MARIE ANNE MUKASAFARI
DEVELOPMENT DISSERTATION BRIEF

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MILK MATTERS – MILK QUALITY AND CHILD NUTRITION IN NORTHERN RWANDA

EBA

Milk matters – milk quality and child nutrition in Northern Rwanda

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Marie Anne Mukasafari currently works at University of Rwanda as a lecturer and deputy dean at School of Animal Sciences and Biotechnology. She recently defended her PhD in Animal Science from Swedish University of Agricultural Sciences, Uppsala in September 2025. She holds a Master of Science in Animal Production from Egerton University and a Bachelor of Science in Veterinary Medicine from University of Rwanda. Her research focuses on how livestock are managed at smallholder farms where more focus was on dairy cows' feeds on milk production and quality within the household. In addition to this, identifying the association of keeping dairy cattle as well as other livestock on child undernutrition (especially stunting) in Rwanda.

Thesis available here: https://pub.epsilon.slu.se/38263/1/mukasafari-m-a-20250826.pdf
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Sammanfattning

”Stunting” är en form av tillväxthämning hos barn orsakad av kronisk undernäring[1]. Djurhållning kan främja barns tillväxt genom att tillhandahålla animaliska livsmedel som mjölk, som ger viktiga näringsämnen som protein och kalcium. Denna rapport sammanfattar min avhandling *Milk matters. Linking dairy cow feed to milk yield and quality, and child undernutrition in Northern Rwanda (2025)*[2]. Syftet med min forskning var att undersöka produktiviteten och kvaliteten inom småskalig mjölkproduktion, och sambanden med nutrition och tillväxt hos barn i Rwanda. De flesta småbrukare i urvalet ägde mjölkkor. Korna utfodrades med ett system där man samlade in foder (av låg kvalitet). Avhandlingen visade att den genomsnittliga mjölkproduktionen var låg, cirka 4 liter per ko och dag. Mjölkkvaliteten var också ett problem. Mjölkproverna visade på förekomst av juverinfektioner (34 procent) och antibiotikarester (13 procent). Förekomsten av stunting var i genomsnitt 27 procent, med en variation på 10–50 procent. Att äga en ko gav en viss minskad förekomst av stunting. Att äga höns var signifikant förknippat med lägre förekomst. Konsumtion av mjölk eller ägg i sig var dock inte direkt kopplat till nivå av tillväxthämning. Ytterligare faktorer som var förknippade med tillväxthämning var kön, födelsevikt, amningsvanor, moderns kroppsmasseindex och utbildning, hushållets ekonomi och livsmedelssäkerhet, kön på hushållets överhuvud och förekomsten av en kökträdgård.

Sammantaget skulle en förbättrad djurhållningen kunna öka mjölkproduktionen och kvaliteten, vilket skulle bidra till att minska tillväxthämningen hos barn och förbättra hushållens försörjningsmöjligheter i småbrukarsamhällen.

[1] Barn med kronisk undernäring utvecklas inte till sin fulla potential och kan få bestående skador. Ett sätt att mäta långsiktiga effekter av undernäring på är att mäta barns längd i förhållande till sin ålder = stunting.
[2] https://pub.epsilon.slu.se/38263/1/mukasafari-m-a-20250826.pdf

Summary

Stunting, a form of chronic undernutrition, is characterized by impaired growth and development in children. Livestock, particularly dairy cows, can support child growth by providing animal-source foods like milk that are essential in nutrients such as protein, calcium, and vitamins. This brief summarizes my thesis *Milk matters. Linking dairy cow feed to milk yield and quality, and child undernutrition in Northern Rwanda (2025)*[3]. The aim of my research was to explore how improving dairy farming practices can enhance milk production and quality and contribute to better child nutrition and growth in Rwanda. This thesis found that most smallholder households in the study sample owned livestock kept lactating cows. The cows were fed through a cut-and-carry system using predominantly low-quality feed. Average milk yield was low, at around 4 L per cow per day. Milk quality was also a concern. Milk samples showed intra-mammary infections (34 percent), and antibiotic residues (13 percent).

The prevalence of stunting among children averaged 27.3 percent, ranging from 10 to 50 percent. Owning a lactating cow showed a tendency to reduce stunting, while poultry ownership was significantly associated with lower stunting. However, consumption of milk or eggs was not directly linked to stunting. Additional factors associated with stunting included sex, birth weight, breastfeeding practices, maternal body mass index and education, household economy and food security, gender of the household head, and the presence of a kitchen garden.

Overall, improving animal husbandry could enhance milk yield and quality, thereby contributing to reduced child stunting, and improved household livelihoods in smallholder communities.

[3] https://pub.epsilon.slu.se/38263/1/mukasafari-m-a-20250826.pdf

Introduction

Agriculture, which encompasses both crop and livestock production, plays a critical role in the economies of sub-Saharan Africa, serving as the primary source of livelihood for the majority of the rural population, particularly smallholder farmers (FAO, 2024). Despite its centrality, the sector is characterized by low productivity and limited returns, which constrain its potential to drive economic growth. The underperformance of agriculture has contributed to persistent poverty and food insecurity across this region compared to other regions in the developing world (Amejo et al., 2018). Indeed, rapid population growth often outpaces economic gains, making it difficult for countries to reduce poverty in a significant way. In rural areas, where most of the poor reside, limited access to markets, agricultural inputs, and social services further compounds the problem (McMahon, 2016).

In developing countries, such as Rwanda, smallholder dairy farmers form the backbone of the local dairy sector and make substantial contributions to rural livelihoods. Many households rely on milk not only as a source of nutrition, especially for children and vulnerable family members, but also as a source of income when production exceeds their household requirements (Flax et al., 2023a). Despite its potential, milk yields from smallholder dairy farms remain relatively low (Duguma, 2022), which limit its access and affordability particularly in rural areas (Zerfu et al., 2024). Low milk yields among smallholder dairy farmers are predominantly caused by poor feeding practices, inadequate veterinary care of the dairy cows, and improper farm management (Terefe & Walelegne, 2024). Various initiatives in East Africa Countries (EAC), including the Rwanda Dairy Development Project (RDDP) which supports livestock farmer field schools (L-FFS) (RDDP, 2016) and the Wakulima Self-Help Group Dairy (WSHGD) in Kenya (VanLeeuwen et al., 2012), aim to improve rural livelihoods by increasing milk yield and promoting better feeds, feeding and management practices. However, the adoption of improved dairy technol-

ogies among poor-resource farmers remains low due to limited access to quality inputs and services, weak extension support, and high costs. Such constraints not only hinder productivity but also contribute to low accessibility and consumption of animal-source foods (ASF). Insufficient ASF intake can result in moderate to severe, and in some cases chronic undernutrition, with young children being among the most vulnerable (McMahon, 2016; Zerfu et al., 2024).

Undernutrition is a serious problem that affects millions of children under the age of five around the world (UNICEF, 2025). Forms of undernutrition include *stunting* (low height for age), *wasting* (low weight for height), and being *underweight* (low weight for age) (Akombi et al., 2017). Undernutrition manifested as stunting is a persistent challenge in many developing countries where it contributes considerably to child mortality and impaired development (Hetherington et al., 2017). Stunting, defined as a low height-for-age z-score (HAZ), often results from chronic nutrient deprivation during the critical first 1,000 days of life (González-Fernández et al., 2024). A key contributor to these conditions is the low consumption of ASF (Zerfu et al., 2024). Animal-source foods such as milk, meat, and eggs are rich in nutrients essential for physical growth, cognitive development, immune support, and bone health. Most children in households with dairy animals are expected to have better dietary diversity and nutritional outcomes (Dumas et al., 2018), however, this may not always be the case. When milk is not consumed within the home it may be due to either low availability or because it must be sold to meet another essential household need (Flax et al., 2021). In households without livestock, low consumption of ASF is often driven by a limited awareness of their nutritional benefits and/or by their high cost (Zerfu et al., 2024).

In Rwanda the prevalence of stunting has decreased from 37.9 percent in 2017 to 33.1 percent in 2020 (Akombi et al., 2017; RDDP, 2023), but remains above the global target of 23.2 percent by 2025 (UNICEF, 2025). Low weight for age (stunting), happens when children don't get enough healthy food or can't

properly absorb the nutrients they need. As a result, they may not grow well, become weak or underweight, get sick more often, and in severe cases, their lives can be at risk. To address stunting in Rwanda, different programmes such as shisha kibondo (feel the goodness); *One Cup of milk per child school feeding initiative; Orora Wihaze activity* (promoting livestock rearing), and *akarimak´igikoni (kitchen garden)* have been implemented (USAID, 2020; World Bank, 2021). In addition to these, in 2023, different interventions have been developed in Rwanda including: providing low-income households with hens for egg production and scaling up the distribution of biofortified products; enhancing child nutrition indicators monitored by Community Health Workers (CHWs); improving attendance at Antenatal Care (ANC) visits, with an emphasis on early contact in the first trimester and enhancing the quality of nutrition counselling (https://www.gov.rw/blog-detail/government-launches-a-comprehensive-plan-to-eradicate-child-stunting). Despite these efforts, the national prevalence of stunting remains high at 33.1 percent, although there has been a decline since 2019 (RDDP, 2023).

The Northern Province of Rwanda, characterized by subsistence farming, has been identified as one of the country's *hunger hotspots* with the highest rate of child stunting at 41 percent (National Institute of Statistics of Rwanda, 2021). Defining possible strategic interventions requires greater knowledge about the management of dairy cows, milking routines, and milk handling at the household level, as well as the impact of owning a lactating cow on the occurrence of stunting among young children.

Methods

Data collection

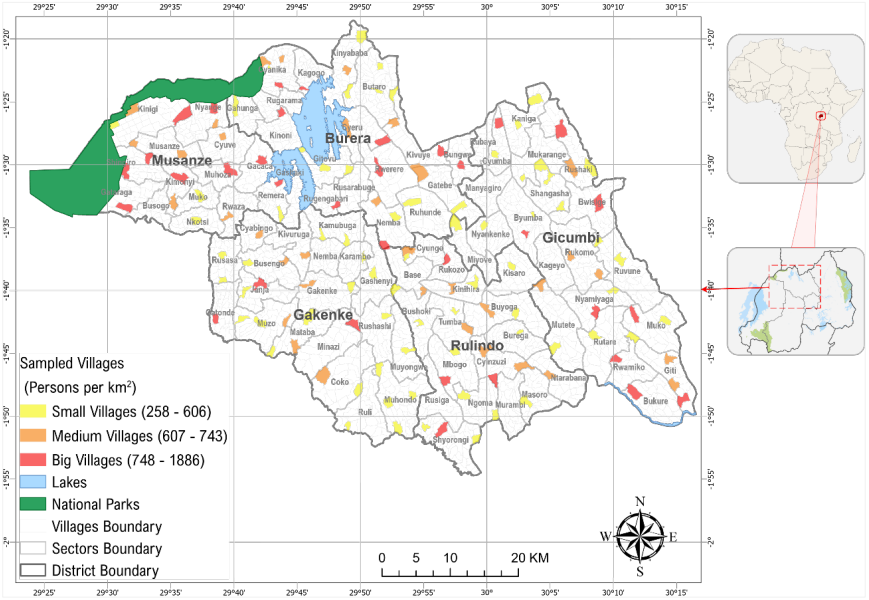
As part of my research, we conducted fieldwork across five districts in Rwanda's Northern Province (Figure 1). We used a multi-stage sampling approach to determine the study population. Villages were categorized based on population size as small, medium and large (Figure 1), where 137 out of 2,744 villages were selected using a geospatial grid-based approach. With the help of village leaders and community health workers, 630 households were identified and selected based on the inclusion criterion of having children aged 1–36 months, among which 178 households owned lactating cows. We excluded households where a child was sick or where mothers were younger than 18 or unable to respond.

We conducted data collection between late November and December 2021 using a web-based sampling tool developed through the Internet-based Management System for Environmental Protection and Disaster Risk Management (iMSEP) (Mansourian et al., 2023). The tool, designed by members of the Undernutrition Programme team with GIS expertise, allowed for efficient and standardized field data collection. We organised two specialised field teams: one focused on child and maternal health, and the other on animal production and veterinary aspects. Our team consisted of twelve trained enumerators, six doctoral students, and one postdoctoral researcher. Using GPS-enabled tablets and an Android-based GIS application, we collected geo-referenced data through structured digital questionnaires.

During the fieldwork, we conducted household interviews, measured children's height and weight, collected blood samples, and gathered animal feed and milk samples. The questionnaire included different sections covering socio-demographic and economic status, dietary diversity, human health, and

domestic violence, dairy management practices, veterinary extension services, and other livestock-related factors *(detailed in the thesis).*

Figure 1. Map of study sites, Northern Province, Rwanda



Source: Mukasafari (2025). Edited by C. Kagoyire.

Interdisciplinary research on undernutrition

This study was part of a larger *"Interdisciplinary Undernutrition Program",* focusing on children and mothers, because these groups are most at risk of nutrient deficiencies and their nutrition strongly determines overall community health. In the program, eight PhD students from different disciplines were included. Northern Rwanda was selected as the study site due to high level of stunting (41%) than national level (33%) (National Institute of Statistics of Rwanda/NISR, 2021).

Main results

Household characteristics

The survey found that most households were headed by men (92%). Land ownerships were generally small, with 70 percent of households having no land, and most families practiced mixed crop–livestock farming to sustain their livelihoods. Livestock keeping was common, with 84 percent owning at least one type of animal. Among households with lactating cows, most owned only one cow. The majority (84%) were poor, earning less than 36,000 Rwandan Francs per month (about 27 USD), and only about 22 percent had reached secondary school.

Prevalence of stunting

In our study, the prevalence of stunting among children ranged between 10.4 to 50.0 percent with an average of 27.3 percent. The wide range of prevalence were related to different contributing factors *(detailed information in thesis)*. There was, however, a much higher prevalence of stunting in different clusters, as observed in boys (34.1%) and in children born with a low weight (50.0%).

We investigated the association between animal keeping, as a source of animal-source food, and the prevalence of stunting in children. We observed that only chicken ownership was associated with a reduced stunting, while owning a lactating cow showed only weak association. This weak relationship may be explained by the tendency of smallholders to sell rather than consume their dairy products. Moreover, we found no association between consumption of milk or eggs and stunting; however, this observation should be interpreted with caution since dietary information consumed by children was based on a short temporal window of 24 hours before the visit.

Cow feeding practices effects on milk yield and quality

Among the households I visited, only 21 percent had experience in rearing dairy cattle. Most of the cows were crossbreed, followed by Ankole cattle. Farmers kept their cows indoors and fed them manually. Collecting or purchasing forages was practiced by 55 percent of farmers. The collected forages were from public areas, like roadsides, and/or made use of crop residues to the less, cultivated forages.

We found that the nutritional quality of the feeds varied. Most feeds possessed a poor nutritional quality, characterised by relatively low protein and energy, and high fibre contents. The fibre contents can be used to indicate the nutritional quality of feed, with values below 45 percent considered as high quality, 45–65 percent as medium quality, and above 65 percent as low quality (Singh & Oosting, 1992). We also observed that 85 percent of households provided mixed feed for their cow, whereas 15 percent provided only one type of feed. This was most likely because of a shortage of dairy feed rather than an attempt to achieve a more balanced diet (Njau et al., 2013; Mutimura et al., 2015). As reported by previous research, possible ways of improving the nutritional quality of the diets for dairy cows may involve the inclusion of high-quality feed resources such as fodder trees, and legume (Kabirizi et al., 2013). In the current study, aside from few crop residues, none of the farmers fed their cattle legumes. The introduction of species such as tree lucerne, characterised by high protein and low fibre contents is an alternative to explore, carrying the additional advantage of being a perennial N-fixing and soil restoring species (Tefera et al., 2019). These could increase the quantity and quality of feed as well as dairy production.

We found that daily milk yield averages 4 L/cow/day, but with a high range as indicated in Table 1. Milk yield was influenced by breed, body condition score (BCS), parity, and milking frequency, but not stage of lactation. Milk yield was

higher for cows with a good body score (fat cow) than those with a moderate or poor body score (thin). Crossbreed cows produced more milk than Ankole cows. Multiparous cows had a higher milk yield than primiparous ones. Milking twice a day instead of just once resulted in a higher milk yield.

Hand milking was universal, and 89 percent of the farmers practiced some form of hygiene routine like washing hands and udder with clean water, whilst 1.9 percent did not employ any hygiene measures. Mastitis screening was practiced by 63.8 percent of farmers. Milk composition and somatic cell count (SCC) varied widely (Table 1).

A high percentage (34%) of the milk samples originated from cows with intra-mammary infections and 12.9 percent of the samples tested positive for antibiotic residues. The relatively high level of antibiotic residues in the milk samples (Paper III) was most likely due to ongoing or recent treatments for intra-mammary infections or other diseases, as reviewed by Manishimwe et al. (2017). These patterns may reflect deficiencies in regulatory frameworks on antibiotic use, as well as insufficient knowledge concerning appropriate and judicious antibiotic practices (Manishimwe et al. (2017).

Table 1. Milk yield, composition, somatic cell counts (SCC), and antibiotic residues in smallholders' dairy farms in the Northern Province of Rwanda

Variables	Minimum	Mean	Maximum	SEM
Milk yield (L/cow/day)	0.5	4.0	12.0	0.19
Fat (%)	1.1	3.1	8.1	0.10
Protein (%)	2.0	3.3	4.8	0.03
Lactose (%)	3.2	5.0	6.7	0.33
Solid not fat (%)	6.7	9.2	12.3	0.06
Density (kg/m3)	1,022	1,033	1,045	0.20
SCC* (cells/ml)	101,000	470,908	2,516,000	44,888
	Positive		Negative	
Antibiotic residues, N (%)	19 (12.9)		128 (87.0)	

SEM: Standard Error of the Mean

* Somatic cell count (SCC) values classified as <300,000 cells/mL are acceptable (65.8% of samples), and >300,000 cells/mL not acceptable (34.2% of samples) (COMESA, 2006)

Source: Mukasafari (2025). Figures from the thesis.

High-quality milk that is clean and free from contamination provides essential nutrients especially for vulnerable people like pregnant mothers, young children and old people. Quality of animal products can be reduced by poor hygiene, close proximity of livestock to human dwellings, and inadequate waste management, all of which increase the risk of microbial contamination. Good hygienic practices at milking in relation to udder (intra-mammary) health are vital (Terefe & Walelegne, 2024). Even though we found 89 percent of households reported washing the udder before milking (paper III: Figure 2), the use of poor-quality water to clean cow udder and milking utensils can increase the risk of contamination to other animals or post-milk contamination if not properly managed (Nyokabi et al., 2021). Treatment with antibiotics on-farm mainly increases the risk of antibiotic residues in milk in cases when farmers do not follow recommendations on the withdrawal period (Manishimwe et al., 2017).

During our study, we found that most livestock were kept close to farmers home (Figure 2).

Figure 2. Livestock keeping at smallholder dairy farms in Northern Rwanda

Photo: Mukasafari (2021)

Such conditions facilitate the spread of pathogens and the accumulation of harmful residues in products. Poor milking hygiene, unwashed hands, and dirty utensils cause intra-mammary infection and contaminate the milk, making it unsafe to drink and shortening its shelf life (Terefe & Walelegne, 2024). In case of disease outbreaks, these risks are heightened, leading to compromised food safety and greater health hazards for consumers, especially young children and pregnant mothers. The consumption of milk with infections poses a serious health risk, since potential pathogens could cause several diseases, e.g. meningitis, and miscarriage (D'Angelo et al., 2022). Maintaining both quantity and quality reflects the farm's commitment to ethical production, animal welfare, and proper handling practices with safe products for household consumption.

Discussion

Why milk quantity and quality matters to consumers

Milk quantity and quality are very important to farmers and consumers because they reflect the value people get from keeping animals and the trust they place in the farm's products. Generally, smallholder households depend on a steady supply of milk to meet their daily milk requirements for own consumption and to sell any extra to generate cash income for other household needs. From our study, we noticed that milk yield was quite low (less than 4 liters of milk per day) considering most farmers keep crossbreed cows, which produce above 6 liters per day (Gillah et al., 2014). This average milk yield can usually be enough for household consumption. Unfortunately, when households need to sell parts of the yield, very little or nothing is left for home use (Flax et al., 2021). This Tcan negatively affect vulnerable groups who rely on milk as essential nutrition.

Undernutrition – especially stunting – in Rwanda

In our study, the prevalence of stunting among children was between 10.4 to 50.0 percent with an average of 27.3 percent. The wide range was related to different contributing factors *(detailed information in thesis)*. There was, however, a much higher prevalence of stunting in different clusters, as observed in boys (34.1%) and in children born with a low weight (50.0%).

We investigated the association between animal keeping, as a source of animal-source food, and the prevalence of stunting in children. We observed that only chicken ownership was associated with reduced stunting, while owning a lactating cow showed only a weak association. This weak relationship may be explained by the tendency of smallholders to sell rather than consume their dairy products, as reflected by the lower proportion of households with children consuming milk compared to those owning a lactating cow in another

study (23.0% vs. 26.2%, respectively; Flax et al., 2021). Moreover, we found no direct association between consumption of milk or eggs and stunting; however, this observation should be interpreted with caution since the child consumption information that was gathered was based only on a 24-hour period prior to the visit by the data collector. In contrast, Mosites et al. (2017) reported a positive association between dairy consumption and child growth.

As farmers keep their livestock close to their steady home, it is worth noticing that livestock keeping, including cattle, may also have a negative effect on stunting (Zerfu et al., 2023). Negative effects of livestock on stunting are predominantly due to infectious diseases and/or parasites transmitted from livestock to humans. During our visit, most smallholder farmers kept livestock in close contact to their home (Figure 2), and their manure, as well as ASF consumption, could result in the transmission of zoonotic pathogens and other illnesses through contaminated food, air, and water sources (Zerfu et al., 2023).

Besides animal keeping, there were many other factors associated with the prevalence of stunting. Variables that were positively associated with a lower level of stunting were birth weight, breastfeeding, and being a girl rather than a boy. For the mothers, it was observed that the level of education and the body index were positively related to a lower rate of stunting in children.

Finally, analysis of household-related data, revealed that households in which the head was a man, as well as household´s economic status and food security were associated with a lower prevalence of stunting. From the findings of this thesis, it was evident that undernutrition is a complex and multifaceted issue requiring interdisciplinary approaches to effectively address its interconnected biological, social, economic, and environmental determinants.

Methodological considerations

This study has both strengths and limitations. Because of the cross-sectional design, we couldn't capture how farmers' feed resources change throughout the year. The design also means we can't conclude whether livestock ownership or ASF (animal-source foods) directly affects child stunting.

The exclusion criteria may have led to selection bias and an underestimation of stunting among vulnerable families. In addition, the stunting prevalence may not be representative because of many households with lactating cows in the sample—possibly Girinka[4] beneficiaries—who might have better access to milk and other ASF. Future research should use longitudinal data, include a broader range of participants, and control for key confounding factors to better understand how livestock ownership affects child nutrition.

[4] Girinka Program is a "One Cow per Poor Family Program" in Rwanda
https://www.rgb.rw/fileadmin/user_upload/RGB/Publications/HOME_GROWN_SOLUTIONS/GIRINKA_REPORT_2018.pdf

Conclusion and policy implications

This development dissertation brief (DDB) identifies key research findings of how to link livestock ownership and access to animal source food like milk and eggs, with child undernutrition among smallholder households in Rwanda. The findings highlight that milk production and consumption play a vital role in improving child nutrition outcomes. However, the relationship between dairy cow management and child undernutrition is complex and multifaceted, influenced by several factors such as household decision-making on milk use, and market-oriented production behaviors. While better dairy management can enhance milk yield and quality, the nutritional benefits for children depend on ensuring that milk remains available for household consumption rather than being sold. In addition to this, poor dairy management can lead to low-quality or contaminated milk, posing health risks such as exposure to antibiotic residues and foodborne pathogens, which may undermine the potential nutritional benefits of milk consumption, particularly among children.

Associations between animal keeping and stunting should not be exclusively considered as causative, as the occurrence of stunting in children arises from a constellation of different factors. The thesis underline, among other factors, the importance of breastfeeding, birth weight, sex of the child, and the mother's nutrition and education level. Because child undernutrition has many interconnected causes, future solutions need to reflect this complexity.

Effective policies should take an integrated approach that considers livestock, child health, maternal factors, and overall household conditions. Such a holistic perspective is especially important for designing interventions that fit the context of Rwanda's Northern Province and similar contexts. Including local farmers and village leaders in the design and decision-making of interventions is essential to ensure their relevance, acceptance, and long-term sustainability. Policies should promote proper use of antibiotics, adherence to hygienic milk-

ing and storage practices, and regular milk quality testing to safeguard public health.

Furthermore, nutrition-sensitive livestock programs should emphasize not only improving milk yield but also ensuring its safe and equitable household consumption. Strengthening farmer's training on animal husbandry, milk hygiene, and responsible antimicrobial use, along with empowering women in livestock management and household can enhance the safety and nutritional value of livestock products. Raising awareness of the importance of animal-source foods for children's growth and health can further improve nutrition benefits of livestock production while minimizing health risks to consumers.

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Better animal husbandry and access to milk and other animal-based foods can contribute to a reduction of the incidence of stunting in children. This thesis is based on research from Rwanda and examines the links between various factors that affect stunting in children, such as animal feed, milking, consumption of milk and eggs, and socioeconomic household variables.

Bättre djurhållning och tillgång till mjölk och andra animaliska livsmedel kan bidra till minskad förekomst av tillväxthämning orsakad av undernäring hos barn. Den här avhandlingen bygger på forskning från Rwanda och undersöker sambanden mellan olika faktorer som påverkar tillväxthämning hos barn, t.ex. djurfoder, mjölkning, konsumtion av mjölk och ägg samt hushållens socioekonomi.

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