



A review of the state of dairy production in Nigeria

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Authors' Contributions:

OOO: Writing — original draft.

LTE: Supervision.

AJA: Project Administration.

AMO: Methodology; Investigation.

AIA: Formal analysis.

Declaration of Conflict of Interests:

The authors declare that we do not have competing interests whatsoever.

Ethical approval:

Not applicable.

Acknowledgements:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.



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Nigeria's population is projected to approximate 400 million by 2050, and food security is essential for sustaining a stable, cohesive, and secure nation. This reality indicates that the existing reliance on imports for the food requirements of Nigerians must be reduced, which can be accomplished primarily through substantial investments in agriculture to enhance productivity and self-sufficiency. Livestock farming, encompassing dairy production, is a sector of significant interest and strategic importance for economic diversification and food security. Nonetheless, the sector's contribution to Nigeria's overall agricultural output is markedly minimal, necessitating strategic measures to stimulate sustainable development. The dairy sector in Nigeria necessitates immediate attention due to numerous challenges, including sub-standard animal husbandry practices, inadequate and low-quality feed, prevalent diseases and insufficient animal health management, restricted access to water in the dry season, detrimental impacts of climate change, minimal investment in research and development, infrastructural deficiencies, and limited access to financing. This review acknowledges the significance of developing homemade solutions to address local issues by establishing clear objectives to enhance milk production through increased productivity among both smallholder and commercial dairy farmers, while promoting backward integration in milk production, collection, and aggregation.

Key words: dairy, policy, Nigeria, milk production

Introduction

Nigeria's current human population is approximately 210 million, making it the seventh most populous country globally [31]. The national population is anticipated to reach 400 million by 2050, positioning it as the third most populous country following India and China. Food security is increasingly problematic, with rising food demand being satisfied by imports. Milk is the predominant dairy product in Nigeria. It constitutes 61 % of the revenue in the dairy sector. It is ingested as either fresh cow's milk or processed forms, including powdered milk, condensed milk, evaporated milk, newborn formula, and fermented milk. There are around 20.6 million cows, of which 2.3 million are lactating, yielding an estimated annual milk production of 672 million kilograms [20].

Approximately 95 % of cattle in Nigeria are privately owned and overseen by indigenous nomadic ranchers. The remaining 5 % is possessed by medium and large-scale farmers in controlled pastures. In Nigeria, milk production is predominantly derived from cattle, with negligible contributions from goats and sheep.

Nigerian cattle provide roughly 570 million kilograms of the annual milk supply, which totals 1.6 billion kilograms, with the remainder sourced from imports. Nigeria's milk production constitutes approximately 13 % of West African output and 0.01 % of global production; nonetheless, it relies significantly on imports (60 %) to address the supply imbalance [35].

In the country, three primary production systems are discernible: pastoral (traditional), semi-intensive, and commercial (intensive), with the pastoral and

semi-intensive systems generating the majority of milk consumed in both rural and urban regions of Nigeria. The Nigerian dairy sector primarily operates on a subsistence basis, yielding approximately 450,000 tons of milk annually [23].

This production has proven insufficient to meet the dairy requirements of Nigeria [23]. The productivity of cattle in Nigeria is reportedly suboptimal due to several factors, including the low genetic potential of indigenous breeds, feed scarcity, disease prevalence, inadequate management, and substandard breeding practices, which may result in prolonged days open, delayed age at first calving, extended calving intervals, reduced lactation duration, and diminished milk yield. The local dairy production in Nigeria significantly lags behind the yearly demand, which was projected at 1.45 billion kilograms in 2010 [23], resulting in a per capita milk consumption of less than 10 kilograms, compared to the global benchmark of 40 kilograms per capita.

Dairy cattle production in Nigeria

The distribution of the cattle population in Nigeria has been significantly affected by the presence of tsetse flies and the diseases they transmit, a phenomenon peculiar to tropical Africa. The most substantial cattle population in Nigeria is located in the extensively tsetse-fly-free northern regions of the country. Consequently, it is unsurprising that historically, the majority of Nigeria's cattle population, predominantly of the humped zebu kind, is raised in the northern region of the country.

Nevertheless, the Keteku, Muturu, Ndama, and Kuri cattle breeds are located in the Southwestern, Southeastern, and Northeastern regions of the country, respectively [10]. In the dry season, many Zebu cattle herds from the North are compelled to migrate southward into tsetse-fly-infested areas for seasonal transhumance to access superior grass and increased water availability [11].

The gradual decline of the tsetse fly problem in Southern Nigeria, primarily due to deforestation, has significantly diminished the natural habitats and wildlife hosts of the tsetse fly. Consequently, through natural selection and co-adaptation, this has resulted in the evolution of less virulent forms of the disease and the emergence of trypanosomiasis-tolerant Zebu cattle populations [10].

Historically, traditional dairy production in Nigeria is predominantly concentrated in the Northern regions, particularly among the Fulani, who have specialised in cattle husbandry for millennia and possess an estimated 90 % of the nation's cattle population. The Fulani males focus on cattle rearing, while the women are responsible for milking the cattle [4, 35, 40].

Inadequate infrastructure, such as road networks, has significantly impeded the delivery of milk products. This elucidates why conventional dairy products are predominantly found in the northern regions of the country [3].

Table 1. Nigeria: Cattle population by production system

	Extensive	Semi-intensive	Intensive
Cattle population	15 111 309	3 089 804	203 548

Source. GLW 3.0 and Federal Ministry of Agriculture and Rural Development, 2017

Nigeria is expected to have 18.2 million cattle. They are mostly overseen in substantial herds by semi-sedentary and transhumant pastoralists. The majority of animals are dual-purpose indigenous breeds, such as the Bunaji, Sokoto Gudali, and Rahaji. Extensive commercial farms cultivate imported exotic breeds and their hybrids. Nigeria has three dairy cattle production systems: the extensive or traditional system, the semi-intensive (agro-pastoral) system, and the intensive (modern) system [6]. Approximately 82 % of animals are reared in large systems, 17 % in semi-intensive systems, and roughly 1 % in intensive systems. A fourth production system, the commercially orientated urban farmers, has begun to appear but remains somewhat marginal [30].

Current milk production totals 585,000 tons annually, or 13 % of West African milk output. A 2014 industry analysis indicates that the dairy sector is the second largest section of the food business in Nigeria. Since 2010, it has shown an annual growth rate of 8 %, with an anticipated revenue of 345 million Naira (USD 2 billion) in 2013 [12]. Nigeria's dairy production is predominantly subsistence-based, exhibiting low productivity; the average annual yield per cow is 213 kilograms, which is less than one-tenth of the global average [30]. The nation is a net importer of milk and dairy products, with domestic production satisfying approximately 40 % of milk demand, while the remaining 60 % is sourced from imports [30]. The per capita consumption of dairy products is approximately 10 kilograms annually, being one-fourth of the global average.

The extensive (pastoral) dairy production system

The comprehensive dairy production system defines arid and semi-arid regions and entails the relocation of animals in pursuit of forage and water. Herders maintain cattle and other livestock, such as small ruminants, while abstaining from agricultural cultivation. Production is primarily subsistence-based, yet quantifying its extent is challenging due to intra-country and inter-country animal migrations [30]. The main characteristics of this production system are the following:

The semi-intensive (agro-pastoral) dairy production system

In a semi-intensive agro-pastoral production system, farmers cultivate crops and rear dairy livestock, with distinct boundaries separating area allocated for cultivation from that designated for grazing [6]. Farmers transport livestock to grazing areas and water supplies based on seasonal variations, with output being both subsistence-oriented and commercial [30].

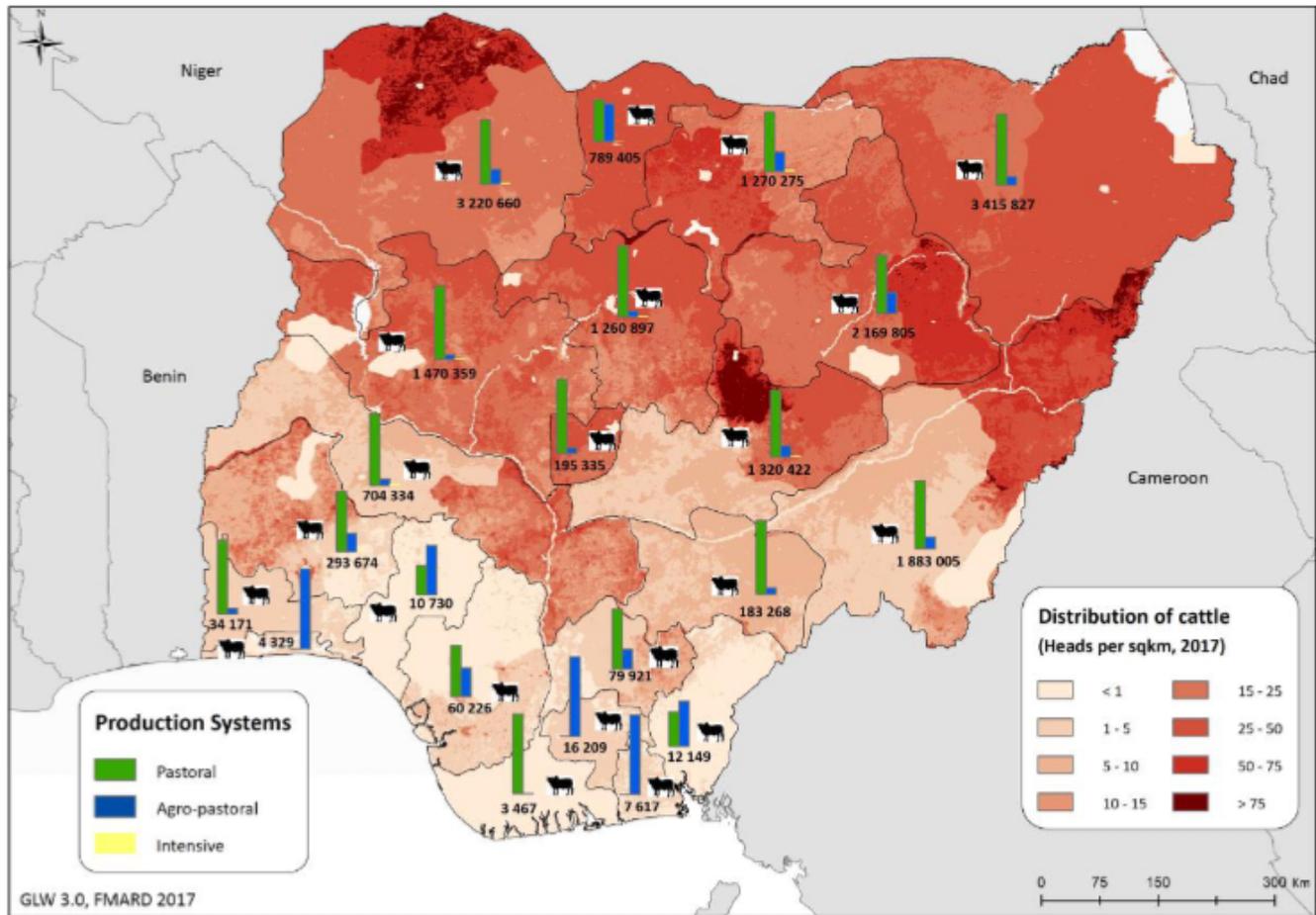


Fig. 1. Milk production systems in Nigeria
 Source. GLW 3.0 and Federal Ministry of Agriculture and Rural Development, 2017

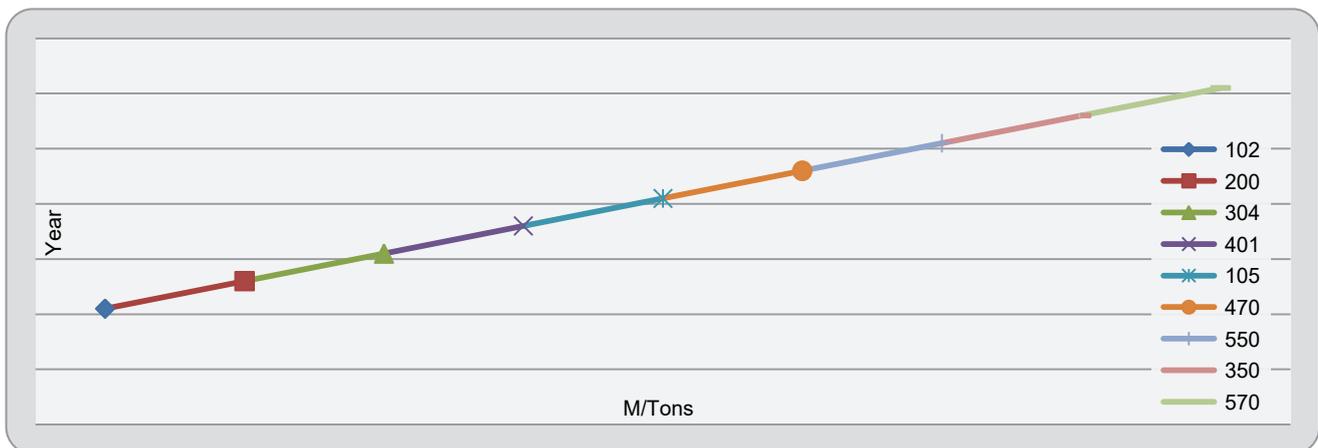


Fig. 2. Dairy milk production in Nigeria, 1981 to 2021, metric tons
 Source. [34]

Intensive (commercial) dairy production system

The intensive or commercial dairy system in Nigeria accounts for around 5 % of the nation’s total milk production [30]. Dairy farms vary in size, encompassing small, medium, and big operations. Production is commercially driven, with farmers striving to optimise productivity:

animals are of exotic and cross-breeds; feeding and bio-security procedures are suitable, with animals housed inside or in sheds or paddocks; milking is mechanised [30]. Approximately 80 % of commercial dairy farms are situated in the North Central region. The primary features of this system are as follows [6, 12, 30].

Four Major Dairy farming system in Nigeria

Two primary categories of dairy producers manage Nigerian dairy cattle. Pastoralists maintain approximately 95 % of the national dairy herd, while commercial dairy producers account for roughly 5 %. The pastoralists are categorized into three sub-groups, each maintaining their livestock for distinct purposes and employing varied breeding procedures. The subgroups are as follows:

Non-settled pastoralists (nomads)

The cattle are primarily passed down through familial lines, with the total herd potentially reaching 300, including sheep and goats. In this nomadic cattle-rearing system, herders relocate between states in pursuit of sustenance and hydration. Pastoralists refrain from agricultural practices, traversing extensive distances for water and pasture, often crossing national and international borders. The livestock typically comprises indigenous breeds such as Bunaji and Gudali. Reproduction occurs naturally without intervention, and feed is sourced from fallow lands, grazing reserves, and crop residues without supplementation. Family labor is employed, resulting in low milk production (0.5–1 kg), which increases during the rainy season. In the dry season, as water levels diminish, they migrate to river basins to secure adequate water supplies.

Settled peri-urban pastoralists (agro-pastoralist)

Cattle are predominantly passed down through familial lineage and are cultivated for commercial objectives. Herdsmen may have resided in certain grazing reserves for over 20 years, possessing 20 to 100 herds of predominantly indigenous cattle breeds. Animals graze in harvested fields and fallow land owned by agriculturalists or adjacent communities, with labor primarily being family-based and reproduction occurring naturally without intervention. Farmers employ a degree of feed supplementation with agricultural by-products; cows are milked once daily, resulting in poor milk production. However, due to the substantial number of animals, a significant volume can be harvested. Milk is subjected to local processing to produce sour milk, sour yoghurt, butter, and soft cheese. Treatment is facilitated through intervention by the government and, at times, the private veterinary sector.

Urban pastoralists

Cattle are bred for commercial purposes, and farmers are market-oriented; the cattle are primarily indigenous, with a limited number of crossbreeds. The herd size per home varies between 5 and 20 heads. Smallholder dairy farming enhances household resilience, food and nutrition security, and provides a significant source of income for rural residents. Farmers are occasionally situated in urban areas and engage in zero-grazing or semi-intensive grazing, acquiring crop residues and agricultural by-products, with feed supplements serving as

the primary source of nourishment. The farmer is market-oriented but lacks proficiency in product processing; therefore, milk could easily become a liability unless effectively utilized. This cohort of herdsmen is amenable to governmental intervention and can be readily organized into clusters to enhance national milk output.

Commercial dairy farming

Substantial herds (exceeding 100 dairy cows), the development of heifer replacements, zero grazing practices, extensive mechanization, heat stress management, and the use of artificial insemination define commercial dairy farming. All activities are centralized in one place, encompassing feed production, raw milk processing, cattle management, and associated infrastructure and facilities. This constitutes a little segment (5 %) of dairy farmers in Nigeria. The quantity of animals varies from 50 to 1,000 milking cows. Zero-grazing is frequently implemented. Enhanced feed production utilizing pastures of high-quality forages such as Hybrid Napier, Brachiaria, Chloris, Gamba, and Stylo is emerging as a non-rainfed feed resource on these farms. Nutrition is augmented by grain and oil-laden agricultural by-products. Forage conservation is occasionally implemented, and mineralized salt licks are also supplied.

The Contribution of Dairy Products to Nutrition and Human Livelihood in Nigeria

Dairy products are a vital and complex element of global human nutrition, profoundly impacting not only basic dietary needs but also the economic and social welfare of communities, particularly in developing countries like Nigeria. Dairy products from cows, goats, and sheep, encompass a variety of dietary items including milk, cheese, yoghurt, and butter, each with a distinct nutritional composition essential for human health. The incorporation of dairy farming into the agricultural frameworks of developing nations such as Nigeria presents significant potential for bolstering food security, enhancing nutritional health, and promoting economic empowerment, especially among rural communities where agriculture is fundamental to their livelihoods. The potential of dairy farming to provide essential income and sustenance for a considerable segment of the rural impoverished highlights its significance in poverty alleviation, job creation, and diminishing income inequality, thus promoting a more equitable and balanced rural economy. The growing significance of the dairy sector in the global economy underscores the essential requirement for national competitiveness, propelled by globalization, trade liberalization, and enhancements in transportation and communication, which together stimulate market competition and provide consumers with a wider array of goods and services, consequently elevating living standards through competitive pricing and diminished market volatility.

Nutritional Significance of Dairy Products

Dairy products are nutritional powerhouses, offering a diverse range of critical nutrients crucial for human health across all life stages. Milk, the principal dairy product, is a superior source of high-quality protein, encompassing all essential amino acids required for tissue construction, repair, and diverse metabolic processes. Dairy products are notably abundant in calcium, a mineral essential for bone health, nerve transmission, muscular function, and blood coagulation. Dairy products supply vital B vitamins, important for energy metabolism and the maintenance of a healthy neural system.

Table 2. Dairy consumption in the six geopolitical zones of Nigeria

Zones	Diary milk consumption
North East	78
North Central	101
North West	87
South East	116
South Central	104
South West	82

Source. [34]

Dairy value addition in Nigeria

The Nigerian milk industry encompasses activities including dairy production, processing, marketing, importation, and consumption. Nonetheless, these activities have not received significant attention despite several initiatives by governmental and non-governmental organizations. The Nigerian dairy value chain comprises a significant proportion of pastoralists, contributing around 95 % of the dairy production. Raw milk is converted into various dairy products, such as wara, nunu, kindirmo, manshanu, and cuku, on a small scale and sold informally on the streets for domestic use by the producers. Diverse dairy products are marketed in the formal sector use a blend of imported and domestically sourced milk. Due to the restricted milk production by pastoralists, a significant portion of the milk inputs utilized by commercial processors is imported [41]. Significant populations of indigenous cattle are mostly found in Northern Nigeria, where herders engage in land and crop residual grazing, and raw milk along with other dairy products are marketed locally at community markets. The majority of commercial dairy farms, which account for less than 10 % of total output, are located in the central region. The predominant population of cattle in Nigeria is located in the northern region. Approximately 99 % of these cows are indigenous varieties, with fewer than 1% imported from the Netherlands and South Africa [7]. In Northern Nigeria, where cattle constitute over 50 % of the population, cow husbandry and dairy farming have substantially enhanced household welfare and serve as a vital source of livelihood for many in the region.

Nigeria's dairy development

As of 1986, the dairy business provided income for around 183,000 rural households [21]. The dairy sector offers employment and generates cash through commercial milk processing facilities and marketing campaigns. Currently, despite the existence of 63 recognised milk processing facilities, only a limited number remain operational. Entities that continue to engage in processing activities operate at under 20 % of their capacity. Foreign milk processing companies that predominantly utilize imported milk powder for the production and sale of milk and dairy products have dominated the Nigerian dairy industry.

Between 1962 and 1968, as well as from 1981 to 1985, the Nigerian government, enhancing the standards of living for all citizens, implemented numerous national development plans. During this time, significant focus was directed towards the dairy industry, which possesses the potential to improve nutrition. The government developed dairy farms with both indigenous and exotic cattle breeds in designated areas throughout the states.

Additionally, mobile collection sites and milk collection units were established. The milk collecting programs commenced in the late 1920s when the veterinary department in Vom, Jos, received support from the Northern area government of Nigeria to create these units in Northern Nigeria. Milk was transported to the collecting units by the pastoralists' wives for the purposes of cream separation and clarified butter fat (CBF) manufacture.

In 1939, the veterinary department in Vom (Jos-Plateau) constructed a milk processing facility focused on butter production. The primary supply of milk for the factory was the Fulani women via a network of milk collecting centres, supplemented by milk from the Vom dairy. In 1940, a comparable project was initiated in Kano State.

Nigeria possesses the fifth largest cattle population in Africa, trailing Ethiopia, Sudan, Chad, and Tanzania, with an estimated 20.5 million cattle, including 2.35 million dairy cows. Notably, 99 % of these cattle are indigenous breeds, contributing to over 90 % of the total annual milk production. The milk is derived from low input, low yielding pastoral systems and is predominantly traded within an informal value chain system [32]. Nigeria must enhance its domestic dairy production due to the escalating population and daily demand for dairy products [20]. Nigeria's dairy import control strategy has been ineffectual, resulting in substantial annual expenditures of foreign cash on dairy imports. Nigeria's population exceeds 180 million and its yearly milk consumption is 1.3 million tons. Regrettably, 60 % of dairy products are imported and utilised. The Central Bank of Nigeria (CBN) reports that Nigeria imports milk and dairy products valued at \$1.5 billion per year.

The Federal Government established the Nigerian Dairy Development Programme (NDDP) to further its dairy transformation strategy by showcasing proof-of-scale in processor-led initiatives for dairy development in

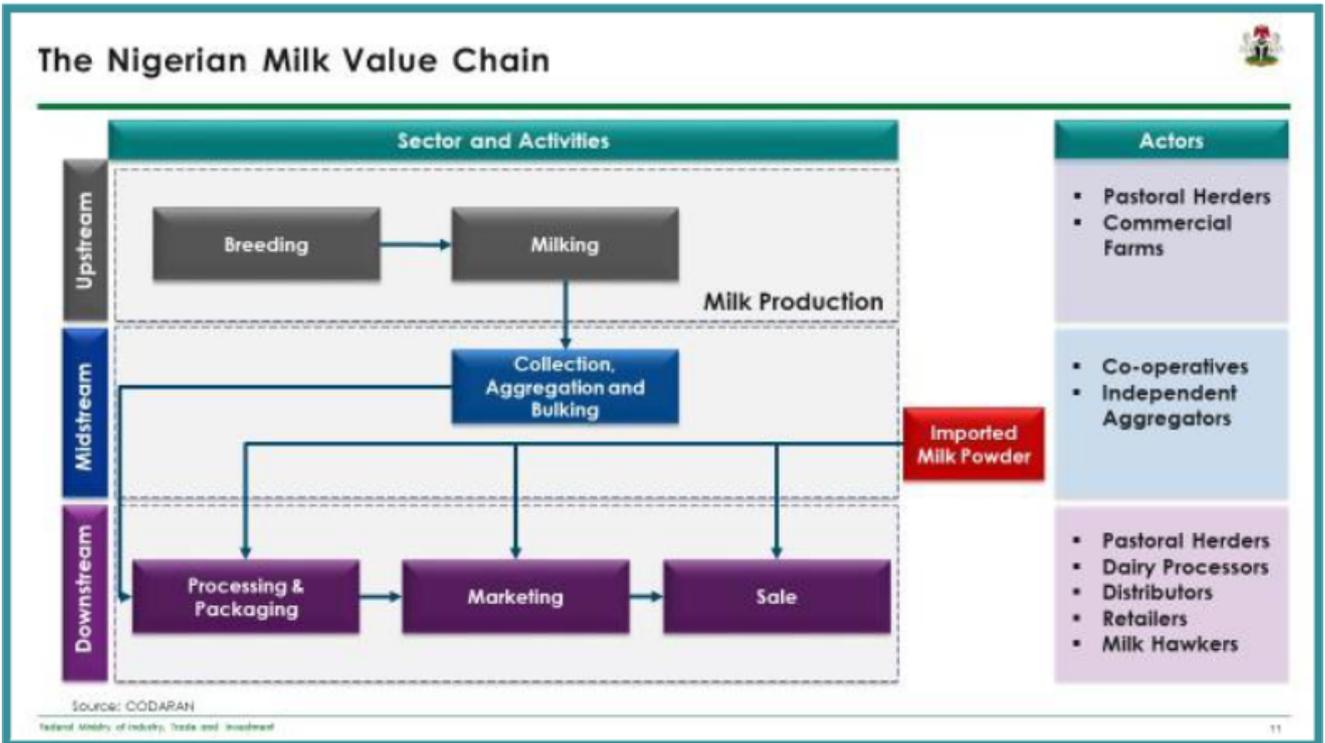


Fig. 3. The Nigerian milk value chain

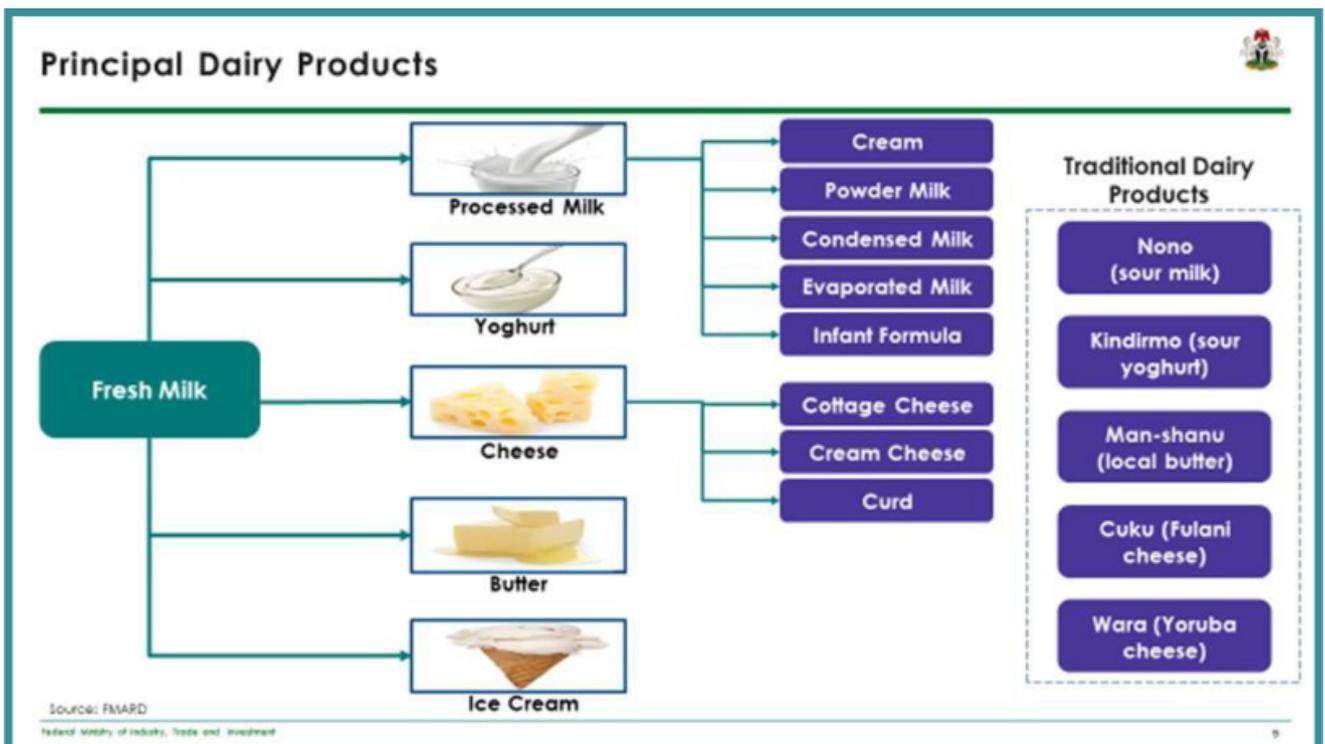


Fig. 4. Principal dairy products

Nigeria. The NNDP initiative enhances the livelihoods of participating dairy farmers in Nigeria by augmenting cow yield and productivity, while also integrating them into the formal dairy value chain. The initiative encompasses a nutrition and gender component aimed at enhancing nutritional outcomes and empowering women in small-holder agricultural communities.

Recent trends in Dairy developments in Nigeria

Recently, the Nigerian dairy sector has experienced notable advancements, including the introduction of government initiatives like the National Livestock Transformation Program (NLTP). The National Livestock Transformation Program (NLTP) indicated that Nigeria

generates 526,000 kilograms of milk annually, whereas annual consumption amounts to 1.2 million kilograms. Approximately \$1.3 billion is expended annually on milk imports. Various governmental and non-governmental parastatals that have significantly contributed to the advancement of the dairy industry in Nigeria include Vom Dairy (Plateau State), Shonga Dairies (Kwara State), the back-to-farm initiative by the Kwara State government, the National Project for Cattle and Buffalo Breeding (NPCBB), the Agege Dairy Development Project (Agege, Lagos), Moor Plantation Dairy Farm (Ibadan), the Intensive Dairy Development Programme (IDDP), the Strengthening Infrastructure for Quality and Clean Milk Production (SIQ and CMP), Cooperatives Union, the National Programme for Dairy Development (NPDD), United African Company (UAC), Friesland Campina WAMCO, New Zealand, Arla Foods, Neon Agro, Chi Limited, and Irish Dairy, among others.

In recent decades, the Nigerian dairy market has predominantly been dominated by European dairy corporations, including Friesland Campina WAMCO, Arla, PZ Wilmar, and Fan Milk, all of whom depend on milk imports for their product manufacturing. Friesland Campina WAMCO is among the few global corporations who procure raw milk locally. The unprocessed milk from the cows of Integrated Dairy, L&Z Integrated farms and Nagari farms are also acquired from pastoralists and peri-urban agriculturists.

In 2010, Friesland Campina WAMCO, Nigeria, became the first entity to get raw milk locally for the production of diverse milk and dairy products, with herders supplying the predominant raw materials utilised in this manufacturing process. Through their dairy development effort, they enhanced local farmers in three ways: augmenting productivity per cow, improving raw milk quality and safety, and assisting farmers in securing a market for their milk.

Friesland Campina WAMCO has contributed to enhancing the livelihoods of numerous individuals and has aided farmers by providing essential infrastructure, facilitating genetic enhancement through artificial insemination and cross-breeding, establishing smallholder dairy farms, and constructing demonstration farms, as well as developing pastures and fodder for livestock, across various states in the country [22].

Friesland Campina has significantly enhanced Nigeria's local milk procurement by creating a milk bulking centre, multiple milk collection centres, and 20 milk collection locations across various states; they are the foremost importer and processor of milk products in Nigeria. In 2022, it was reported that 10 % of the 60 million kilograms of raw milk utilized by the corporation will be supplied domestically in the forthcoming years at a price equivalent to the global market rate. Friesland Campina WAMCO has effectively collaborated with the Federal Ministry of Agriculture and Rural Development, the Ministry of Trade and Industry, the Central Bank of Nigeria, various State Governments, the National

Animal Production Research Institute, and the Dutch Government, among others. They have aided the pastoralists by supplying temperature-regulated milking cans and 80 solar-powered boreholes throughout the states. They have facilitated the formation of 23 dairy cooperatives across several locations: 15 in Oyo State, 3 in Ogun State, 5 in Oyo State, 1 in Niger State, 2 in Kwara State, and 1 in Ondo State. The dairy cooperative union has facilitated the policy-making process and eradicated intermediaries in the dairy value chain, hence simplifying market price regulation. The Central Bank of Nigeria (CBN) reports that the country annually expends between \$1.2 billion and \$1.5 billion on milk and dairy imports to compensate for the deficiency in local production.

In July 2019, the Governor of the central bank, Godwin Emefiele, proposed a backward integration strategy for obtaining raw materials, aimed at significantly attracting investors, enhancing investments in the dairy sector, and concurrently discouraging milk imports.

Application of new technologies to improve dairy production

The employment of digital technology, proactive implementation, and the deployment of sophisticated automated process control systems are essential for ongoing dairy advancement in contemporary society. Contemporary dairy farmers and processors enhance cow comfort, milk quality, production, and sustainability using advanced agricultural technologies, innovative feed additives, methane digesters, robotics, and water and energy saving methods. Carbon-neutral and plant-based milk products have gained prevalence in the dairy sector, resulting in safer and more nutritious dairy offerings [2].

The implementation of advanced dairy farming techniques, the Internet of Things (IoT), various artificial intelligence methodologies, and other digital technologies, including energy inputs from Renewable Energy Sources, can aid farmers in addressing traditional agricultural challenges and enhancing milk production [15]. It guarantees the elevated productivity of excellent milk and establishes the degree of contemporary dairy sustainability [29].

The contemporary dairy industry has embraced digitalization and sophisticated agricultural technologies, enabling farm managers to efficiently fulfil their responsibilities and guarantee food security. The battle for market share and increasing demand for milk and dairy products expedite the advancement of digital technologies in the dairy sector, facilitating sustainable expansion and enhancing agribusiness efficiency [29]. Smart dairy farming, employing advanced sensing and data analysis technologies, is a widely embraced concept that addresses the increasing demand for high-quality dairy products, mitigates environmental issues, optimizes resource utilization, and enhances animal health. Contemporary dairy farmers have mastered genetic modification to enhance

milk production from fewer cattle by focusing on sustainable agricultural practices. Consequently, reduced greenhouse gas emissions are produced. Cows exhibiting superior productivity compared to their ancestors are selected and bred utilizing advanced technology, including artificial insemination, genetic breeding, and phenotyping techniques. This allows dairy farmers to breed cows with enhanced genetic traits for milk production in a secure setting, preserving genetic diversity and maintaining essential biological mechanisms (including health, resilience, robustness, welfare, and longevity) in predominant dairy cattle breeds. The implementation of digital technology in dairy farms indicates a significant requirement for advanced expertise among dairy staff [8]. The depletion of freshwater resources due to population increase, natural calamities such as droughts, fires, and floods, along with increasing global food demand, renders sustainable water management one of the most significant concerns.

Cogato et al. [15] indicated that robotic milking systems exhibit superior water efficiency compared to traditional milking parlours, since they utilize an exact quantity of water for automatic milking and cleaning processes. Likewise, the water consumption of cattle cannot be evaluated. Implementing a mix of water conservation methods, including air temperature reduction and cow preparation protocols, might substantially decrease the overall yearly water use on dairy farms. Production methods, energy use, and dairy waste are acknowledged as the primary contributors to environmental impact [20]. Packaging materials, especially for infant formula, and energy use throughout specific life cycle stages should be prioritized, as they are the primary contributors to the overall environmental effect. Therefore, green engineering and innovative packaging materials must be investigated to guarantee sustainable dairy development and minimize environmental impact.

Nigerian Dairy industry policy

The National Dairy Policy framework is essential for directing public and private sector actions and investments in Nigeria's dairy industry to achieve self-sufficiency in milk production and enhance global competitiveness. It aims to establish a framework and guiding principles for the development of an efficient and sustainable dairy industry to meet national demand for milk and dairy products. Numerous factors hindering dairy development in Nigeria include substandard animal husbandry practices, insufficient and low-quality feed, prevalence of transboundary diseases, ineffective animal disease management, impacts of climate change, infrastructural deficits particularly in cold chain and milk collection facilities, decreasing grazing areas, and restricted access to water and pasture, especially during the dry season. This policy will foster collaboration among industry stakeholders in addition to resolving these challenges. The dairy value chain may effectively satisfy customer demands

at reasonable rates while providing appropriate returns to industry stakeholders. This policy delineates the interventions by the government and other stakeholders concerning dairy research, milk production, animal reproductive health, extension services, marketing of milk and dairy products, milk processing, consumption, human resource development and training, financial services, as well as institutional, legal, and regulatory matters.

Nigeria's annual demand for milk and dairy products is estimated at 1.6 billion kilograms, with imports now valued at USD 1.3 billion [31, 37]. Milk imports primarily comprised powdered milk from Denmark, the Netherlands, the USA, South Africa, New Zealand, and the EU.

Nigerian Government policies on Dairy production

The objective of the Nigerian Dairy policy is to establish a framework that directs governmental and private sector initiatives and investments in the dairy industry to accelerate the achievement of self-sufficiency in milk products and enhance global competitiveness.

The strategy aims to enhance the production and productivity of smallholder and commercial dairy producers by providing help in extension services, facilitating access to finance, and developing infrastructure.

Facilitate backward integration in milk collection, aggregation, and processing by offering incentives for investments in cold chain services, efficient transportation, and financial access.

Establish a comprehensive institutional framework by creating a Dairy Development and Marketing Board tasked with engaging pertinent stakeholders to promote the sustainable advancement of the dairy sector.

Foster intentional awareness and involvement to facilitate the achievement of the policy's vision and objectives through the active participation of both public and private sector stakeholders.

Integrate and formalize disorganized dairy processors.

Improve the efficiency, effectiveness, and global competitiveness of the Nigerian dairy industry to provide inexpensive and accessible milk products, thereby reducing imports and enhancing the nutritional health of Nigerians.

Prior to 2011, when the Agricultural Transformation Agenda (ATA) and the Nigerian Industrial Revolution Plan (NIRP) for 2011–2015 were implemented, governmental policy on dairy development mostly concentrated on enhancing milk production, with less focus on processing, marketing, and consumption. The Agricultural Promotion Policy (APP, 2016–2020) and the Nigerian Industrial Policy (NIP) significantly advanced the Agro Allied Sector. The combination of these occurrences and the necessity to adequately address the dairy industry's strategic significance for economic diversification prompted the development of the National Dairy Policy (NDP). The NDP represents a strategic transition that emphasizes consumer needs, the utilization of external markets, and the enhancement of dairy productivity and efficiency.

The dairy value chain may optimally satisfy customer demands at reasonable rates while guaranteeing satisfactory returns for industry stakeholders. This policy delineates the interventions by the government and other stakeholders concerning dairy research, milk production, animal reproductive health, extension services, marketing of milk and dairy products, milk processing, consumption, human resource development and training, financial services, as well as institutional, legal, and regulatory matters.

Impact of climate change on dairy milk production in Nigeria

Globally, milk production is conducted by more than 150 million dairy farms. Smallholder dairy farmers predominantly produce milk in most developing countries, and milk production has become a vital source of income for numerous households globally [28]. Global milk production increased from 530 million tons in 1988 to 843 million tons in 2018, representing a growth of about 59 % [23]. The United States, China, Pakistan, and Brazil rank next in milk production, collectively contributing 22 % to the global total. Since the 1970s, South Asia has been the principal catalyst for the expansion in milk production in the developing world, exhibiting significant growth [23].

Germany, France, Australia, Ireland, New Zealand, and the United States own the largest milk surpluses [33], whereas China, Italy, Russia, Mexico, Algeria, and Indonesia exhibit the most significant milk deficits [27]. In numerous developing countries, milk production has been constrained by issues including the health of dairy farmers, financial resources, fluctuating weather conditions, and the low genetic potential of dairy livestock [18]. In contrast to industrialized nations, many developing nations have hot and variable climatic conditions that are detrimental to milk production. Sudan, South Africa, Kenya, and Ethiopia are the leading milk-producing nations in Africa [24]. Milk production in Africa is witnessing a gradual decline due to poverty and adverse climate conditions. Nigeria yearly produces approximately 560,000 to 570,000 tons of fresh milk, whereas the anticipated industry and domestic consumption and market demand is 1.7 million tons [19].

Literature indicates that in Nigeria, milk production is associated with the northern nomads and ranchers. The reduction in output in Nigeria is primarily ascribed to climate change and various internal and external variables [19, 23]. Heat stress induced by elevated temperatures and humidity diminishes milk production in dairy cows [1, 26]. Elevated temperatures beyond a cow's thermoneutral zone induce pain and physiological alterations, leading to a reduction in milk production [9, 13]. Extreme heat and elevated temperatures are challenging for dairy cows to endure, leading to a reduction in milk output and increased vulnerability to illnesses and other health complications [17]. Excessive rainfall exposes dairy farm

animals to severe cold, resulting in irregular physiological functioning and reduced fodder availability, which leads to a critical decline in body weight and milk production [25].

This consequently diminishes the profits of dairy farmers who rely on it for their economic sustenance and human nourishment. Given these circumstances, Nigeria expended about 28 billion on milk imports in 2022 [31]. These occurrences generated a knowledge deficit and prompted the formulation of the study to determine the actual effects of climate change on dairy milk production in Nigeria. Climatic variables such as temperature, precipitation, and relative humidity adversely affected milk production in both the short and long term. Elevated temperatures induce heat stress in dairy cows, resulting in decreased dry matter intake, which subsequently diminishes milk quality and production [34]. Extended droughts adversely impact dairy milk production. Escalated infestations of bovine diseases, precipitated by excessive rainfall, compromise the animals' health and lead to a significant reduction in milk production. Increased microbial activity in dairy cows at high relative humidity results in diminished milk quality and quantity. Cows exposed to sunshine maintain healthy physiological characteristics that enhance milk production in dairy cows. The ECM value signified the swift reaction of milk production to climate change perturbations. Enhancing milk production in Nigeria to satisfy market demand necessitates immediate and proactive measures to address climate change.

Problems of Dairy Marketing In Nigeria

The Nigerian dairy sector is marked by challenges in the adoption of innovations such as artificial insemination and modern pasture establishment by pastoralists and commercial dairy farmers, inadequate accessibility to dairy farmers during both the rainy and dry seasons, and the absence of an organised structure among dairy farmers. The deficiency of infrastructure in the Nigerian dairy sector has resulted in persistently poor milk production, post-milking wastage, diminished earnings for dairy farmers, and a lack of access to animal protein for citizens.

The informal selling of the commodity frequently raises public health issues with milk due to insufficient investment in safe handling skills, equipment, and compliance with norms. In reaction to evolving consumption patterns in metropolitan areas, commercial processors are implementing various marketing and product improvements to engage new consumers.

Way forward

Establishment of marketing infrastructure from manufacturing to consumption, enabling e-commerce and a Market Information System. The promotion of private sector-driven dairy marketing is essential. Competition should be predicated on the efficiency and quality of milk

produced in the market. Maintain sustainable soil fertility to maximise feed production for dairy.

Nigeria possesses significant potential to enhance its dairy output, generate jobs, and create value-added goods. Predisposing elements encompass a favourable climate in numerous regions of the country (particularly in the Central and Northern States), overall robust animal health, advantageous ecologies for the cultivation of fodder crops within mixed agricultural systems, and the presence of under-utilized land for pasture production.

The value chain strategy for enhancing sector development involves utilizing cross-bred cattle that exhibit superior productivity compared to indigenous breeds, establishing specialized smallholders (peri-urban farmers) for milk production, and providing milk collection facilities in regions of comparative advantage where farmers are already organized into cooperatives.

Challenges affecting livestock production must be addressed to promote the sustainable development of a nation by ensuring sufficient food supply to satisfy the needs of the increasing population.

To accomplish this, it is anticipated that federal and state governments will implement livestock policies that will advance the intended objective. A comprehensive solution must account for the unique characteristics of pastoralists and farmers. This strategy has the potential to influence and advance sustainable dairy development in Nigeria while maintaining food security. Should all the identified factors be effectively managed via mass literacy initiatives, governmental provision of essential social services, policy implementation, awareness campaigns, and comprehensive training for dairy farmers by extension agents, alongside the enforcement of hygienic practices during milking to mitigate foodborne illnesses, as well as the exploration of economic benefits from dairy farming significant advancements in the dairy sector may ensue, potentially alleviating food insecurity in Nigeria.

Executing the goals delineated in the National Dairy Policy (2023–2028) would enhance the industry's growth and competitiveness, aligning with the Government's dedication to economic diversification, food security, and livelihood improvement in the nation.

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Огляд стану виробництва молочної продукції у Нігерії

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Прогнозується, що до 2050 року населення Нігерії становитиме приблизно 400 мільйонів, а продовольча безпека є важливою для підтримки стабільної, згуртованої та безпечної країни. Ця реальність свідчить про те, що залежність від імпорту для задоволення потреб нігерійців у продовольчих продуктах необхідно зменшити, чого можна досягти насамперед через значні інвестиції у сільське господарство для підвищення продуктивності та самозабезпечення. Тваринництво, зокрема виробництво молочної продукції — це сектор, який становить значний інтерес та стратегічне значення для диверсифікації економіки та продовольчої безпеки. Тим не менш, внесок цього сектору в загальний обсяг сільськогосподарського виробництва Нігерії є надзвичайно мізерним, що вимагає стратегічних заходів для стимулювання сталого розвитку. Молочний сектор Нігерії потребує негайної уваги через численні проблеми, серед яких — неякісні методи тваринництва, неадекватні та низькоякісні корми, поширені хвороби та недостатнє управління здоров'ям тварин, обмежений доступ до води в сезон посухи, негативний вплив зміни клімату, недостатні інвестиції в дослідження та розробки, недоліки інфраструктури та обмежений доступ до фінансування. Цей огляд визнає важливість розробки власних рішень для вирішення місцевих проблем через встановлення чітких цілей щодо збільшення виробництва молока, підвищуючи продуктивність як серед дрібних підприємців, так і серед комерційних молочних ферм, одночасно сприяючи зворотній інтеграції у виробництві, зборі та агрегації молока.

Ключові слова: молочні продукти, політика, Нігерія, виробництво молока