnain et al., 2020).

Before cocoa nibs are roasted, cocoa beans are cleaned, pre-dried through a roasting process, and subjected to winnowing to separate cocoa nibs from the shells. Before grinding, the nibs are roasted – a critical step in flavour development. Roasting reduces the microbial load of cocoa, acidity and astringency, and lowers moisture content (Kongor et al., 2016). Cocoa nibs are subsequently ground to generate cocoa liquor before being used in chocolate manufacturing. For cocoa butter and powder, cocoa liquor is pressed using a hydraulic system. In chocolate production, the conching process is described by Indiarto et al. (2021) as an integral and final part of the chocolate production process that enhances the final taste, aroma, texture, and consistency associated with high-quality chocolates. In this process, the chocolate is mixed thoroughly for several hours and at high temperatures, to smoothen all sugar and cocoa solids while allowing the evaporation of excess moisture and acid off the chocolate. The high temperatures help in the development of flavour.

Extensive research has ascertained the polyphenolic-rich content and associated health benefits of consuming cocoa. Cocoa beans are high in polyphenols (flavonoids, anthocyanins, and proanthocyanins) and are known for their antioxidant and anti-inflammatory properties (Tušek et al., 2024). Several research articles highlight the correlation between cocoa consumption and its benefits to cardiovascular health (lowering blood pressure), diabetes, cancer, cognition, and vision (Martin & Ramos, 2021; Tušek et al., 2024). Free radicals produced in the body are associated with oxidative stress, leading to cell destruction and the development of chronic diseases. The anti-oxidative properties of eating cocoa can protect the body against the actions of free radicals (Scapagnini et al., 2014). Flavonoids in cocoa prevent the growth and spreading of tumor cells through the inhibition of angiogenesis. For cognition, studies have suggested that cocoa flavonoids are linked to high cerebral blood volume, and the anti-oxidant and anti-inflammatory properties of cocoa have a good effect on the nervous system and subsequently are beneficial to cognition (Tušek et al., 2024). Aside from chocolate's sensory characteristics,

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phenylethylamine and theobromine present in chocolate are responsible for the good mood associated with consumption. Improved mood helps to reduce stress and increases attention span. These effects positively influence cognitive function (Tušek et al., 2024). A study by Jafarirad et al. (2018) reported a decrease in hs-CRP, TNF-ALPHA, and IL-6 inflammatory markers in diabetic patients after consuming dark chocolate (84% cocoa) for 8 weeks. The findings showed a reduction in blood glucose, HbA1c, LDL-C, and triglycerides. Overall, the nutritional and health benefits associated with cocoa consumption have been established in scientific research. To improve on cocoa quality and nutrition, sustainability in the cocoa chain must remain a hallmark.

COCOA SUSTAINABILITY INITIATIVES

The cocoa industry faces numerous challenges that have negatively impacted the business. A future projection indicates that the absence of sustainability in the cocoa value chain will result in decreased productivity with time. The main cocoa-growing countries in West Africa are faced with issues concerning poor labour, pests and diseases, low farm yields, deforestation, and soil degradation (Ingram et al., 2018). Voluntary Sustainability Standards are the most sought-after form of sustainability implementation strategies. Also, there are several sustainability measures and strategies championed by individual corporate initiatives, NGOs, Associations, and CSOs. The Sustainable Development Goals adopted by the United Nations have reiterated the need for more robust initiatives that are in line with achieving the SDGs by 2030 (United Nations, 2015). The Swiss Platform for Sustainable Cocoa in 2021 laid down strategic goals, termed Road Map 2030, that will focus on some targeted areas including living income, climate, forest and agroforestry, child labor, traceability and transparency, gender equality, and innovation in the cocoa value chain to help promote social, economic and environmental sustainability in the cocoa industry (Swiss Platform for Sustainable Cocoa, 2021).

Voluntary Sustainability Standards (VSS)

These standards are requirements put in place to ensure producers, importers, exporters, retailers, service providers, manufacturers and all other various stakeholders in the cocoa value chain meet to ensure continuity in sustainability. Some areas championed by these standards include cooperative governance, occupational health, and safety, policies tackling negative environmental impacts, labour and human rights concerns, land usage, and farm management, increasing the livelihood of farmers, waste management, traceability, and transparency (Ingram et al., 2018). They have been in existence for over two decades and have significantly helped in sustainability. The four main VSSs used are UTZ, Rainforest Alliance, Fairtrade, and Organic certifications. Over the years, a lot of cocoa processors, chocolate manufacturers, and retailers have increasingly signed on to these certifications and incorporated them as part of their operational systems to help attain sustainability in the entire value chain. According to a study by the International Trade Centre, an estimated 2.7 million hectares received certifications in 2013 mainly in Ghana, Côte d'Ivoire, Brazil, Peru, Dominican Republic, Honduras, Vietnam, and Indonesia (International Trade Centre (ITC), 2015). In 2016, Voluntary Sustainability Standards recorded a 30% share in cocoa bean production globally (Ingram et al., 2018), with UTZ certified having the largest impact. These standards play pivotal roles in cocoa processing. UTZ, Rainforest Alliance, and Fairtrade are controlled by private corporations (prominently cocoa and chocolate traders) while the Organic Certifications are mostly regulated by state institutions like the European Organic Standard

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(Carimentrand, 2020). Willer et al. (2019) reported that cocoa has been the second most highly certified crop by Fairtrade between 2013 to 2017. While UTZ has gained ground among cocoa farmers, Fairtrade has recorded a high growth rate in terms of Sign-Ons. Between 2013 and 2017, UTZ-certified areas increased by over 125% while Fairtrade-certified cocoa areas went up by 174%. Most UTZ or Rainforest Alliance-certified cooperatives still received the Fairtrade certifications. Most cooperatives do this to diversify their exportation prowess, rendering them the opportunity to not depend on a sole exporter and a single label (Lernoud et al., 2018).

COCOA SUSTAINABILITY INITIATIVES IN WEST AFRICA

The West African regions have been the largest beneficiaries of the numerous sustainability interventions implemented. Most cocoa beans processed around the world are grown by smallholder farmers in these areas whose livelihoods depend on their produce (Giacometti et al., 2015) Major challenges identified in the cocoa value chain have been associated with farmers and their immediate environment. Some key issues noted are poverty, deforestation and climate change, pests and diseases as well as child labour (Ingram et al., 2018; Ruf et al., 2019). Sustainable certification schemes have been a widely used measuring standard over decades in assessing quality beans for processing and responding to sustainability challenges (Ollenderf et al., 2022). Support from NGOs and corporate entities to ensure continuity drives the sustainability efforts in the cocoa industry. For instance, Fairtrade Africa (with support from Fairtrade International) currently supports the cocoa industry in Ghana, Côte d'Ivoire, and Sierra Leone through the West Africa Cocoa Programme (WACP) launched in 2016 to build strong, operational, resilient, and proactive fairtrade small scale producer organizations (SPOs). The program seeks to empower SPOs and translate knowledge gained through training and technical support to their members. This is aimed at addressing economic, social, and environmental sustainability in cocoa cultivation (Fairtrade Africa, 2023). In addition, the ISO standards on sustainable and traceable cocoa developed in 2019 are used by companies to incorporate sustainability measures in their operations. It allows them to declare produce as sustainable on their packaging after auditing by an independent certification body (Carimentrand, 2020).

Sustainability Initiatives in Cote D'Ivoire and Ghana

As the leading producers of cocoa globally, tackling sustainability challenges from these regions is critical. While huge investments and progress are being recorded, more sustainability initiatives must be enforced. Currently, most sustainability implementations are quantified through certification schemes. Other private-government collaborations contribute immensely to promoting sustainability.

Certification Schemes

UTZ, Rainfall Alliance, and Fairtrade certifications have the most certified cocoa areas in Africa, particularly in Ghana and Cote d'Ivoire. The core mandate of UTZ is to provide expert training and guidance on good agricultural practices and farm management, and tackle issues relating to improved working conditions to promote sustainability. UTZ certified 23% of the world's cocoa farming areas with Cote d'Ivoire leading (1.4 million hectares), followed by

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Ghana (over 567,000 hectares) and Nigeria (over 195,000 hectares) (Willer et al., 2019). An impact study by Ingram et al. (2018) measured the work done in these regions through sustainability initiatives. The study reported higher net income and profit, high productivity, and better labor conditions for certified (UTZ) farmers in Ivory Coast and Ghana than non-certified farmers (Ingram et al., 2018). Rainfall Alliance focuses on promoting good agricultural practices that seek to protect the environment while improving crop yield. Forty-eight percent (48%) of Rainfall Alliance-certified areas are in Africa with Côte d'Ivoire being the highest-certified region (Lernoud et al., 2019). A new development recognizes the current merger of UTZ and Rainfall Alliance to strengthen the fight for continuous sustainability. This merger was done in 2018 and, together, it is now known as Rainfall Alliance. In 2020, they developed a common standard that integrates the objectives and goals of the two bodies (Rainfall Alliance & UTZ, 2020). The Fairtrade certification seeks to address issues relating to poverty among local farmers. It requires produce buyers to pay a set fair trade minimum price to producers. This price set is regulated based on the average cost of production and serves as a buffer in harsh market price situations. Premiums are received by cocoa producers and cooperatives in addition to the purposes of investing in their businesses and communities. Fairtrade certifications are growing among cocoa farmers, accounting for close to 10% of cocoa areas worldwide (Lernoud et al., 2019).

Table 1: An estimated volume of production and producer numbers from Ghana and Côte d'Ivoire in 2015(Bymolt et al., 2018)

	COTÊ D'IVOIRE		GHANA	
	Number of producers	**Volumes (MT)**	**Number of producers**	**Volumes (MT)**
UTZ	193,444	486,842	92,671	169,057
Rainfall Alliance	96,448	297,325	57,825	103,954
Fairtrade International	32,494	111,300	109,229	79,678

Initiatives by Corporate Entities

Companies like Barry Callebaut, Olam, Cargill, and Nestle among others continue to support Ghana and Côte d'Ivoire with sustainability interventions. Typically, the objectives of these private companies that control major shares of the cocoa and chocolate industry are to alleviate challenges that involve child labour, deforestation, bean quality, traceability, farmer poverty, and support to producer communities (Amiel & Laurans, 2019). Corporate initiatives mainly focus on ways and means of achieving set sustainable targets. Monitoring of progress is mostly done qualitatively unlike the certification standards that have precise requirements that should be met. The Cargill Cocoa Promise sustainability program established in 2012 is targeted to improve the livelihood of farmers and the community, protect the planet, establish confidence among consumers, and an inclusive transformation effort to help the cocoa sector. The Cocoa Horizon and cocoa compass programs by Barry Callebaut and Olam seek to help in the fight against poverty, and labour issues, and promote sustainable farming. The Cocoa Compass program distributes sustainable cocoa seedlings and shade tree seedlings to local farmers. Cémoi's transparency cocoa program launched in 2015 also contributes to the social,

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environmental, economic, and quality sustainable challenges faced in the sector through the promotion of agroforestry, training for local farmers, championing professionalism among cooperatives, easy access to microfinance by smallholder farmers and monitoring of working conditions. Chocolate companies including Hershey (Shared Goodness Initiative), Nestle (The Cocoa Plan), Mars (Cocoa for Generations), Ferrero, Mondelez (Cocoa Life), and Lindt & Sprüngli have invested in sustainability initiatives that also contribute to high productivity, improving nutrition, protecting the environment, traceability, and income. The Nestle Cocoa Plan, implemented in Ghana and Côte d'Ivoire sensitized and created awareness among 87,000 farmers on forest laws, distribution of shade trees, agroforestry pilots, good agricultural practices, and financial inclusion (Carimentrand, 2020).

Government-led Initiatives and Partnerships

Both Côte d'Ivoire and Ghanaian government (COCOBOD) regulators work to ensure productivity and tackle challenges in the sector. COCOBOD promotes sustainable cocoa farming in Ghana through training, sensitization, and optimum regulation of produce. The regulatory body provides seedlings for farmers, and fertilizers and finances the spraying of cocoa farms. Furthermore, COCOBOD champions crop diversification to ensure cocoa farmers are self-sufficient and resilient (Aneani et al., 2011). In 2022, Cote d'Ivoire embraced a national strategy for sustainable cocoa farming dubbed "Déclaration de politique et Stratégie Nationale pour une Cacaoculture Durable (SNCD)" aimed at addressing issues on child labour, deforestation, and income in the cocoa farming sector by 2030. In 2019, Ghana and Côte d'Ivoire implemented the Living Income Differential (LID) policy. This policy aimed at increasing farmers' income by the addition of a $400 premium on each ton of cocoa purchased while strategically positioning producer countries' influence in market pricing globally. (Boysen et al., 2023). Additionally, in 2017, both Ghanaian and Côte d'Ivoire governments in partnership with the World Cocoa Foundation, Sustainable Trade Initiative, The Prince of Wales, and International Sustainability Unit agreed to a goal of curbing cocoa-related deforestation and preserving the lands. The program known as the Cocoa and Forest Initiative has partnered with other international organizations to also promote sustainable production and community engagement in designing models that will help solve forestry challenges (World Cocoa Foundation, 2023). In 2023, COCOBOD together with local and international stakeholders developed a National Implementation Guide for GS ARS 1000, detailing requirements needed for the continuous production of quality and traceable cocoa beans. This initiative was necessary to keep addressing the growing demand by consumer countries to source only sustainable cocoa. This requirement is still in line with the three key sustainable areas: economic, environmental, and social challenges.

THE FUTURE OF COCOA SUSTAINABILITY

A lot of work is being done to ensure sustainability. With the SDGs leading the front, the future of cocoa sustainability looks promising; however, there is the need for more robust initiatives, larger investments, and commitment to ensuring a lifelong sustainable impact. On child labor, the study by Ingram et al. (2018) reported a high awareness of the subject in cocoa-growing communities. Children are significantly receiving formal education in institutions. Overall, there is a high awareness of sustainability among cocoa industry players. There is a need for the private sector to invest in cocoa processing and confectioneries in Ghana and Côte d'Ivoire to help grow the cocoa value chain in West Africa. Such developments will significantly position the region in the future as a key player in global market pricing.

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CONCLUSION

This review has identified and highlighted the numerous works done to ensure sustainability in the cocoa value chain. However, in ensuring longevity and production of high-quality cocoa beans and confectioneries, continuous investment in sustainability should be a priority, especially in origin countries that have relied largely on the support of international organizations in the sustainability fight. The local government must champion the needs of local growers, and develop policies that will allow high investments in cocoa processing to help bridge the gap in value addition – a major challenge in the West African region.

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