FEASIBILITY OF INTEGRATING ORGANIC MILK PRODUCTION INTO CERTIFIED SMALLHOLDER ORGANIC FARMS IN KIAMBU AND KAJIADO COUNTIES, KENYA

A THESIS SUBMITTED IN FULFILLMENT OF REQUIREMENTS FOR DOCTOR OF PHILOSOPHY DEGREE OF UNIVERSITY OF NAIROBI

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DECLARATION

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DEDICATION

This work is dedicated to my dear wife, Ruth Vusaka and my son, Arthur Baraka and the entire Odhong' family for their love, support, encouragement and committed partnership in the success of my life

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ABBREVIATIONS

ABLH	Association of Better Land Husbandry
AFMA	Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
CBO	Community Based Organization
CGIAR	Consultative Group on International Agricultural Research
COSHEP	Community Sustainable Agriculture and Healthy Environmental Programme
DANIDA	Danish International Development Assistance, Danish Ministry of Foreign Affairs
EAOPS	East Africa Organic Product Standards
EPOPA	Export Promotion of Organic Products from Africa
EPZ	Export Processing Zone
EU	European Union
FAO	Food and Agriculture Organization of the United Nation
FAOSTAT	Food and Agriculture Organization of the United Nation Statistical Year Book
GDP	Gross Domestic Product
ICPALD	IGAD Center for Pastoral Areas and Livestock Development
IFOAM	International Federation of Organic Agriculture Movement
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
KDB	Kenya Dairy Board
KIOF	Kenya Institute of Organic Farming

KIPPRA	Kenya Institute for Public Policy Research and Analysis
KOAN	Kenya Organic Agriculture Network
KOFA	Kenya Organic Farmer Association
MoLD	Ministry of Livestock Development
NGO	Non-Governmental Organization
NAEP	National Agricultural Extension Policy
OMAP	Organic Market Assistance Programme
ProGrOV	Productivity and Growth in Organic Value Chains
SACDEP	Sustainable Agriculture Community Development Programme
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
USA	United States of America

ABSTRACT

Organic livestock production can be considered as a system of production that better fulfils animal needs, promotes use of organic and biodegradable input for production and reduce the use of conventional veterinary treatments. As demand for organic dairy products increases in Kenya, especially in Nairobi, so does the need to supply the growing demand. Increased diversification of organic production is needed to meet the growing demand. The objective of this study was therefore to investigate the potential, challenges and feasibility of integrating organic milk production in smallholder crop-livestock farms in Kiambu and Kajiado counties of Kenya and validate the efficacy of *Tephrosia vogelii* Hook., *Tephrosia villosa* Pers., and *Carica papaya* Linn. leaves and *Carica papaya* Linn. against gastrointestinal nematodes. Data was obtained through purposive cross-sectional survey of 55 certified organic crop producers with dairy cattle. It was complemented with additional information from longitudinal and targeted semi-structured interviews from 24 farmers randomly selected from previous cross-sectional survey. A laboratory experiment was also conducted to validate the efficacy of crude aqueous plant extracts (*Tephrosia vogelii* Hook., *Tephrosia villosa* Pers., and *Carica papaya* Linn. leaves and *Carica papaya* Linn.). Result from the study showed that lack of organic inputs to control pest and diseases (78%) and lack of organic feed (64%) were the most important constraints for farmers to integrate organic dairy production. The average herd size was 3.53 with all the dairy cows were zero-grazed. Most of the cubicles were less than $2.50M^2$(75%) and majority of the farmers used acaricides on a weekly basis to control ticks (47%), while all incidences of diseases were treated by a veterinarian. Dried and poultice paste of *T. vogelii* leaves and *C. papaya* seeds had more than 95.8% and 98% reduction in egg hatch and larval development inhibition at concentration of 500 mg/ml respectively.

Egg hatch assay revealed more than 95.8% reduction in egg hatch at concentration of 500 mg/ml for dried and poultice paste of *T. vogelii* leaves and *C.papaya* seeds. Larval development inhibition assay results showed that both dried and poultice paste of *T. vogelii* leaves and *C.papaya* seeds extract yielded more than 98% inhibition at a concentrations of 500mg/ml. Based on the LD_{50} dried extract of *C. papaya* seeds was most potent extracts for the inhibition of both egg hatching (49.94mg/ml) and larval development (49.32mg/ml). Integration of organic dairy production in smallholder farming systems requires sufficient organic feed for cows, organic inputs to control pest and diseases, re-construction of animal structures and additional land for regular outdoor run to meet the welfare needs of the cows. Prospects for conversion of smallholder farming systems to organic dairy production will partly depend upon availability of research based advice on the use of appropriate robust breeds, development of organic feed production strategy to supply smallholder farmers, availability of pest and disease control input under local conditions, the ability of the farmers to make structural adjustments on the cow housing and allocate more land to the dairy enterprise. Capacity building on the basic requirements for organic dairy production is essential to ensure that interested farmers make the necessary adjustments to integrate their enterprises.

CHAPTER 1

GENERAL INTRODUCTION

The development of modern agriculture has mainly focused on increasing productivity rather than holistic management of natural resources to ensure food security and sovereignty. This has been accompanied by a myriad of challenges such as loss of soil fertility, decline of agro-biodiversity, water pollution (Badgley *et al*., 2007; Singh, 2000) and health problems associated with the use of synthetic products (Pimentel, 1996) and debate about the development of sustainable food production systems, adapted to different farming conditions. As a result, alternative production systems based on holistic views has been developed in different parts of the world over the last century, and become with time an integrated part of the agricultural sector. Organic agriculture is a holistic production management system, which promotes and enhances agro-ecosystem health, including bio-diversity, biological cycles and soil biological activity (EAOPS, 2007). It seeks to minimise the use of external inputs, reducing the use of synthetic drugs, fertilizers and pesticides and aims at optimising the health and productivity of interdependent communities of soil life, plants, animals and people. Organic agriculture considers ecological, social and ethical impacts of farming. The adoption of the principles of organic agriculture enhances soil fertility, biodiversity and minimizes land degradation, erosion, poisoning and other negative effects of chemical activities on the environment (Vaarst, 2010). Organic agriculture is considered to be the oldest precursor of sustainable agriculture (Lockeretz, 1990) and appears to be a viable and sustainable development option, particularly for (groups of) smallholder farmers in Africa (FAO, 2007; Lyons and Burch, 2008; EPOPA, 2008; UNEP-UNCTAD, 2008). It is increasingly recognized as an important alternative, because of its environmentally friendly production systems that offer a wide range of economic, social and cultural benefits (Taylor, 2006; Halberg *et al*., 2009; Peden *et al*., 2007).

There are two levels of organic farming, certified organic production and non-certified. Certified organic systems are objectively assessed by a certifying body as conforming with set organic production standards and principles and subject to inspection that conforms to agro-ecological principles. Non-certified organic agriculture comprises "*agricultural systems that use natural process rather than external inputs to enhance agricultural productivity*" (Altieri, 2012). Many traditional farming systems found in developing countries practice organic techniques without seeking or receiving premium price given to organic food in some domestic markets.

During the last decades, certified organic agriculture has developed rapidly all over the world. Global demand for organic products has continued to grow steadily, with global sales of organic food and drink increasing by more than 39% between 2007 to 2013 (Willer and Kilcher 2009; Sahota, 2014). Consumer demand for organic products is mainly concentrated in North America and Europe with the two regions contributing 95.3 percent of global revenues (Sahota, 2014). The Kenyan market for certified organic products is still small and most of the organic products are exported to Europe, North America and Japan (Ndugire, 2010). The low domestic market for organic products could be due to lack of awareness, low-income levels and lack of other infrastructure for local market certification (Kalibwani, 2004). Despite these challenges, organic farming has seen rapid growth in large scale farms with production shifting from producing vegetables and fruits for export to other products such as essential oils, dried herbs and spices. In

2011, there were 12,647 smallholder farmers certified to produce various crops in Kenya (Willer *et al.*, 2014).

Organic dairy production is a rather new farming system in most parts of Africa; presently there are no certified organic dairy farms in Kenya. However, there are few non-certified dairy farmers who supply milk to various organic markets and restaurants in Nairobi (Ndungu, 2013). Most certified crop producers also keep dairy cattle in their farms and integrate crop and dairy production to maximize returns from their limited land and capital, minimize production risk, diversify sources of income, provide food security and increase productivity. However, milk production in these farms is not certified despite the critical role that livestock plays in these production systems. Certification of the farms is enterprise specifics and is mainly based on the assessment of the crop enterprises without regard to other enterprises on the farms.

The roles that dairy cattle play in smallholder farming systems are diverse. However, within the organic farming systems, livestock are a way to attain the organic principles of ecology, which states that "*organic agriculture should be based on living ecological systems and cycles. Work with them, emulate them and help sustain them*" (IFOAM, 2014). It means that the organic farm should base its production on ecological processes and recycling. Livestock production should therefore form an integral part of many organic farms, because of its role in nutrient recycling on the farm (Hermansen, 2003; Powell *et al.*, 2004). When livestock are integrated into the whole system, it creates a situation where the livestock contribute to the system and at the same time the system should contribute to the livestock to ensure that the organic principle of fairness is obtained.

Organic agriculture faces major challenges with regard to harmonization and successful integration of organic animal husbandry into the whole organic production system (Hovi *et al*., 2003). Smallholder farmers report uncertainty regarding strategies that can support an animal's natural needs, health and welfare and also make profit from organic livestock production (Nalubwama *et al.*, 2014). This necessitates an evaluation of the challenges and opportunities that exist within the local context making it possible to develop sustainable strategies in which livestock and crops can be produced within a coordinated framework to enhance milk quantity and quality. To enable integration of organic milk production in smallholder farming systems, issues of animal health, animal welfare, environmental preservation and milk quality which are increasingly being viewed by consumers as important consideration for consuming agricultural products must be given the requisite attention. The lack of technical information support for converting producers is worrying, given that organic farming, like other forms of sustainable and low-input agriculture, is considered to be knowledge intensive. Therefore, a central task for the future is to develop and validate sustainable strategies that address challenges to harmonization and integration of organic dairy production into the whole farming system and to transfer the knowledge generated to the farmers because agricultural development depends to a great extent on how successfully knowledge is generated and applied.

1.2. Objectives

1.2.1. General Objective

The general objective of this study was to investigate the potential, challenges and prerequisites for integration of organic dairy production in certified crop smallholder organic farms and to validate the efficacy of different plant extracts as alternative strategies for used for control of helminths. Furthermore, it was an objective of the study to suggest outcomes which can be used in the advisory service or/and in further research for better management routines in smallholder organic dairy production in the tropics.

1.2.2. Specific Objectives

The specific objectives of the study were:

1. To identify constraints and opportunities of integrating milk production in certified crop farms and identify potential for improvements
2. To identify the management factors affecting animal health and animal welfare in certified crop farms in Kenya
3. To evaluate the potentials for conversion of smallholder dairy farms to organic dairy farms
4. To evaluate the potential of *Tephrosia vogelii*, *Tephrosia villosa* and *Carica papaya* leaves and seeds extracts for the control of helminths in organic dairy production

1.3. Research Questions

The following research questions were addressed to achieve the objectives of the study:

i. What are the challenges that certified crop farmers face in integrating organic dairy production in their farms?
ii. How does dairy cattle management, health and welfare in certified crop farms compare to the accepted standards of organic dairy production?
iii. What are the possibilities of certified crop farms fully integrating dairy cattle production into the organic system?

iv. What is the *in vitro* anthelmintic activity of aqueous extracts of *Tephrosia vogelii* Hook., *Tephrosia vellosa* Pers. and *Carica papaya* Linn. leaves and *Carica papaya* Linn. seeds used by farmers for management and control of helminths?.

1.4. Outline of the thesis

This thesis is organized in 7 chapters. **Chapter 1** introduces the background and justification for the study. It highlights the relevance of organic agriculture in Kenya. The objectives and the research questions are also presented. **Chapter 2** presents a literature review on the dairy production in Kenya, development and status of organic agriculture at the global and national level and relates the organic principles to animal production. **Chapter 3** reports the findings of the exploratory survey conducted to identify the challenges faced by certified crop farmers in integrating organic dairy production in their farms. **Chapter 4** describes how the dairy cattle management, health and welfare in smallholder dairy farms compare to the practices of organic dairy production. **Chapter 5** considers the possibility of converting smallholder dairy farms to organic dairy production. This chapter systematically describes the smallholder dairy production systems and evaluates the proximity of the system to organic production based on some key variable indicators essential for conversion. In **chapter 6** the efficacy of aqueous extracts of *Tephrosia vogelii* Hook., *Tephrosia vellosa* Pers. and *Carica papaya* Linn. leaves and *Carica papaya* Linn. seeds were evaluated *in vitro* to validate their use in ethnoveterinary medicine among some farmers. **Chapter 7** provides an integrated analysis of the results from Chapter 3 to 6 into a general discussion. The chapter also provides the conclusions based on the finding of this study and presents the recommendation for future development of the organic dairy sector in Kenya.

CHAPTER 2

LITERATURE REVIEW

2.1. Dairy production in Kenya

The livestock sector contributes about 10% of Kenya's Gross Domestic Product (GDP), 42% to the agricultural GDP (KIPPRA, 2013).The contribution of livestock is comprised of mainly dairy and meat production, eggs, hides, skins and wool from cows, sheep, goats and poultry. Milk is Kenya's most economically important livestock product, providing about 70% of the total gross value of livestock's contribution to the agricultural sector (ICPALD, 2013). Kenya produced 3.73 MT of milk in 2012 (FAOSTAT, 2014) and it is projected that milk consumption in the country will increase to 4.1 billion litres in 2014 (KDB, 2009). Kenya has one of the highest levels of per capita milk consumption in sub-Saharan Africa (ILRI, 2007). It is estimated that the annual per capita milk consumption in Kenya is 145 litres, which is more than five times the milk consumption in other countries in East Africa (CGIAR, 2008).

In Kenya, the dairy industry is dominated by smallholder milk production. Smallholder dairying is an important avenue for rural development in developing countries through its contributions to increase livestock and farm productivity, income generation from milk and dairy product sales, the provision of jobs and the transfer of money from urban to peri-urban and rural areas. About 600,000 smallholders produce more than 70% of the country's marketed milk (EPZ, 2005). A distinct feature of smallholder farms is that they are family farms. They are generally characterized by integration of crops and dairy production on holdings with usually less than 5 ha, with one to five cattle that play important multiple roles (Tulachan *et al.*, 2000; Devendra, 2001). Smallholder farmers use exotic and or crosses of exotic with local cattle breeds in the herd (Bebe *et al*., 2003).

2.2. Mixed crop-livestock systems

Mixed farming systems, in which crops and livestock are integrated on the same farm, are widespread in Sub-Saharan Africa. They are more important than any other system in terms of their contribution to the total output of animal products and contribute to enhancing the livelihoods of the poor through provision of food, income generation, draught power and employment (Lenne and Thomas, 2005; Herrero *et al.*, 2010). Increasing human population combined with climatic, economic, social, and institutional changes are transforming systems for producing crops and livestock—from systems based on extensive, shifting cultivation and grazing to ones that are more specialized and capital intensive.

Crop-livestock systems have experienced socio-economic changes and environmental challenges. These changes have been brought about by the transformation from subsistence to a more monetary economy due to infrastructure and educational development. Such developments are often accompanied by an increasing scarcity of land for extensive farming and by continuous use of farmland without fallow and are exacerbated by population growth (Tittonell *et al.*, 2005). Mixed crop-livestock farming systems in Kenya are no exception. Smallholders have diversified their farming activities to include various food crops and local animals, and some have introduced exotic cash crops and improved animal breeds. Crop-livestock farming systems are of growing importance, not only because existing systems are expanding, but also because formerly specialist livestock or crop production systems are diversifying into crops and livestock (Steinfeld *et al*., 2006).

2.3. Organic principles in relation to animal production

Organic agriculture is based on four key principles; health, ecology, fairness and care (IFOAM, 2014). **The principle of health** is briefly explained as follows: *"Organic agriculture should sustain and enhance the health of soil, plant, animal and human as one and indivisible."* This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health of animals and people. Therefore health is considered as the wholeness and integrity of living systems. Health in organic production is not only considered as the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health (IFOAM, 2014). Organic standards offer a framework for animal health management. In organic production, disease prevention should be based on: the choice of appropriate breeds or strains of animals; the application of animal-husbandry practices appropriate to each species, encouraging strong resistance to disease and the prevention of infections; the use of good quality organic feed, regular exercise, and access to pasture or runs in the open air and an appropriate density of livestock (EAOPS, 2007). In cases of sickness, phytotherapeutic and other alternative treatments form of treatments may be used where they are proven to be effective in curing sickness or healing an injury. However, the use of pharmaceuticals is permitted in organic livestock production in large parts of the world, but only if preventive and alternative practices are unlikely to be effective in curing sickness or healing an injury and must be done under the supervision of a veterinarian, if they are the best way to reduce suffering, save life or restore health. When pharmaceuticals are used, the withholding periods after treating animals with synthetic veterinary drugs or antibiotics shall not be less than double the period required by legislation or a minimum of 48 hours, whichever is longer. The aim of the standards is to prevent animal products that may have been affected by pharmaceuticals from entering the food chain.

The principle of ecology states that organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them. Organic production should be based on ecological processes and recycling and must be adapted to local ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources. The principle of ecology refers to the integration of the animals (individually and as herds) into the whole agro-ecosystem and, on a larger scale, into the whole food system in ways allowing all elements to support each other (Vaarst and Alroe, 2012). The organic production system should be constructed in such a way that crop and livestock production contribute to the maintenance of the ecological system.

The principle of fairness requires that organic agriculture be build on relationships that ensure fairness with regard to the common environment and life opportunities. Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings. The principle insists that animals in organic production systems should be provided with the conditions and opportunities of life that accord with their physiology, natural behaviour and well-being (IFOAM, 2014). Fairness towards the individual animals implies a fair treatment in all life situations, from birth to death, including transport and handling (Vaarst and Alroe, 2012). Farmers must provide conditions that meet the animal needs. Providing these conditions is completely dependent on humans' knowledge, insight, empathy, and ability to relate to the animals and their needs (Vaarst *et al.*, 2004). When livestock are integrated into the whole system, it creates a situation where the livestock contribute to the system and at the same time the system should contribute to the livestock to ensure that the principle of fairness is obtained.

The principle of care stipulate that organic agriculture should be managed in a precautionary and responsible manner to protect the health and well being of current and future generations and the environment. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Organic livestock production should therefore be done in a way that ensures sustainability of the production systems. Consequently, organic livestock production should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones.

2.4. Global Development of Organic Agriculture

In 1924, Rudolf Steiner challenged the contemporary agricultural practices that led to the proliferation of chemicals in agriculture (Paull, 2009). In the same year, he delivered a series of eight lectures that laid the foundation for an alternative form of agriculture with the aim to 'heal the earth'. This process led to the development of 'biodynamic agriculture' and more generally to 'organic farming' (Paull, 2011). However, the term 'biodynamic agriculture' was developed in 1938 by Ehrenfried Pfeiffer in his book "Bio-Dynamic Farming and Gardening" while the term ‘organic farming’ was developed by Lord Northbourne in 1940 in the book “Look to the Land” (Northbourne, 1940; Paull, 2006). Biodynamic farming shares a lot in common with organic methods of farming, including soil building, crop rotations, and composting.

The development of organic agriculture can be categorized into three phases: the formulation of ideas in the 1930’s and 40’s, the breakthrough of organic thinking in the 1960’s and 70’s, and finally during the 1980’s and 90’s the institutionalization (Lund, 2002). The individual that pioneered the first phase which involved the formulation of ideas included Sir Albert Howard, Lady Eve Balfour and Lord Baron Northbourne. Through study of several agricultural areas, Sir Albert Howard, concluded that the health of soil, plants, animals and humans were interrelated, and that livestock manure and composting was a key feature for healthy soil (Vogt, 2007). In 1939, Lady Eve Balfour, conducted an experiment to compare organic and conventional farming. She published her finding in 1943 in a book titled, The Living Soil and the Haughley Experiment. The publication by Balfour provided farmers with a comparison between organic and conventional farming methods and paved the way for adoption of organic production methods in Europe (Conford, 2002). Lord Northbourne, coined the term “organic farming” to describe a system of agriculture that focused on the interrelationships between all organisms on the farm in his book Look to the Land (Northbourne, 1940). The publication and research by Howard, Balfour and Northbourne provided the basis for the development of organic agriculture in Europe and the rest of the world.

The second phase of development of organic agriculture was stimulated by the environmental concern in the 1960’s and 70’s (Vogt, 2007). Concerns regarding the spread of pesticides through the food-chain to animals and humans added to the movement by novel environmentalists who engaged in the development and eventual formation of IFOAM in 1972 (Geier, 2007).

The institutionalization of organic agriculture took place during the 1980's and 90's. During this period organic agriculture received political support and became more integrated in the agricultural sector. Nordic countries introduced subsidies for organic agriculture in the 1980's (Lund, 2002). The first European Union regulation on organic farming was presented in 1991 (EC, 1991). Today, 86 countries all over the world have organic regulation (Willer *et al.*, 2014).

2.5. Development of Organic Agriculture in Kenya

The development of organic agriculture in Kenya was led by the interest of several categories of organizations to achieve rural development through a low cost approach to help farmers address declining agricultural productivity, high poverty levels, food insecurity and low incomes (Taylor, 2006). Promotion of organic agriculture was mainly done by non-governmental organizations (NGOs), faith-based organizations, individuals and community-based organizations (CBOs) (Bett and Freyer, 2007). The six key organizations involved in the establishment and development of the organic agriculture sector in Kenya included: Kenya Institute of Organic Farming (KIOF), Manor House Agricultural Centre; Sustainable Agriculture Community Development Programme (SACDEP), Association of Better Land Husbandry (ABLH) and Baraka Agricultural College and the Sustainable Agriculture Centre for Research and Development in Africa. All the organizations and institutions were established in the 1980's.

In the 1990's, farmers participating in the KIOF extension and training program initiated the Kenya Organic Farmers Association (KOFA) and published organic farming standards for members based on standards by IFOAM and the European Union (EU) (Taylor, 2006; Kledal *et al.*, 2009). The aim of KOFA was to develop local and international market for organic products from their members. Later, the Kenya Organic Exporter Association was formed by large scale farmers and commercial companies exporting organic products.

In 2005, organic agriculture stakeholders in Kenya, including KOPA and KOFA, formed the Kenya Organic Agriculture Network (KOAN), an umbrella network to support the growth of the organic sector (Kledal *et al.*, 2009). KOAN's main goal is to develop key competencies, skills and strategies in the areas of organic agriculture production, marketing, training, extension, certification and standards, networking, policy and advocacy. KOAN has mainly focused on the promotion and development of certified organic farming to produce agricultural products for export and the local market. However, in Africa and most of Asia, organic production exists in two parallel forms, one which is mainly focused on certified organic farming for exports to Europe and USA and another non-certified mainly focused at improving food self-sufficiency using agro-ecological methods and often supported by NGO's (Altieri, 2012).

2.6. Global Status of Organic Agriculture

Certified organic agriculture is developing rapidly all over the world. Land under organic agriculture increased from 32.2 million hectares in 2007 (Willer *et al.*, 2009) to 37.5 million hectares of certified cropland and pasture in 2012 (Willer *et al*., 2014). Currently, certified organic farming is practiced in 162 countries by more than 1.9 million producers (Willer *et al.*, 2014). The land under organic agriculture has increase in all regions between 2007 and 2012 as shown in Table 2.1, with Oceania having most of the global organic agricultural land. Africa has the highest number of organic producers (530,000) despite the fact that the land area under organic production represents less than 3% of the total organic land.

Table 2.1: Changes in organic agricultural land by region (including in-conversion areas) between 2007 and 2012

Region	**Organic agricultural land in 2007 (ha)**	**Organic agricultural land in 2012 (ha)**	**% Change**
Oceania	12,110,758	12,164,316	0.4
Europe	7,758,526	11,171,413	44.0
Latin America	6,402,875	6,836,498	6.8
Asia	2,881,745	3,217,867	11.7
North America	2,197,077	3,012,354	37.1
Africa	870,329	1,145,827	31.7

Source: Adapted from Willer *et al*., 2009; Willer *et al*., 2014

The international sales of organic products have also continued to increase in over the years. Global sales of certified organic food and drink reached US$64 billion in 2012 (Sahota, 2014). It is estimated that global organic food and drink market will grow by 14.3 percent over the period 2012-2016 (Researchmoz, 2013).

2.7. Status of Organic Agriculture in Kenya

Organic agriculture in Kenya is still small but fast growing. The area under certified organic production increased from 4636 hectares to 4969 between 2007 and 2011. Currently, Kenya has 12,647 certified organic producers mainly found in Central Kenya and the Rift Valley regions (Willer *et al.*, 2014). The produce marketed by these farmers include vegetables fruits, salads, herbs, spices, pulses, and processed products that includes honey, jams, daily products, dehydrated vegetables, herbal teas and dried fruits.

The organic market in Kenya is expanding rapidly with more than ten retail outlets in Nairobi and others scattered in the main towns selling organic products (Hine *et al*., 2008). There is no data on the volume of organic products sold in the country. However, a recent study by Kenya Organic Agriculture Network (KOAN) showed that the level of awareness among consumers of organic products in Kenya had increased by 11% in the last 7 years (Ndungu, 2013). The Kenyan domestic organic market is facilitated by seven main commercial actors; Kalimoni Greens Organic Shop, Bridges Organic Health Restaurant, Green Dreams Limited/Food Network East Africa, Masai Eco farms, Meadows, Pure Health Products and Kenya Institute of Organic Farming (KIOF) (Kledal *et al*., 2009).

Currently, there are four weekly organic farmers' markets in Thika town, Hurlingham, Gigiri and Karen, six specialized food stores stock organic products in designated sections or as part of their normal products and three main supermarket chains in the country stocking organic products. Two certified organic restaurants by the organic restaurant chain, "Bridges Organic Health Restaurant" and one by one by 'Healthy Foods Creation.' A number of hotels and restaurants, respectively in Nairobi, Kisumu and Mombasa, provide organic on order (Kledal *et al*., 2009).

2.8. Organic Legislation and Certification in Kenya

There are no official policies for organic agriculture in Kenya. However, the national organic agriculture policy development process began in 2010. Key milestones including policy concerns, policy analysis and options, draft policy formulation and stakeholder dialogue have be covered during the policy development process (Kamaru, 2013). The National Organic Agriculture Development Policy is expected to promote the industry and give direction to the sub-sector, enhance production and development of the local and export markets; strengthen and raise the profile of the sub-sector and contribute towards poverty eradication and improved food and nutrition security.

Certification of organic production in Kenya is done by five international certification bodies, namely: Soil Association (UK), Ceres (USA), EcoCert, (France), IMO (Germany) and Bio Suisse (Switzerland). However, to minimize the cost of certification by the external certifiers, most of the certifiers use locally trained inspectors (Taylor, 2006). In 2005, a national certification body called Encert was established to certify organic products for the national markets (Kledal *et al*., 2009).

The East African Organic Products Standard (EAOPS) and the East African Organic Mark "Kilimohai" were launched in 2007 (UNEP-UNCTAD and CBTF, 2010).The organic standards describe the specific requirements that must be verified by an accredited certifying agent before products can be classified as organic within the region. The EAOPS and the East Africa organic mark were developed to promote national and regional trade and to build recognition, assurance and confidence among consumers.

CHAPTER 3

CHALLENGES OF CONVERSION TO ORGANIC DAIRY PRODUCTION AND PROSPECTS OF FUTURE DEVELOPMENT IN INTEGRATED SMALLHOLDER FARMS IN KENYA

3.1. Abstract

Certified organic livestock production does not exist in Kenya, yet livestock forms an integral part of many organic farms due to their role in nutrient recycling. The purpose of this study was to identify the challenges of conversion to organic dairy production. Fifty five semi-structured interviews of smallholder farmers with dairy cattle and organically certified crop enterprises in Kiambu and Kajiado counties were conducted to explore and discuss the factors that hinder conversion of their dairy enterprises. The average age of the farmers was 52 years, 65% of them female. The farms averaged 3.8 acres, 87% privately owned, but skewed to the left with 75% of the respondent's farms owning less than 3.8 acres and thus unable to produce sufficient fodder for their cattle. Cattle were kept mainly (63.5%) to augment income obtained from organic crop production. Artificial insemination was the only method used for breeding. With more than 5 years of crop-dairy integration, 61% of the farmers had considered managing their livestock organically. However, lack of organic inputs to control pest and diseases (78%) and lack of organic feed (64%) were identified as the most important constraints for converting to organic dairy production. Future prospects for integrated organic dairy production in smallholder production systems therefore depends on willingness of the farmers to convert, availability of research based advice on sufficient organic feed, disease and pest control inputs under local conditions.

3.2. Introduction

Organic agriculture considers ecological, social and ethical impacts of farming. The adoption of the principles and practices of organic agriculture potentially enhances soil fertility, biodiversity and minimizes land degradation, erosion, poisoning and other negative effects of chemical activities on the environment (Diacono and Montemurro, 2010; Vaarst, 2010; Gabriel *et al.*, 2013). In the Global South, organic production exists in two parallel forms, one which is mainly focused on certified organic farming for exports to Europe and USA and another – non-certified – mainly focused at improving food self-sufficiency using agro-ecological methods and often supported by NGO's (Altieri, 2012). In the Global North, organic farming is mainly certified and driven by a combination of consumer demands and political support to the sector through agricultural payment schemes (Farnworth and Hutchings, 2009).

Besides a large variety of organic crop products, the main livestock products sold are eggs and dairy products, with more than 10% of the milk in some European countries being produced organically (AFMA 2011, Organic Denmark 2012). In Kenya, certified organic dairy production does not exist and milk production is dominated by integrated smallholder farms. These farms are mainly concentrated in the Kenya highlands, areas with elevation of ≥ 1000m above sea level and the agro-ecological potential for cropping and dairying is medium to high; they use exotic and/ or crosses of exotic with local cattle breeds and produce more than 70% of the country's marketed milk (Wambugu *et al*., 2011; Muriuki, 2011).

The organic market in Kenya is expanding rapidly with more than ten retail outlets in Nairobi and others scattered in the main towns selling organic products (UNEP-UNCTAD, 2008). Emergence of organic restaurants and initiation of more organic markets is likely to increase the market for certified organic products. Moreover, with the growing middle class and the large number of international citizens in Nairobi it is not unrealistic to imagine markets for organic milk developing over the coming years.

According to the East African standards for organic dairy production, animal management allows the animal to express natural behaviour, feeding is based on 100% organic feedstuff except in situation where organic feed is not available (maximum 40% of non-organic feed is allowed), and pest and disease management seeks to avoid the use of synthetic drugs (EAOPS, 2007), thus preventive use of pest treatments is not allowed. Based on these production guidelines organic dairy production aims at sustaining animals in good health, realizing high animal welfare standards and producing milk of high quality. To be considered as organic a farm must be certified and produce following the standards set out in the East African Organic Product Standards (EAOPS).

The aim of this study was to explore and discuss the challenges, opportunities and prospects of integrating organic dairy production in Kenyan smallholder farms seen from farmers' perspectives, and identify major factors for future development of the organic dairy sector in Kenya.

3.3. Materials and methods

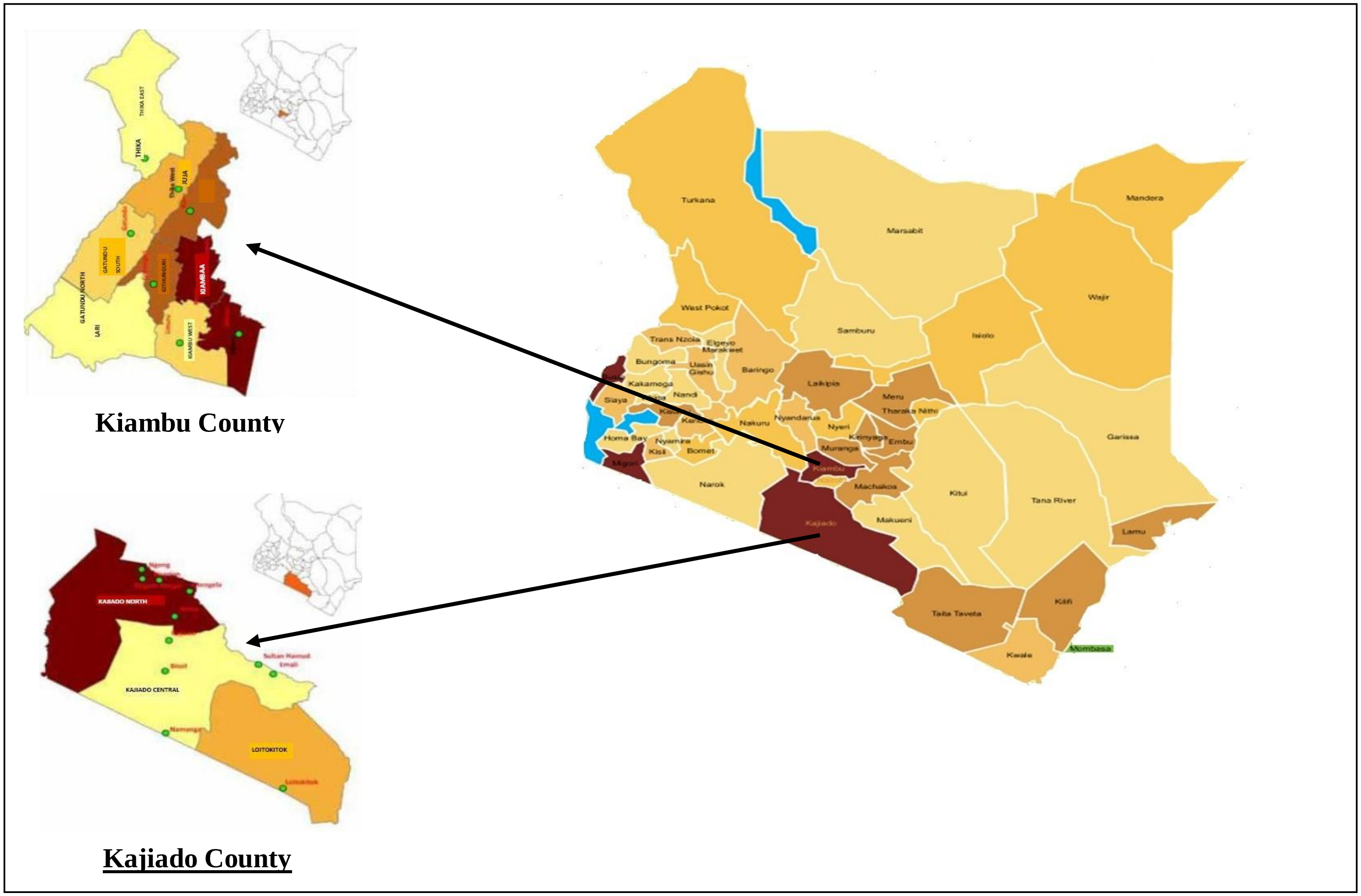
3.3.1. Study area

Farmers who participated in the survey were from Kajiado county (Ngong) and Kiambu County (Dagoretti and Kikuyu). The two areas have the highest number of certified organic crops producers in Kenya supplying the Nairobi organic markets. Their main produce include vegetables (both exotic and indigenous; potatoes, green pepper, green peas), ginger, and okra. The areas are sub-humid and have an annual mean temperature of 10–18° C, a bimodal rainfall pattern higher than 800 mm annually and are ≥1000 m above sea level. Ngong is located 21 kilometres to the South West of Nairobi while Kikuyu and Dagoretti are located 18 and 20 kilometres West of Nairobi respectively. The study sites are shown in figure 3.1

3.3.2. Survey Methodology

A cross-sectional survey of 55 smallholder organic farmers with dairy cows and certified crop enterprises was conducted. Purposive sampling was used to identify certified organic farmers with dairy cattle. A list of 314 registered farmers in these areas was obtained from Kenya Organic Agriculture Network (KOAN) and a local non-governmental organization known as Community Sustainable Agriculture and Healthy Environmental Programme (COSHEP). The farmers were contacted through phone calls and all the farmers with at least one dairy cow were subsequently interviewed at a place of their convenience. All the interviews were carried out either during farmer group meetings or at the farmers' private homes. Each farmer was interviewed individually in both cases. The surveys were conducted in February 2012 and each interview lasted approximately 50 minutes.

Figure 3.1: Map of Kenya Showing the Study sites



Source: www.kenyampya.com/userfiles/images/njambi/counties/

3.3.3. Data Collection

Six enumerators with suitable qualifications (bachelors or higher degree; speaking Kiswahili and English), and experience in data collection were involved in conducting the survey. The team received one day's classroom training to understand the survey questionnaire. Data collection was done through individual interviews, conducted in Kiswahili or English using semi-structured questionnaires with open ended and closed questions (Annex 1). The questionnaire was pre-tested to assess respondents' comprehension of the concepts and wording of the questions. Interviews sought information related to organic certification status, farm characteristics, farmers' dairy management practices, knowledge on organic dairy production, challenges to conversion to organic production and the prospects for future development of organic dairy production. Each interview was recorded and a detailed set of notes taken.

3.3.4. Data analysis

Descriptive statistics including analyzing for associations were generated from the data using SPSS for Windows version 14.02 (SPSS Inc., ©1989-2005).

3.3. Results

3.3.3. Characteristics of the crop-dairy production system

Majority of the certified organic farms visited during the survey were managed by female farmers (65%) in both counties covered by the study. The characteristics of the farms and the farmers are presented in Table 3.1. In Table 3.2, the age distribution and the farmers' education level is given, and as can be summarized from this table, 52.76% of the certified organic farmers in both counties were educated beyond secondary education and were older than 50 years.

Table 3.1: Overview of the farmers and the farm characteristics in Kiambu and Kajiado Counties

Characteristics	**Kiambu (n= 27)**	**Kajiado (n= 28)**
Median age of farmers (years)	53	55.5
Median land size (acres)	0.5	3.63
Median number of cows	1	3
Gender		
Male	10 (37%)	10 (35.7%)
Female	17 (63%)	18 (64.3%)
Dairy management system		
Tethering	6 (22.2%)	6 (21.4%)
Zero –grazing	21 (77.8%)	22 (78.6%)
Main source of feed		
Purchases from other farms	20 (74.1%)	10 (35.7%)
Own production	5 (18.5%)	16 (57.1%)
Collection from various sources	2 (7.4%)	2 (7.2%)

Table 3.2: Frequency of level of education completed and the age (% all of respondents)

Level of Education Completed	**Age categories of respondent (Years)**			
	<30	**31-40**	**41-50**	**>50**
Primary	3.63	-	1.81	10.91
Secondary	-	12.73	1.81	23.64
College/University	3.63	9.09	3.63	29.12

The average size of each farm across the two counties was 3.8 acres with most of the farmers in Kiambu having less than 0.76 acres of land for both crop and livestock production. However, as illustrated in Figure 3.1, there was a large difference between the two counties in land distribution. Thus, the potential for on-farm feed production differed between the two counties, as also illustrated in Table 3.3.

Farmers with less than 0.76 acres of land relied on feed purchases from other farms (64.71%) while majority of farmers with more than 3 acres of land produced their own livestock feed (93.33%) as shown in Table 3.3.

Eighty seven percent of the respondents in Kiambu and Kajiado counties kept Holstein-Friesian the rest kept different types of Friesian X Zebu crosses. Zero-grazing was the main system used in both areas (78%) while the rest practiced tethering. The size of land did not influence on the system of feeding the dairy cattle in average over both counties. Artificial insemination was the only method used for breeding. On 61% of farms family members were the main source of farm labour (no significant difference between the two study areas), while casual labour and permanent employment was used on 30% and 9% of the farms in Kiambu and Kaijiado, respectively. All the farmers financed their farming activities through personal finances. All the farmers did not keep regular records of animal production, animal health or breeding. Exotic and indigenous vegetables were the main type of crop grown in both counties, and the farms were generally diversified with 15 types of crops to supply the local markets. The main crops grown included: kales, tomatoes, onions, spinach, cabbage and cauliflower.

Figure 3.2: Average size of Land owned by farmers in Kiambu and Kajiado Counties

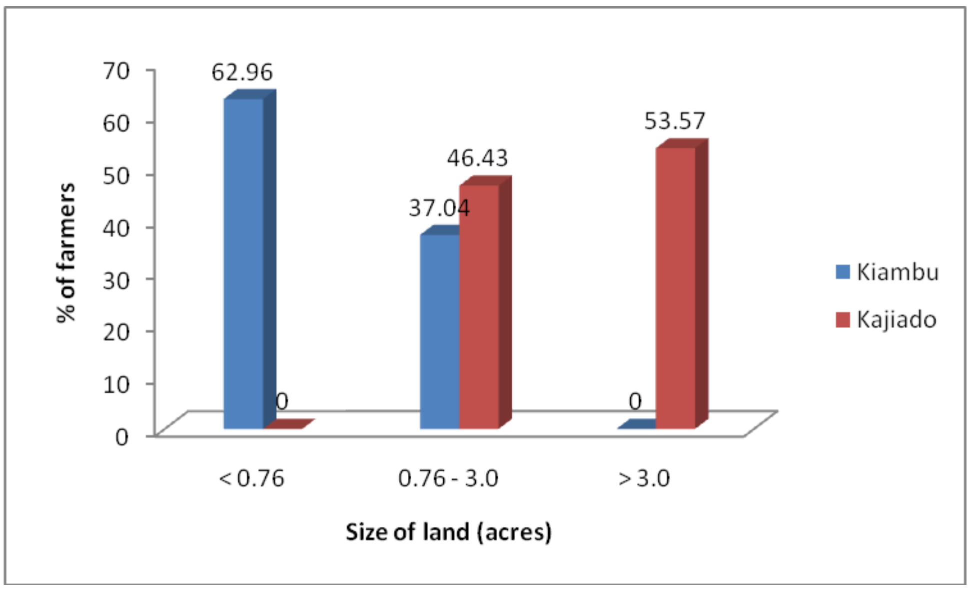


Table 3.3: Average size of land in acres and the source of animal feeds

Land size(acres)	Own production	Purchases from other farmers	Various sources
<0.76	23.53	64.71	11.76
0.76-3.0	13.04	78.26	8.70
>3.0	93.33	6.67	-

3.3.4. Reasons for keeping dairy cattle

Seventy six percent of the farmers had dairy cows within the farms where they grew their crops while the rest had their crops in different locations. Sixty one percent of the farmers had practiced crop-dairy production for more than 5 years, meaning that they had cows before they converted to organic crop production. The main reasons for integrating crops and dairy production in both counties were to get more income, to get manure for their crop enterprises and for home consumption of milk products (Table 3.4).

3.3.5. Challenges of organic dairy production

Given a selection of pre-formulated challenges, the farmers in both counties reported that the most important barrier to conversion to organic dairy production at the moment was lack of organic inputs to control external and internal parasites especially ticks and helminths, and secondly, lack of input to use for treatment of diseases like mastitis and East Coast Fever. Smallholder dairy farmers expressed that they were not sure of the efficiency of some of the cultural or biological methods used to control pest and diseases. The second most abundant choice from the list of challenges to organic milk production was lack of organic feeds for livestock. One in three farmers also indicated that there was no market for organic livestock products in both counties. Most of the milk produced by the farmers was sold locally, and the possibility of earning higher prices from organic milk production was low. Other challenges chosen by the farmers are presented in Table 3.5.

Table 3.4: Main reasons for keeping dairy cattle in Kiambu and Kajiado Counties (n=43)

Main reason	Kiambu (%)	Kajiado (%)
Get more income	48.15	67.86
Use manure in their organic farms	29.63	50.00
Home consumption	33.33	42.86
Diversify production and spread risk	-	3.57
Availability of feed for livestock	-	3.57

* The options for responses were pre-formulated, and the farmers could choose as many options as they wanted.

Table 3.5: Farmer perceived challenges for converting the dairy herd and milk production to organic production in accordance with the East African organic standards (n=55).

Perceived Challenges for converting to organic dairy production	Kiambu (%) (n=27)	Kajiado (%) (n=28)
Lack of organic input to control pest and diseases	85	71
Lack of organic feeds	56	71
Lack of capital/ land	44	61
Lack of market for organic livestock products	37	36
Lack of training on organic dairy production	19	32
Low production from organic production	22	25
Lack of labour	-	14
Climatic conditions e.g. drought	-	14
Lack of support from government	4	7

* The options for responses were pre-formulated, and the farmers could choose as many options as they wanted.

3.4. Discussion

3.4.3. Age of the farmers

A significant proportion of the smallholder farmers surveyed (62%) were over 50 years old. Mburu et al, (2007) studied smallholder dairy cattle enterprises in different agro-ecological zones in the Kenya highlands and found that the average age of the farmers was 53. The fact that so few young farmers are on the farm could partly be explained by the fact that household heads often will be the oldest generation of the family. Nevertheless, it can also point to a potential risk for the sector in the future, and indicate a need for incorporation of the youth in development programs and education that stimulates organic agricultural development, and makes farming attractive both as agricultural and rural development as well as a business opportunity.

3.4.4. Small land size a challenge for crop livestock integration and animal welfare

The characteristics of certified organic farms with dairy cattle is not distinctly different from other mixed smallholder farms in the region in terms of land size, animal numbers and breeds kept (Wambugu *et al*., 2011; Muriuki, 2011). Integration of crops and dairy production is the common practice in this system due to the critical role played by livestock in provision of manure used to maintain soil fertility and extra farm income. It is only relevant to talk about crop-livestock integration when the crops and livestock complement each other on the farm, so that crop residues and by-products are used as feeds for cattle, and manure from livestock are used to improve soil fertility to support crop production (De Haan *et al*., 1997), and the different livestock species fit into the farm and help create a whole farming system in terms of closed nutrient cycles. The farm land sizes were small, partly due to high population density, inter-generational inheritance of land (subdivision and fragmentation), and the rapid growth of the city of Nairobi into these areas (Mabiso *et al*., 2012). Besides, small land sizes create a challenge to animal welfare needs, in terms of allowing the cow(s) to graze and express natural behaviour. It points to the necessity of intensifying both crop and dairy production in these areas, and to find ways to reduce land fragmentation and to ensure that smallholder farmers can efficiently use land to support organic dairy production. The challenge posed by small land size is that farmers are not able to have sufficient animal feed production on-farm and at the same time

3.4.5. Organic feed and animal nutrition, a question of prioritization?

Lack of organic feeds was an important barrier to conversion to organic dairy production as well as to fully integrate the crop and livestock production on farms, since most of the farmer did not grow their own pasture or feeds for dairy cattle and had to depend on purchases from other farms. According to the East African Organic Product Standard, at least 60% of feed for dairy cattle must be organic (EAOPS, 2007). In addition, there was no means to ascertain if the purchased feed was organic or not. The lack of feed resources was mentioned as one of the main challenges and a reason for keeping the herds small. A well-balanced farming system is characterized by the ability to sustain itself in a closed nutrient cycle, and hence, both fodder production and production of any other crop is limited to the size of land available. However, in Kajiado more than 54% of organic farmers had more than 5 acres, which would potentially allow production of significant amounts of fodder for the cows. Thus, this might be an economical question; which pays better for the famers, cash crops or organic milk? Increasing human population and urbanization in the study areas is expected to increase the pressure on arable land, but maybe also increase the demand for good quality milk for human consumption. Smallholder farmers must develop strategies to ensure consistent supply of sufficient feed for their dairy cattle.

3.4.6. Pest and disease management

Results suggested that lack of organic input to control pest (ticks and helminths) and diseases (Mastitis and East Coast Fever) was one of the important barriers to conversion. Organic farming relies on ecological based practices such as biological management, and prohibits use of synthetic chemicals without veterinary supervision. Comparative studies in Europe show that gastrointestinal worms and lungworms diseases are more abundant in organic farms (Hoglund *et al*., 2001; Vaarst and Thamsborg, 1994) while recent studies in Brazil revealed no significant difference on the population of gastrointestinal helminths in dairy cows kept in organic and conventional production system (da Silva *et al*., 2012). The main challenges to health in both conventional and organic farm in Europe are lameness, mastitis and infertility (Lotthammer and Wittkowski 1994).The health of dairy cows in organic farms is same or better than those in conventional farms (Sundrum, 2001; Lund and Algers, 2003). Unlike in Europe where most of the disease challenges are production diseases, the major constraints to livestock production in East Africa are vectors and vector-borne diseases exemplified by ticks and East Coast fever (Nalubwama *et al*., 2011). Control of these diseases is often heavily dependent on the use of acaricides (Vaarst *et al*., 2006). This point to the need for more scientific research on organic practices to prevent and manage livestock pests and diseases. It could be development of technologies which can be commercialized or used by farmers from their own production e.g. of plants and herbs. Knowledge and information also needs to be more commonly available, and in many cases generated to fit specific contexts. Organic dairy production will probably be difficult to achieve without access to natural remedies for pests and diseases.

3.4.7. Record keeping

The observation that majority of the smallholder dairy farmers do not keep production, reproduction and health records is in agreement with other studies (Chagunda, 2006; Tebug *et al*., 2012). This makes it difficult to get information related to the performance of the farms. It is an area where farmers need to improve to be able to benefit from the business opportunities of organic milk production. Since record keeping is essential for daily farm management and for financial management of the dairy enterprise; verification of organic status of animals, production, harvesting, and handling practices associated with the organic products and animals and is a requirement by the organic standards to demonstrate compliance with the organic standards (EAOPS, 2007). All farms must provide documented evidence of the farming practices employed on farm prior to certification. Therefore converting farmers must develop provide documentary evidence to get certification and also retain certification after it has been granted.

3.4.8. Extension services

One in four of the interviewed farmers reported that lack of knowledge on organic dairy production practices was a major challenge. Intensive knowledge required to support growth and development of organic production systems is not available in the public extension service. Van den Band (1998) recognized agricultural extension services as one of the factors that accelerate development. The National Agricultural Extension Policy (NAEP) advocates for a demand driven extension service and participation of the other players in the delivery system (Republic of Kenya, 2004) but has little to offer in form of information on organic production. Developing tailor-made organic training on organic livestock production for extension officers will provide the much needed knowledge and skills required for transfer to the farmers.

3.4.9. Financing organic production

Conversion to certified organic dairy production requires financing to implement the basic requirement for certification. The high risks associated with agriculture makes potential creditors cautious about lending to the sector (Nyikal, 2007a). As a result, farmers have to depend on their own savings to invest in organic production which may limit opportunities for expansion. Lack of financing for organic production is likely to affect the rate at which farmers are able to convert their enterprise. Financing of smallholder organic dairy farming should be a major concern if the sector is expected to thrive. It is expected that organic dairy farming among smallholder farms will face similar challenges experienced by other smallholder dairy farmers. this being the case then there may be need to develop alternative sources of funding other than the competitive market since smallholder production does not exhibit effective demand for credit (Nyikal, 2007b).

3.4.10. Markets for organic dairy products

In Europe, organic dairy production is described as targeting a specific premium market that demands high quality standards during the whole production process (Sundrum, 2001). Lack of organic markets and market access remains one of the fundamental factors holding back the development of the organic sector in the region (Valerian *et al*., 2011). In Kenya, there is no specific market for organic milk even though potential may exist among the middle class and international community in Nairobi. However, growing consumer concerns about human health, food safety, animal welfare and environmental impact of intensive farming practices has led to increased interest in organic products. The Kenyan market for organic products is still small but the demands for organic products are expected to grow. The increase in numbers of supermarkets and restaurant offering organic foods is an indicator of the positive growth in this sector. Other reasons that have been attributed to the slow growth of organic sector in Kenya include lack of awareness, low-income levels, lack of local organic standards and other infrastructure for local market certification (Kalibwani, 2004). With the publication of local organic standards and the development of local infrastructure for certification, challenges regarding product authenticity are being addressed. To increase demand and growth of organic production for livestock products more effort needs to be focused towards creating awareness about the product and how it is produced, and the availability of the products among the consumers especially those in urban centres. A number of strategies have been adopted by Kenya Organic Agriculture Network (KOAN) to develop organic market in Kenya and beyond. These strategies include a promotion of organic products in order to interest more consumers and build a consumer base and provision of technical service support through the Organic Market Assistance Programme (OMAP). The programme provides technical expertise in organic market and product development, advice farmers and assists producers in preparing for organic certification. Creating sustainable market opportunities to smallholder farmers will provide an incentive for continued production. As a way of expanding market opportunities for organic producers in Kenya, there is vital need to understand the complexity of the inter-related reasons why there has been little growth in the organic market activity in the region, and why organic farmers are not accessing these markets.

3.4.11. Policy framework

The development of the national organic agriculture development policy began in 2010. The policy is motivated by the fact that organic farming has the potential to feed more people, which has been demonstrated especially in tropical countries (Badgley *et al*., 2006; Hine *et al*., 2008; Halberg *et al*., 2006), and that the production method and practices leave the environment strengthened rather than depleted for the future generations. The objectives of the national organic agriculture development policy are to promote the industry and give direction to the sub-sector; enhance production and development of the local and export market leading to increased income earned by the organic stakeholders and improved standards of living; strengthen and raise the profile of the sub-sector hence more support from both the public and private sectors and contribute towards poverty eradication and improved food and nutrition security. A strategic plan is needed to ensure that the necessary political, technical and financial resources required to develop the subsector become available and to make clear the priority areas requiring support from development partners.

3.5. Conclusions and Future Perspectives

Conversion of smallholder dairy farms to certified organic production is mainly constrained by small land sizes, lack of organic feeds and lack of organic inputs for control of pest and diseases. There is need to develop strategies that will ensure smallholder farmers are able to get sufficient feed for the cows, manage ecto-parasites and endo-parasites which are endemic challenges to milk production is such systems. One of the key drivers to conversion could be developing consumer demand which guarantees a premium price for organic milk and milk products. Future prospects for integrated organic dairy production in smallholder production systems therefore depends on the willingness of the farmers to convert, availability of research based advice on sufficient organic feed, disease and pest control inputs that are effective under the local conditions.

CHAPTER 4

DAIRY CATTLE MANAGEMENT, HEALTH AND WELFARE IN SMALLHOLDER FARMS: AN ORGANIC FARMING PERSPECTIVE

4.1. Abstract

Organic production principles aim at achieving good animal health and welfare status of livestock. Good animal health and welfare is not only beneficial to the animals but also has the potential of increasing farm income. The objective of this study was to investigate the aspect of benchmarking animal management, health and welfare in smallholder dairy farms to be able to give recommendations which can guide organic livestock production as stipulated by International Federation of Organic Agriculture Movement and the East Africa Organic Product Standard, particularly on animal production, health and welfare issues. A longitudinal study of 24 farms was conducted to document and discuss management practices and their potential effect on animal health and welfare. Observation and documentation of animal housing design, cleanliness, feeding management and types of feed available to the cow, milking management, disease and pest management was done in Kajiado and Kiambu Counties of Kenya. Farmers were requested to record the incidence of veterinary treatments during the period of the study. An analysis was performed for indicators of health and welfare with husbandry type, aspects of the housing system, farm characteristics, and management routines. The average herd size was 3.15 in Kiambu and 3.91 in Kajiado, with all the cows' zero-grazed.75% of the cubicles were small (less than $2.50M^2$). Most of the farmers sprayed their animals weekly (47%) to control ticks, while all incidences of diseases were treated by a veterinarian. Most of the cattle housing flooring were made of concrete (87%) with only 1 farmer regularly using bedding for the cows. Cows were mainly fed fresh Napier grass (60%) in Kiambu while natural grasses (43%) was the

main feed used by farmers in Kajiado. This study indicated that four major challenges exist for organic dairy cattle, which have to be addressed in relation to future research and development: 1) the use of robust breeds and the breeding strategies, 2) grazing and access to outdoor areas, 3) feeding in terms of stability and self sufficiency of enough nutritious feed, and 4) handling of diseases and pests using poisons, chemical medicines, and hence development of viable alternative disease handling strategies.

Key words:

4.2. Introduction

Organic agriculture is a holistic approach to agriculture and food systems, which promotes and enhances agro-ecosystem health, including bio-diversity, biological cycles and soil biological activity (FAO, 1999). The growth of organic agriculture is attributed to increasing consumer demand for products perceived as tastier, healthier and produced in an environmentally sustainable system (Pimentel *et al.*, 2005; Hughner *et al*., 2007; Reed, 2010). The concept of organic livestock production can therefore be considered as a system of livestock production that better fulfils animal needs (Lund, 2006; Verhoog *et al.*, 2007), promotes use of organic and biodegradable inputs for production (Chander *et al*., 2011) and reduces the use of routine, conventional veterinary treatments (EAOPS, 2007).In addition, it incorporates humans and animals as part of a larger ecological system (Baars *et al*., 2004; Verhoog *et al.*, 2004).

Organic livestock farming aims at improving animal health and welfare. In this system, animal health is not only viewed as the absence of disease but also as resilience in terms of the animal's ability to absorb shocks and pressure from the surroundings and react so that they do not fall ill. As such, health is a positive characteristic achieved through the application of animal health promotion strategies and practices, rather than the routine use of conventional veterinary medicines (Vaarst and Alroe, 2012). The use of veterinary drugs, antibiotics or chemicals is permitted if preventive practices are ineffective and treatment to cure sickness or heal an injury is necessary. Treatment must be done under the supervision of a veterinarian (EAOPS, 2007). Animal welfare in organic livestock production is multifaceted and many aspects of an animal's life contribute to its welfare. These include good health and productivity, ability to express natural behaviour, absence of pain or stress, positive emotions, ethical considerations and numerous others (Duncan, 1996; Fraser and Broom, 1997; Lund, 2006; Haynes, 2008).

Animal health and welfare is influenced by the ways in which livestock production systems are constructed (Vaarst and Alroe, 2012). Kenyan milk production systems are dominated by smallholder farmers. The average milk production in smallholder dairy farms is generally low (Owen *et al*., 2005; Musalia *et al*., 2007; Lukuyu *et al*., 2011), and higher production is limited by feed scarcity, infectious diseases and parasites, poor animal husbandry practices and limited access to extension and veterinary services (Ayantunde *et al*., 2005; Njarui *et al*., 2011; Onono *et al*., 2013). Despite these challenges smallholder livestock production on mixed crop–livestock farms is expected to remain dominant in Sub-Saharan Africa for the foreseeable future. Rising incomes, urbanization and preferences by the growing middle classes for a diet that includes livestock products is expected to guarantee income for livestock producers (Delgado *et al.*, 1999; Jayne *et al.*, 2003). As a result intensification of dairy production by keeping exotic breeds and zero-grazing is widely promoted to meet the increasing demands for dairy products and sustain livelihoods from limiting production resources like land, capital and labour (Bebe *et al*., 2008).

Intensification is expected to influence the way these systems operate and affect the health and welfare of livestock in these systems.

Taking into consideration the situation of smallholder dairy farming system in the two counties in Kenya coupled by literature review on the condition of these systems from other studies, the objective of the study was to explore and analyze the animal management, health and welfare in smallholder farming systems and discusses these issues in relation to the recommendations made by International Federation of Organic Agriculture Movement (IFOAM) and East Africa Organic Product Standard (EAOPS). In addressing these objectives this study aimed at enriching the debate around organic dairy production and smallholder crop-dairy systems to assist in identification of viable options in space and time to which efforts on organic dairy development could be focused.

4.3. Materials and methods

4.3.1. Study area and selection of farms

A detailed description of the study area is presented in the previous chapter, section 3.3.1. Twenty four farms were selected at random from a list 55 farmers who participated in the cross section study. A total of 13 farms in Kiambu County and 11 farms in Kajiado County were selected. The small sample size was based on the need to understand the production system in detail, available resources and logistical considerations. Given the low number of certified crop organic farmers with dairy cattle in both areas 24 farms were considered to be a representative from the population. The longitudinal study evaluated the management practices, animal health and welfare in the farms.

4.3.2. Data collection

Data was collected using 2 farm monitoring sheets (Annex 2 and Annex 3). The farm monitoring sheets were used to document both the baseline information at the beginning of the longitudinal study and the repeated observations that were made over the period of the longitudinal survey. The baseline information collected at the beginning of the study included; animal housing, cubicle sizes, land size and land allocation to various enterprises. To assess the animal housing design the following parameters were used; presence and adequacy of roofing, presence, type and state of walls, floor type, presence of resting yards, nature and adequacy of feeding and watering areas. All these were assessed by visual observation and taking measurements. Information related to milk production, feeding, occurrence of animal diseases, treatment, breeding, milking practices, animal housing as well as other farm characteristics were observed and documented during the repeated farm visits. Information on milk production and concentrate feeding disease occurrences and treatments were recorded using a monthly data card that was given to the farmers each month (Annex 4). Each farm was visited at least four times, with the first visit in the August of 2012 and last visit in April, 2013 to cover the two main seasons experienced in these areas. Feeding management including type and amount of feed as well as frequency of feeding, type and frequency of mineral supplementation and frequency of watering were obtained by asking the farmer or the worker responsible for feeding the animals.

Milking management, disease management and parasite management were also obtained by observations of how the processes were conducted. These included information on: milking procedure, disease control and prevention measures such as use of acaricides and vaccinations, and routine practices such as de-worming. The hygiene status of the floor was assessed by evaluation the frequency of slurry removal and by direct observation by the investigator during farm visits.

4.4. Results

4.4.1. Land holding and land use pattern

There was a significant difference in the average total landholding by smallholder farmers in the two counties. In Kajiado County the average landholding was 8.23 acres while in Kiambu County the average land holding was 0.74 acres. The average land sizes for pasture, cropping, home/compound and animal house are shown in Table 4.1. The animal houses were set up in the backyard near the farmer's houses and all the dairy cows were raised within the zero-grazing units.

Fifteen percent of the dairy farmers in Kiambu County had an average of 0.3 acres allocated for pasture within their farms, while in Kajiado County, all the farmers had an average of 2.20 acres allocated to growing pastures. 30% farmers in Kiambu County grew pasture along the hedges of their farms but this did not constitute significant land allocation. Seventy three percent of the farmers in Kajiado had an average of 2.78 acres of their land not cultivated or allocated to a specific enterprise. The cows were not grazed in any of the farms and feed was cut and carried to the cattle.

Table 4.1: Land holding and use on smallholder farms in Kiambu and Kajiado Counties

	Kiambu (N=13)		Kajiado (N=11)	
Type of land use	**Mean (N)**	**SD**	**Mean (N)**	**SD**
Land for home/compound	0.19	0.05	0.49	0.29
Land for animal house	0.14	0.07	0.18	0.06
Land for cropping	0.36	0.17	3.25	2.47
Land for cut and carry grass	0.3*	0.20	2.20	1.61
Land not cultivated	-	-	2.78**	2.88
Total land holding	0.74	0.28	8.23	6.70

*, ** only two and eight respondents in Kiambu and Kajiado respectively

4.4.2. Housing design and hygiene

Table 4.2 shows the details of the structures used to house the cows. In both counties 87% of the animal house flooring was made of concrete. More than 72% of the cubicles in both counties were small compared to the recommended size of 1.2m by 2.1m in the extension manual for animal housing (MoLD, 2007). One of the 24 farmers used saw dust/ wood shavings as bedding in the cubicles. Thirteen percent of the farms did not have specific cubicles for milking their cows and used one of the cubicles used as a resting area for milking. All the farms did not have a calving area or a sick pen.

In most cases the animals were soiled with slurry on various areas of their bodies. In all the cows examined, the limbs, the flanks and the udder were soiled. The main cause of soiling on the animal was accumulation of slurry in the cow house. Removal of slurry and cleaning of the cow housing floors was done at least once per day in 77% and 64% of the farms in Kiambu County and Kajiado County respectively. In the other farms, it was done only occasionally, either once every two days or once per week.

Table 4.2: Details of the cow housing system on the farms in Kiambu and Kajiado Counties

Parameter detail	Kiambu (N=13)		Kajiado(N=11)	
	Number	Percentage	Number	Percentage
i. Cow shed flooring				
○ Concrete	12	92.3	9	81.8
○ Soil	1	7.7	2	18.2
ii. Milking area				
○ Available	11	84.6	10	90.9
○ Not available	2	15.4	1	9.1
iii. Bedding in the cubicles				
○ Saw dust/wood shaving	0	0	1	9.1
○ No bedding	13	100	10	90.9
iv. Cubicle size				
○ Small size	10	76.9	8	72.7
○ Adequate/ large sized cubicles	3	23.1	3	27.3
v. Ratio of number of cow to the number of cubicles in the animal house				
○ 1:1 – 1:1.9 (cows/cubicles)	4	30.8	5	45.5
○ 1:2 -1:2.9 (cows/cubicles)	4	30.8	2	18.2
○ >1:3 (cows/cubicles)	5	38.5	4	36.3

4.4.3. Grazing and outdoor access

All the adult dairy cows were housed in the zero grazing units during the study. Only calves in 5 of the farms grazed within the compound during the day but were housed overnight.

4.4.4. Herd structure

There was no significant difference in the average herd size in both Counties (Table 2). The majority of the studied households owned between 1 and 3 cattle. Milking cows constituted the highest number in the herd structure in Kiambu County while in Kajiado County milking cows and calves were equal in number (Table 4.3). The only breed of dairy cattle kept by the farmers was Holstein-Friesian and no farmer kept a bull in the herd.

Table 4.3: Herd structure of visited farms at the beginning of the study

	Kiambu (N=13)		Kajiado (N=11)	
Types of cattle/ Herd size	**Average Number ± SD**	**% in herd structure**	**Average Number ± SD**	**% in herd structure**
Milking cows	1.35 ± 0.65	43.9	1.55 ± 0.82	39.5
Dry cows/ Heifers	0.69 ± 0.63	22.4	0.91 ± 0.83	21.0
Calves	1.00 ± 0.58	33.7	1.55 ± 1.04	39.5
Average Herd size	3.15 ± 0.80)	-	3.91 ± 2.07	-

4.4.5. Calf management

Ninety two percent of the farms had calves at one time during the period of the study. Calves were housed separately away from adult animals on all the farms. All farmers fed their calves twice daily; this was done soon after milking. The amount of milk fed to the calf varied from farm to farm and with the age of the calves. Other than milk, calves were mainly fed natural grass or Napier grass or dry crop residues. Protein supplementation for calves was only done regularly on 8% of the farms. Both farms were located in Kajiado. The age of weaning from milk ranged between farms with 38% of the farms weaning the calves at between 11 and 12 weeks while 25% of the farms weaned their calves at between 9 and 10 weeks. Of the farms that weaned their calves earlier, 8% continued to feed calves with pellets till the calves were more than 12 weeks old. Eighty three percent of the farms had a calf pen for keeping the calves. 58% of the calf pens were raised floors made of wood with slated floors, while the others had floors on the ground. Bedding for the calf pens were provide in 17% of the farms. The sizes of the pen in all the farms were similar with an approximate size between $1.8M^2$ and $3M^2$. All the calves in the farms were dehorned before three months. Anesthesia was used in all cases during dehorning.

4.4.6. Milk production and milking practices

Milking was done in parlours in 71% of the farms. Concentrates were used by 75% of the farmers in both regions and were only fed during milking. The estimation of commercial concentrates (dairy meal) for feeding milking cows ranged between 2 to 4 kg per day. All of the cows were milked twice per day, in the morning at 0600 - 0800hrs and in the evening at 1700hrs to 1900hrs. Hand milking was the only method used for milking on all the farms. Only 13% of the farmers washed their hands with a detergent before milking while 6 farmers did not wash their hands before milking in both regions (Table 4.4). Udder and teat washing with water was done before milking by all the farmers in both counties. 50% of the farms observed foremilking was not conducted. 71% of the farmers in both counties used milking jelly to soften the teat before milking. Milk was stored and transported in aluminium cans on 75% of the farms, while other farmers mainly use plastic jars during milking. 33% of the farms used detergent for dipping the teats of the cows after milking. Hand washing and order of fore milking were not consistent on most of the farms.

4.4.7. Breeds and breeding management

All cows in the study were exotic breeds. Artificial insemination was the only method of breeding used by all the farmers. The farmers observed the animals and called the inseminator when a cow was in heat. Artificial insemination services were mainly offered by private individuals who provided advice to farmers on the best bulls. The main criterion for sire selection for most of the farmers was improving milk production.

Table 4.4: Milking Procedure in Kiambu and Kajiado Counties

Parameter detail	Kiambu (N=13)		Kajiado (N=11)	
	Number	Percentage	Number	Percentage
i. Hand washing				
○ Wash hand before milking with soap/disinfectant	1	7.7	2	18.2
○ Washing hands with water only	6	46.2	5	45.5
○ No hand washing	5	38.4	1	9.1
○ Inconsistent practice in milking procedure	1	7.7	3	27.2
ii. Order of fore milking				
○ Foremilking before cleaning	1	7.7	0	0
○ Cleaning before foremilking	1	7.7	5	45.4
○ No foremilking	5	38.5	3	27.3
○ Inconsistent practice in order of milking	6	46.1	3	27.3

4.4.8. Disease and pest management

All the farmers in both study sites used acaricides preventively on their farms. Majority of the farmers used acaricides once every week, 38% and 55% in Kiambu and in Kajiado counties respectively. Table 4.5 shows the detailed frequency of acaricide use in both counties. Hand spraying was the only method of application used in both regions. 62% of the farm in Kiambu County and 36% in Kajiado County did not practice routine de-worming for calves or other cattle during the period of the study (Table 4.5). During the 8 months of the study, one case of East Coast Fever was reported in Kajiado. Four cases of mastitis were reported in both areas of which three of the cases of mastitis were in Kiambu County. In all cases the treatments were conducted by a Veterinary Officer from the respective location at the expense of the farmers.

Table 4.5: Helminths and tick control practices in the farms

Parameter detail	Kiambu (N=13)		Kajiado (N=11)	
	Number	**Percentage**	**Number**	**Percentage**
i. Frequency of application/use of acaricides				
○ Weekly	5	38.46	6	54.55
○ Once every 2 weeks	4	30.77	3	18.18
○ Once a month	4	30.77	2	27.27
ii. Frequency of de-worming				
○ Once every 3 months	1	7.69	1	9.09
○ Once every 5-6 months	4	30.77	6	54.55
○ None	8	61.54	4	36.36

4.4.9. Feeding management

Zero-grazing was the method of cattle rearing practiced by all the farmers. There was a difference in the type of feed given to the animal in the two counties. In Kajiado the farmers mainly fed assorted species of green grasses followed by Napier grass during the wet season. During the dry seasons between December and February hay was the most common feed for the dairy cattle. Hay which was mainly used in Kajiado during the dry season was purchased from the agro-veterinary shops around the area. In Kiambu, the most common feed during the wet and dry season was Napier grass. In Kiambu, there were a number of farmers who grew Napier grass for sale to dairy cattle farmers. However, the second most important feed resource during the wet and dry seasons in Kiambu and Kajiado Counties were different species of grasses collected from various sources and hay respectively. In Kiambu, maize stover also contributed a significant amount of the feed at the beginning of the dry season. The maize stovers used for feeding the cows were mainly purchased from other farmers.

Animal feed was mainly sourced on the farm from Kajiado, while in Kiambu the farmers employed a farm worker who collected feed from various sources including road side and hedges. Mineral salt block was available in 5 out of all the 24 farms visited. Water was fed to the cows' ad libitum. There was supply of clean tap water in both regions.

4.5. Discussion

4.5.1. Land holding and use

The results show similar landholding patterns and use in smallholder dairy farming system in other tropical countries. Most smallholder farmers own less than 5 ha and allocate most of the lands to crop production than pasture production (Lanyasunya *et al*., 2006; Njarui and Mureithi

2006; Waithaka *et al*., 2006; Musalia *et al*., 2007; Lukuyu *et al*., 2011). Decreasing land sizes in densely populated highlands where most of these farming systems are located makes zero-grazing an important strategy through which smallholders intensify their production. Small land sizes make it difficult for the farmers to produce sufficient feed for the dairy cattle. As a result, the farmers must rely on feed from other external sources which may vary in quality and quantity depending on the seasons and may not be necessarily organic. The challenge of land also makes it difficult for smallholder farmers to design production systems that can meet the basic requirements of animal health and welfare. Changes to incorporate the animal health and welfare needs of the animals based on the organic standards and principles must involve trade-off between dairy production with other critical enterprises like crop production. To establish the merits or demerits of substituting one enterprise for another a critical analysis on the profitability and practicality of the competing enterprises needs to be done. Meeting the animal health and welfare under smallholder systems will require a review of how these production systems are constructed.

4.5.2. Farm structures and hygiene

Dairy cattle in this study were housed all the time. The design of housing in this study was such that most of the floors were made of concrete and lacked beddings, the cubicle sizes were small and the cow to cubicle ratio was low in many farms. Thus the housing structures in most of the farms were not properly suited for the cows. The farm structures not only risked to the welfare of the cows but also the health of the cows. The length and width of cubicle impend comfortable lying and movement of cows yet cows show a strong motivation to lie down (Cooper *et al*., 2007). Without comfortable and easily accessible lying area, cows will have difficulty in lying, entering and rising (Nguhiu-Mwangi *et al*., 2008). As a result, cows may spend more time standing or lying. This increases risk for injuries thus affecting cow health and welfare.

Lack of bedding on concrete floors as observed in the study increases the risk of a cow slipping or falling. Cows in such conditions have to alter their gait to lower friction while walking (Phillips and Morris, 2000). This can lead to injury and a disinclination to walk, making the cows less likely to visit the feeding are despite motivation to do so, possibly reducing feed intake and production. Concrete floors have been associated with an increased occurrence of hoof lesions due to claw horn disruption compared to straw yards (Frankena *et al*., 1992, Somers *et al*., 2003).

The organic standard does not give specification on the minimum space requirements for dairy cattle or the stocking density. However, farmers are required to provide animals with beddings where it is appropriate, clean the holding areas regularly, provide living conditions that prevents abnormal behaviour, injury and disease according to natural behaviour of the animals. To be able to fulfil this requirement structural adjustment of the farms will be required. These changes involve re-designing of the cow housing, changes in the flooring systems and changes in the management of the cow environment. These adjustments may be capital intensive and the question many farmers would ask is whether the additional expenses to cater for the health and welfare needs of the cows are justified. One of the major challenges in making these additional investments is lack of information on benefits of these investments on the animal's health and welfare and economic gains to the farmers.

4.5.2. Grazing and outdoor access

In this study, all cows were zero-grazed. This creates a major conflict in relation to the organic principles and recommended practices. The goals of organic principles are that dairy animals should be managed in a way that allows the expression of natural behaviour and according to their natural behavioural needs. This includes letting the animal to have sufficient space for free movement according to their natural behaviour (EAOPS, 2007), and to graze because this is a natural way of feeding for ruminants. Access to outdoor areas and freedom of choice that allows an animal to express individual preferences is also considered to constitute the concepts of naturalness (Lund 2006; Waiblinger *et al*., 2004; Verhoog *et al*., 2007). The EAOPS permit, bringing fodder to the animal if it is a more sustainable way to use land resources than grazing. However, under such conditions regular outdoor runs must be provided for.

Providing for the health and welfare needs of the dairy cows in smallholder production systems require that some farmer purchase more land while other will need to re-allocate the more land to dairy production. These changes may require additional capital to invest in purchasing more pieces of land and additional labour to ensure that grazing areas or areas for outdoor runs are managed effectively to enhance the health and welfare needs of the cows.

However, there are no clear guidelines that can to be used to evaluate compliance on a number of issues that directly affect animal health and welfare based in the East African Organic Product Standards. For example the EAOPS do not give detailed guidelines on what “sufficient space for free movement” is or what “regular outdoor run” means to ensure that animal health and welfare is not compromised. The standards need to provide definite details for farmers to be able to understand and implement. Since there are no risks of dairy cow loosing organic status as a result of lack of sufficient space, then the farmers may not see the need for implementing these requirements.

4.5.3. Calf management

In organic dairy production natural living for calves involves cow-calf contact and natural milk feeding from a cow (suckling). Suckling also enables the cow to express natural behaviour and ensures natural communication between the cow and the calf (Grondahl *et al*., 2000; Flower and Weary, 2003). Calves in this study were isolated from their mothers within the first two weeks of birth and were either bucket fed or bottle fed until they were weaned. However, this is much better than the way in which calf management is practiced in most European countries where calves are separated from the cows shortly within a few hours after birth (de Passille *et al.*, 2008). This type of calf feeding is the most common practice by smallholder farmers with zero-grazing units (Bebe, 2008; Lukuyu *et al*., 2011). Organic feeding standards require calves to be fed with maternal milk or organic whole milk from their own species. Feeding of vitamins, trace elements and supplements from natural sources is also permitted. The organic standards does not define specific time period for weaning and only states that "*Animals shall be weaned only after a minimum time that takes into account the natural behaviour and physical needs of the animal*". In cows, natural weaning has been found to occur from at least 6 months (Webster, 1994) up to 12 months (Reinhardt and Reinhardt, 1981). Various studies have shown that natural weaning provides welfare benefits of health, psychological wellbeing and natural behavioural expression for both the calf and dam (Solano *et al*., 2007; Wagenaar and Langhout, 2006; Wagner *et al*., 2012).

The variation observed in the amount of milk fed to calves in different days shows that there is no specific feeding management strategy in the farms, yet feeding is the key component in the replacement management procedure within farms is the successful raising of healthy calves (Radostitis, 2001). Lukuyu et al. (2011) observed that the most important constraint to optimum feeding in calves were low milk production by dams and competitions between milk for use in the household and for sale were probable.

The other challenge is calf rearing was lack of bedding and dirty calf pens in most of the farms affected the welfare of the calves and could be associated to numerous calves' diseases like gastroenteritis and pneumonia. These two diseases accounted for 44% of calf mortality in farms around Nairobi (Gitau *et al*., 2010). The diseases lead to huge economic losses and deprive the farms of replacement stock for their herds.

4.5.4. Feeding management

The quantity and quality of feed is a major contributor to animal good animal health and welfare. To support animal health and welfare, feeding is required to meet the physiological conditions of the animals. The East African Organic Product Standard requires that diets for dairy cows must derive a minimum of 60% of the dry matter intake (DMI) from organic feedstuff daily. Access to fresh fodder through grazing is preferred as preserved fodder may only be used where fresh fodder is not available. Organic production views animals in the farm as part of the system and thus recommends that at least 60% of the feed shall come from the farm itself or be produced in cooperation with other organic farms. In Kajiado, farmers produced most of the feed on their own and did not use chemical fertilizers in the grasses that were fed to the cow. However, during the dry season farmers relied on hay which was purchased from the local agro-veterinary shops.

It was therefore difficult for farmer to determine how the purchased feed was produced. In Kiambu, feed was sourced from outside the farm throughout the year. The main source of feed was purchase of fodder from neighbouring farmers specialized in fodder production and collecting feed from various sources by the farm workers. In Kiambu, maize stover was purchased from farmers who were not organic farmer.

The standard provides opportunities for farmers who have limited amount of land and are not able to graze their animal to use preserved feed as long as their organic status is known. The greatest challenge to the farmer will be to get organic feed for their dairy cows. This is due to lack of traceability of the source of feed and the production method. Incorporation of maize stover produced by non-organic farms will also need to be stopped since production of maize in most parts of the country involve used of pesticides and chemical fertilizers.

The amount of concentrates fed to the animal varied from one farm to another. Previous studies show that the quantity of concentrates offered to dairy cattle in smallholder farming systems was generally low (Njarui *et al*., 2011). The amount of concentrate fed depended on the abilities of the farmers to buy the concentrate. Production and feeding of protein-rich crops has been recommended as a method to reduce the necessity of commercial concentrates in smallholder production systems. The greatest challenge to supplementing the protein requirement thorough this method is the lack of sufficient land to grow the protein rich-crops in smallholder farmers. This means that even if protein rich crops are to be used as substitute smallholder farmers still have to buy the crop from other farmers. There is need to develop practical solutions to ensure adequate feed for dairy cows in smallholder systems.

4.5.5. Use of poisons and chemical medicine in disease management

The occurrences of disease in the farms involved in this study were relatively low with only one case of East Coast Fever and four cases of mastitis. However, East Coast Fever, anaplasmosis, babesiosis, trypanosomosis and contagious bovine pleuropneumonia are some of the cattle diseases reported to be endemic in smallholder production systems (Muraguri *et al*., 2005; Zilberman *et al*., 2011). The use of pharmaceutical are discouraged in organic dairy production and may only be used under the supervision of a veterinarian if it is the best way to reduce suffering save life or restore health. A guideline is given on the withholding periods after treating animals with synthetic veterinary drugs or antibiotics.

In this study, the use of acaricides was a routine practice. Routine use of acaricide is common in smallholder farming systems (Maingi and Njoroge, 2010; Wesonga *et al*., 2010). To conform to the requirement of the organic standard, alternatives to chemical methods of controlling ticks should be adopted in smallholder farms, for example, hand picking of ticks (Rubaire-Akiiki *et al*., 2006). The routine use of acaricide against ticks is use as a preventive measure to tick-borne diseases which are a major cause of losses in smallholder farms. Given the important role played by dairy cattle in the livelihood of most of the farmers, loss of an animal is considered too risky unless effective alternative tick control method or insurance against losses should they change their practices.

The standards does not provide any conditions that may lead to the removal of organic status of an animal based on use of synthetic drugs for disease treatment or parasite control even under repeated treatments. Though the flexibility in the organic standard concerning the maintenance of organic status regardless of the number of treatments provide an opportunity for smallholder farmers faced by numerous disease and pest challenges, this may lead to non-compliance and make use of these synthetics the norm rather than an exception. Since maintaining health is an integral part of animal welfare more work need to be done to develop methods of disease control that are acceptable in organic production.

4.5.6. Breeding management and breeding objectives

Holstein-Friesian was the only breed kept by farmers in this study with Artificial insemination being the only method of breeding used in the farms. The smallholder farmers keep exotic breeds as a key component of their intensification strategy in order to increase milk production (Murage and Ilatsia, 2011). Holstein-Friesian is considered as a "high maintenance" animal requiring high energy concentrate and regular veterinary treatment. Exotic breeds have higher nutritional demand, low milk, poor adaptability and low production efficiency in smallholder production systems (Kahi *et al*., 2000; Wakhungu, 2000).

Most cows kept by smallholder farmers are sourced from commercial herds which may have different sets of objectives. The farmers who use artificial insemination (AI) use the same breeding bulls as conventional farms with the aim of increasing milk production. The choice of AI bull to use is usually determined by the farmer or based on advice from the AI service providers. This is unlikely to change in the near future since the dairy sector in Kenya depends on conventional breeding programmes in Kenya, Europe and USA as the main source of breeding bulls.

Selection of animals should be based on the requirements of the production system or environment because it plays a role in safeguarding animal health and welfare. In organic livestock production, breeding should not only focus on increased milk production but also consider other important traits required to meet the health and welfare needs of the animal in smallholder systems like resistance to diseases, adaptation to the local environment and utilization of available feed resources. Animals that are genetically adapted to specific conditions are more productive and the cost required for production is lower (Simm *et al*., 2004).

Correct breeding and selection of appropriate dairy breeds should be viewed as a preventive health strategy for organic dairy systems (Marley *et al*., 2010). Long term consideration during breeding and selection may help fulfil the requirements of organic production. Recognition of the role of organic production at the policy level will also play an important role in the future development of organic dairy production since most policies advocate for intensification of productivity by increasing animal output and productivity (Devendra, 2001; Bebe *et al*., 2002).

4.5.7. Human choices related to animal farming

Human factors strongly determine our behaviour towards animals, animal production and animal welfare (Boivin *et al*., 2003). This is because the decisions in the farms are dependent on the farmers and have major implication on animal health and welfare. These decisions include the number of cows to keep, the size of cubicle to build and animal management in general. This study showed that in most farms there were low animal to cubicle ratio, small sized cubicle, lack of bedding, dirty loafing areas and cubicles in most of the farm. Ensuring good animal welfare depends on the ability of the farmers to recognize discomfort and ailments facing the animals and taking remedial actions on the causes of discomfort or ailments. Improving the animal welfare situation in the farms studied will require the farmers to make critical decision concerning the stocking rates, management and structural changes.

The principles of fairness link human and animal relation as part of animal welfare. Vaarst and Alroe (2012) outlined the interfaces between naturalness and human care giving and how the two can be viewed to constitute the concept of animal health and welfare in organic animal farming. The interface of human care giving involve taking responsibility for the animals in the farms that they are not suffering and that they do not experience pain, distress, injuries, frustration, disease, hunger, or thirst. Farmer should interacting gently and with care with animals in daily life and create a framework which allows naturalness and makes it possible to observe the animals sufficiently without necessarily interfering. In organic livestock production farmers have an obligation to care for the needs of the animals to guarantee their health and welfare.

4.6. Conclusion

The management of cows in smallholder farming systems has an effect on their health and welfare status. Management in these systems are dependent on the way in which the different component of the system are organized and the availability of resources. Meeting the views of organic dairy production will require adjustments within the smallholder farming system and it is our view that this is achievable in some farms. However, the unique characteristics of each farm needs to be considered when assessing and developing strategies to improve animal health and welfare because smallholder farmers are not a homogenous group. Implementation of strategies developed may require additional resources.

Farmer have poor attitude towards issues related to animal welfare. There is need to address the perception and an attitude of the farmers has it affect their relation to the cows within the farms. Training farmers on organic principles is not only central to safeguarding the health and welfare of dairy cattle in these farms but also has the potential to affect the profitability of the dairy enterprises. Future research to integrate organic dairy production in smallholder farms should focus on addressing the challenges of diseases, pest and feed which are a major source of health and welfare concern in these systems.

CHAPTER 5

FEASIBILITY OF CONVERTING SMALLHOLDER DAIRY FARMS TO ORGANIC PRODUCTION

5.1. Abstract

Conversion of smallholder dairy farms in the Nairobi area to integrated organic livestock farming systems is viewed as one of the ways of meeting the growing demand for organic milk in Kiambu and Kajiado counties. In order to evaluate the feasibility of converting the smallholder dairy farms to organic production, the Organic Livestock Proximity Index (OLPI) was adapted to suit existing Kenyan production systems and used to evaluate a total of 24 smallholder dairy farms from Kiambu county (13 farms) and Kajiado county (11 farms). A total of 29 variables classified into 6 indicators were used to evaluate the proximity of each farm to organic production according to the IFOAM principles and standards. Information was obtained through direct observation and inquiry from the farmers. The mean percentages indicator values for all farms were: Nutritional management (53.1%), disease prevention (56.7%), breeding (75%), animal welfare (47.1%), conversion process (13.9%) and food safety and marketing (69.2%). Seven farms in Kiambu and three farms in Kajiado had an OLPI of less than 50%. The results show that all the dairy farms need to substantially improve nutritional management, disease prevention, animal welfare and their livestock conversion process. Capacity building on the basic requirements for organic dairy production is essential to ensure that interested farmers make the necessary adjustments to convert their enterprises.

5.2. Introduction

Farmers' motivations to convert to organic agriculture vary greatly between different areas. In Europe and North America, organic agriculture was initiated by farmers and consumers looking for alternatives to the growing chemical agriculture and subsequently implemented in and promoted by changes in government policies or support for farmers through subsidies (Michelsen, 2001). However, the advancement of organic agriculture in most of Africa has been without any formal government policy but as result of promotion by non-governmental organizations, private initiatives and foreign partners working with sustainable farming initiatives and organic value chains for export products to Europe or the USA (Agro Eco and Grolink, 2008; UNEP-UNCTAD, 2008). Growing consumer attention for organic food and farming in Africa has led to increased recognition and involvement from governmental entities in the organic movement. Currently, the process of policy development for organic farming in Kenya is ongoing (Kamaru, 2013).

Certified organic farming has grown rapidly in most of the African countries in the recent years. In Kenya, the area under certified organic production increased from 4,227 hectares to 4,969 between 2009 and 2011 (FiBL and IFOAM, 2013). A potential explanation for this growth is the widespread acceptance and awareness of organic production among producers and consumers in Nairobi and other major towns in Kenya. A recent study by Kenya Organic Agriculture Network (KOAN) showed that the level of awareness of organic food among consumers in Kenya was 55%, compared to 44% in 2006 (Ndungu, 2006; Ndungu, 2013). It is expected that the increased level of awareness will translate into more consumption for organic products in the country (Ndungu, 2013).

Most of the organic products supplied in various markets in Kenya are produced by smallholder farmers who integrate crop and livestock within the same farms (Kimemia and Oyare, 2006), which means that they have a certified organic crop production and a non-certified livestock production. However, the growing demand for organic milk in Nairobi points to the need for organic dairy producers to meet this demand. Since smallholder farmers dominate milk supply to major urban centres including Nairobi, conversion of smallholder dairy farms to organic dairy production is seen as one of the ways of meeting this demand.

Conversion to certified organic dairy production potentially involves changes to farm structure, management and finance. These changes must be effected using permitted materials and practices, with reference to the standards and with monitoring from the certification body over a given period of time. During the conversion process each farm unit requires careful assessment of the resources available and the interaction between components of the systems. In order for the organic producers to maintain the credibility and trust they must continuously optimize their production in line with the organic principles (Alroe and Halberg, 2008) and the farms must be regularly evaluated by a certifying body.

The objective of this study was to gain insight on the ability and potentials of smallholder farmers to convert their dairy cows to organic milk production. To achieve this objective, important issues connected to conversion were explored.

5.3. Materials and Methods

5.3.1. Sampling and obtaining data

Information was obtained through direct observations of the farms and a questionnaire applied to producers using the semi-structured informal interview technique (Gillham, 2005). All the information was obtained between August, 2011 and April 2012. A total of 24 farms from Kiambu County (13 farms) and Kajiado County (11 farms) were sampled.

5.3.2. Conversion Proximity Variable Identification

Based on the requirements for certification (EnCert, 2009), principles of organic farming (IFOAM, 2014) and East Africa Organic Product Standards (EAOPS, 2007), indicators and variables essential for conversion were identified. The variables were then used to design a methodological criterion which was used to approximate conversion of dairy production units to organic. To achieve the set objective, the Organic Livestock Proximity Index (OLPI) methodology (OLPI, applied to dairy goats), proposed by Mena *et al.* (2011) was modified. The modification involved reducing the number of indicators from 10 to 6. The indicators not included in the OLPI were not relevant to smallholder production systems. These comprised of sustainable pasture management, soil fertility and contamination, weed control and pest control. The variable included in the indicators also considered the requirement for certification by EnCert. The criterion for the evaluation had 29 variables that were classified into 6 indicators (Table 5.1) in order to integrate organic livestock proximity index more suitable for the Kenya situation.

Table 5.1: Indicators, Weighted Coefficient and Variables used for calculating the Organic Livestock Proximity Index derived from the East Africa Organic Standards and EnCert Certification Requirements

Indicator	**Weighted factor**	**Variable included in each indicator**
1. Nutritional management	0.24	1.1. The farmers produces at least 60% of feed consumed by the animals from the farm, rented land or a nearby farm
		1.2. At least 60% of feed consumed by the animals is organic or from organic sources
		1.3. Animal have access to fresh fodder or preserved fodder through feeding or grazing
		1.4. The farmer does not use of synthetic growth promoters to stimulate production
2. Disease prevention and veterinary care	0.2	2.1. The farmer promptly treats animals in cases of sickness or injury
		2.2. The farmer quarantines animals, which are sick or newly introduced to the farm
		2.3. The farmer carries out natural disease treatment or use other alternative solution to treat diseases (herbalism or homeopathy)
		2.4. The farmer does not use antibiotics or other conventional veterinary treatments as preventive measures or only uses conventional veterinary treatment in life threatening situations
		2.5. The farmer does not use vaccines as a preventative measure (only obligatory vaccines are used)
3. Breeding and reproduction	0.09	3.1. Animal breeding is natural or through AI (no hormones are administered to synchronize heat, induce birth, etc.)
		3.2. Animals used are local breeds less susceptible to diseases
		3.3. Bulls used are not breed by embryo transfer techniques
		3.4. Animals should be able to give birth in a natural way
4. Animal welfare	0.23	4.1. Farmers allow calves to suckle (The farmer uses natural lactation) for 7 months

		4.2. Indoor area is at least $6m^2$ per animal
		4.3. Available space within the farm for regular outdoor run (outdoor area is at least 4.5 m^2 per animal)
		4.4. Animal have permanent access to open spaces or have regular outdoor access
		4.5. The farmer does not systematically tie up or isolate animals
		4.6. Animals have sufficient access to water, feed, ventilation, light and adequate temperature and humidity
		4.7. Animals have access to protection from direct sunlight, rain, mud and wind
		4.8. The farmer does not cut horns except for the points, castrate or carry out other mutilation without using approved procedures
5. Conversion process	0.1	5.1. The farmer has planned to convert to organic production for the last 1 year
		5.2. The farmer is already receiving advice and/or training by organic certifiers
		5.3. The farmer adequately records information on dairy cows
6. Food safety and marketing	0.14	6.1. Farmers follow recommendation of drug withholding period after treatment (Twice the legal withdrawal period or 48 hours if period not specified)
		6.2. Strict hygienic-sanitary control (of premises, equipment, and milking and milk management)
		6.3. The farmer sells his or her products to local industries for processing
		6.4. The farmer sells directly to the final consumer
		6.5. There exist a specific organic milk market with or without a premium price for the milk producer

5.3.3. Conversion proximity evaluation

The 29 variables which comprise the 6 OLPI indicators were coded as binomial or dummy variables (0, 1) in order to homogenize the different original units of measure and thus facilitate calculation of the value for each indicator. This procedure was used because organic regulations are based on well defined criteria or thresholds regarding use of permitted (1) and non-permitted (0) inputs and practices. The real value acquired by each indicator is the mathematical average of the values (or responses 0 or 1) of their own variables (Grimm and Wozniak, 1990). The values for the indicators are then standardized to a common or relative percentage scale (%). The optimum value (100%) of unweighted indicator is achieved when the responses of all its variables are positive (codified as 1). Calculation of the percentage value for each indicator (I_j) was obtained through the sum of the responses of its variables (0 or 1) multiplied by 100. The equation used was:

$$I_j = \frac{\sum_{i=1}^{m} v_i}{m}(100)$$

Where:

j = 1, 2, 3,.....,6 indicators

i = 1, 2, 3,…..,29 variables

v_i = variables for each indicator

The weighted coefficients were adjusted with regard to the management characteristics of smallholder farming systems in Kenya. The indicators were weighted based on the contribution of each indicator to the overall cost of dairy production, the importance of each indicator for practical organization of an organic farm and the complexity in eliminating or substituting use of inputs or practices during organic production. The weighted value of each indicator (PI_j) was obtained by multiplying the value of each indicator (I_j) by its specific weighted factor (PF_j). The equation used was:

$$PI_j = I_j (PF_j)$$

Organic Livestock Proximity Index (OLPI). Construction of the Organic Livestock Proximity Index was based on the multi-criteria focus for weighting and aggregation of information (Munda, 2004). The OLPI of each livestock farm was obtained through the sum of the pondered values for the six indicators (PI_j), using the following equation:

$$OLPI = \sum_{j=1}^{6} PI_j$$

5.3.4. Statistical analysis

The smallholder dairy farms were grouped based on the counties using the weighted OLPI as a classification variable. Later, the indicators of the different counties were analyzed using a single factor. The SPSS statistical program for Windows version 14.02 (SPSS Inc., ©1989-2005) was used to generate the descriptive statistics.

5.4. Results

All the farms scored highest in relation to animal breeding and reproduction with a score of 75% being reported for this indicator. The lowest indicator scores were reported for conversion process and management. Table 1 shows the mean percentage values for all the other indicators evaluated in the study.

Table 5.2: Mean indicator values (percentage of approximation of smallholder farms to organic) for farms in Kiambu and Kajiado counties

Indicators	Kiambu (N=13)	Kajiado (N=11)	Average (N=24)
Nutritional management	50.0 ± 0.00	56.8 ± 3.52	53.1 ± 1.72
Disease prevention	55.4 ± 2.43	58.2 ±1.82	56.7 ± 1.55
Breeding	75.0 ± 0.00	75.0 ±0.00	75.0 ± 0.00
Animal welfare	47.1 ± 3.21	48.9 ± 2.64	47.9 ± 2.08
Conversion process	10.3 ± 4.44	18.2 ±8.24	13.9 ± 4.45
Food safety and marketing	69.2 ± 2.88	69.1 ± 3.15	69.2 ± 2.08

In all farms calves were not allowed to suckle and weaning was done in most of the farms before the calves were 12 weeks. The practice of weaning before 12 weeks was only an exception 25% of the farms (2 in Kiambu and 4 in Kajiado). Cows did not have permanent access to open spaces for outdoor run and animals had no outdoor access on a regular basis on all the farms studied. The cow sheds in both regions were small and only 16% of the farms in Kiambu and 18% farms in Kajiado had indoor areas of at least $6m^2$ per animal. All the farms surveyed provided sufficient access to water, feed, ventilation and mutilation were not conducted without following approved procedures.

The percentage OLPI values ranged from 40.9% to 63.3% for both counties. The three farm with the highest OLPI in Kajiado scored 59.7%, 62.8% and 63.3%. A distinctive feature of these farms was that they had at least 60% of feed consumed by the animals coming from the farm, rented land or a nearby farms, had clean livestock facilities and two of the farms had space within the livestock unit that could be used for regular outdoor run for the cows. In Kiambu, the two farms that had the highest OLPI scores (56.8% and 59.7%) had clean livestock facilities and the farms also had strict hygienic-sanitary control (of equipment, and milking and milk management). On the farms that had low OLPI in both counties, farmers weaned their calves before 11 weeks, the indoor areas for the animals were less than $6m^2$ per animal, the farms had no space within the farm that could be used for regular outdoor run for the cows and had no organization for conversion progress and management.

All the feed given to the animal on all the farms surveyed in both Kiambu and Kajiado were not organic nor from organic sources. None of the farms in Kiambu county had at least 60% of feed consumed by the animals coming from the farm, rented land or a nearby farms while in Kajiado three farms reported to obtain at least 60% of their feed from the farm, rented land or nearby farms. However, in all the farms surveyed the cows had access to fresh fodder through feeding and no synthetic growth promoters were used in animal feeds.

The farmers relied on veterinary services from private practitioners in cases of disease or injury within the farms. Regular preventive treatment for parasites especially ticks was practiced in all the farms.

33% of the farmers indicated that they had plans to convert their dairy herds to organic farming. However, no farmer in any of the regions had taken required steps to enable the farms to start the conversion process or received any training on the conversion process or attended training on issues related to conversion to organic production. Only 8% of the farms had consistent production, health and breeding records on their dairy enterprises.

Table 5.3: Mean value*weight*100 and standard error for seven indicators in the OLPI in Kiambu and Kajiado

Indicators	**Kiambu (N=13)**	**Kajiado (N=11)**	**Maximum OLPI score**
Nutritional management	12.0 ± 0.00	13.6 ± 0.8)	24.00
Disease prevention	11.1 ± 0.49	11.6 ± 0.36	20.00
Breeding and reproduction	6.8 ± 0.00	6.8 ± 0.00	9.00
Animal welfare	10.8 ± 0.74	11.2 ± 0.60	23.00
Conversion process	1.0 ± 0.44	1.8 ± 0.82	10.00
Food safety and Marketing	9.7 ± 0.40	9.7 ± 0.44	14.00
OLPI	51.4 ± 1.56	54.8 ± 1.94	100.00

All the farms were free from notifiable diseases and none of the farms had milk analysis in the past one year for somatic cell scores. All the farmers also sold their milk directly to the final consumers. There was no significant difference in OLPI for both Kiambu and Kajiado. There was similarity in most of the mean values for various indicators for both Kiambu and Kajiado. Table 5.3 shows mean percentages for OLPI and for the seven indicators included in OLPI.

5.5. Discussion

5.5.1. Nutrition Management

The regulation requires that livestock be fed on organically produced feedstuffs from the farms or nearby organic farms with only a limited proportion of conventional feedstuff (maximum of 40%) allowed (EAOPS, 2007). However, it was difficult to obtain feed that can be considered to be organically certified. This was mainly because most of the feed stuff used in the farms were not produced within the farms or from nearby sources. Despite three farms in Kajiado reporting that they obtained their feed from the farms the sources were not necessarily organic because in some occasion they fed non-organic maize stalk to the dairy cows. Organic farmers relied mainly on fodder from within their farms, or from nearby farms, indicating that possibilities of such farms meeting the requirements for feeding. This was the main reason for the low index reported for nutrition management of 12.0 and 13.6 in Kiambu and Kajiado respectively.

In both regions, farmers employed a farm worker whose main responsibility was to take care of the dairy unit and source for the feed from various sources. As a result the sources of the feed used by the farms were varied with grass sourced from the road side or hedges of other farms being one of the major sources of feed. Sourcing feed from the road sides and hedges is not a sustainable strategy for converting farmers because road sides and hedges cannot be converted to organic. This implies that after conversion farmers have to rely on other sources of feed for their cows. Fresh fodder was preferred because it was readily available and was obtained for free by farm workers from the road side or bought at lower prices from the other farmers. On different occasions, farmers bought feed from traders who cut the feed from their farms or from hedges in their farms and sold on the roadside while others bought feed (mainly hay) from the agro-vets. Hay was mainly used to feed cows during the dry season, when other cheaper sources of animal feeds were not available. Dairy cows were fed on fresh fodder on most occasions except during the dry season when preserved fodder is used. During the drought period the farmers were generally constraints since these feed sources were not available and purchased fodder is relatively expensive. Fodder preservation was not a common practice among the dairy farmer and most of them lacked storage facilities for fodder within their farms.

The requirements for certification are that there should be no more than 2 dairy cows per hectare of land (EnCert, 2009). The land requirement is to enable the farms to meet the demands for feed production of the cows. Although 3 farms in Kajiado obtained animal feed resources from the farms or from nearby farms, none of the farms surveyed would qualify for organic certification due to the land requirement per dairy cow. However, in cases where farmers are able to source feed from certified suppliers of organic animal feed, the farmers would be required to have sufficient land to provide for regular outdoor runs and have structures that meet the needs of the cows.

Nutritional management in organic dairy production must meet the nutritional requirement of the cow at the various stages of development rather than maximum production (Hermansen, 2003). Adequate nutrition has a positive effect on animal health and is therefore very important in disease prevention. The focus of the farms desiring to convert their dairy enterprises to organic should be on developing strategies to ensure that they have reliable sources of quality feed for the cows. The farms surveyed do not have the capacity to produce sufficient quality feed for the cows on their farms. Conversion of these farms therefore depends on other sources of organic livestock feed. Developing dependable collaboration between dairy farms and other organic fodder producing farms is one of the options to ensure that converted farmers will have sufficient feeds for their dairy cows.

The most important strength related to potential conversion to organic production of the dairy farms with regard to nutrition management in both regions was none use of prohibited feed such as animal excrement and chemical additives to stimulate milk production. The use of feed additives to increase milk production in smallholder dairy production systems is rare mainly because such additives are expensive and there is limited information on their use.

5.5.2. Disease Prevention and Veterinary Care

There was unfavourable approximation on most farms in relation to disease management and veterinary care of 11.1 and 11.6 in Kiambu and Kajiado respectively. Farmers promptly treated their cows in cases of sicknesses or injuries. Most of the farms did not have a quarantine facility for animals that were sick. This was mainly because the herd sizes were less than three. However, this is a health risk to the farm during disease outbreaks. Antibiotics or veterinary treatment or vaccines for preventive measures was not used on all the farms.

Farmers' reliance on use of conventional medicine for treatment of animals' routine control of endo-parasites and ecto-parasites with conventional drugs was one of the major contributors to the unfavourable approximation. Restrictions on prophylactic parasite control have been identified as potential risks for heavy parasite burdens unless adequate husbandry and monitoring systems are put in place (Roderick and Hovi, 1999). Parasitic control can prove to be a great challenge in smallholder farming system where feed is sourced from other places and may have parasitic infestation. In this system grazing management practices which have been adopted by large scale farms to control both ecto-parasite and endo-parasites may not provide viable alternative for solution for parasite control especially in peri-urban areas where land is a scare resource. As such, alternatives to chemoprophylaxis methods of controlling parasites should be adopted.

Though the uses of pharmaceuticals is permitted under the supervision of a veterinarian to reduce suffering, save life or restore health, disease prevention and management in organic cattle husbandry should focus on adopting preventive measures within the farms. Preventive measures should be based on the following principles: choice of appropriate breeds or strains of animals, application of animal husbandry practices appropriate to the requirements of each species, use of good quality organic feed, together with regular exercise and access to pasture and/or open-air runs, ensuring an appropriate density of livestock and appropriate housing maintained in hygienic conditions.

5.5.3. Breeding

Animal breeding and reproduction in both counties had the highest proximity to organic regulations at 6.8 in both counties. This is mainly because all farms practice artificial insemination which is a permitted practice in organic livestock production. However, the use of artificial insemination on the farms does not imply that the farmers select animals suitable for organic production conditions for breeding. Breeding and selection of appropriate dairy breeds is a critical component of organic livestock production (Rozzi *et al*., 2007). This is because one of the strategies proposed for disease prevention in organic livestock production is that appropriate breeds or strains of animals should be selected. This implies that the overall genetic merit of the cows in organic production systems should be selected based on a wider ranges of qualities. These include for example milk yield, pest (parasite) and disease tolerance or resistance and mothering ability.

The use of local breeds that are less susceptible to diseases would reduce incidence of diseases on the farms. However, breeding practices among smallholder farmers favours the use of exotic dairy breeds, particularly Friesian, (Bebe *et al*., 2003) which is inconsistent with technical recommendations that favour the use of the smaller dairy cattle breeds. The use of larger breeds and or upgrading to high exotic grades is generally discouraged due to their high nutritional demands, low milk yield, adaptability and production efficiency under smallholder farming systems (Kahi *et al*., 2000; Wakhungu, 2000). In other countries like Switzerland, traditional breeds are selected for organic systems to develop the compatibility between genetics and the management systems (Bapst, 2001). Smallholder farmers are dependent on the breeding stock from large scale conventional farmers whose breeding objectives do not necessarily target the desired attributes for smallholder dairy farming systems. The use of artificial insemination with semen from Europe and USA with the objective of increasing milk production without regard to other important dairy attribute is still a common practice on many smallholder farms.

Currently, there are no breeding schemes or strategies in most sub-Saharan countries to breed cows that are more adapted to the local weather conditions and the common diseases faced by farmers in smallholder farming systems. As a result, conversion to the organic dairy production model may still be a challenge to smallholder farmers until alternative solutions addressing diseases and parasites are found.

5.5.4. Animal Welfare

The dairy farms in Kiambu and Kajiado had low aggregate score (10.8 in Kiambu and 11.2 in Kajiado) relating to animal welfare indicators on the farms. The organic standards in relation to animal welfare include providing conditions which ensure quality living in regard to nutrition and water access, housing facilities, physical, physiological comfort, safety, expression of main forms of behaviour, social contacts with animals of the same species, absence of unpleasant emotional and physical experiences such as pain, suffering, fear, stress, disease and injuries (EAOPS, 2007; IFOAM, 2014). The aim of maintaining good animal welfare condition for the dairy cows is to offer optimal conditions for developing their reproductive and productive functions and satisfying their biological needs (von Borell and Sorensen, 2004). There was no cow-calf contact in any farm, calves were not allowed to suckle and weaning was done on many farms before the calves were 7 months old. As such a change in practices with regard to calf rearing is required.

The dairy unit structures on most farms were buildings within the family compound, which in many cases also had crop enterprises. Most of the available land was however allocated to crop enterprise. The current farm organization does not allow much room for expansion. The fact that most dairy cows' housing structures were smaller than the recommended $6m^2$ is a clear indication that the welfare needs of the cows are not met and will require major changes in farm structures. Stocking density is an important factor in organic dairy systems, with a direct link to welfare problems, specific diseases like lameness and herd performance. Similarly, it is not possible to allocate more space for regular outdoor run for the animal unless farm organization is changed.

Though there are a number of farms that have large pieces of land which may be allocated to meet these specific welfare needs (more indoor space and space for outdoor run). The current construction of most farms does not allow for expansion that will immediately provide for more indoor and outdoor space for to meet the requirements of organic unless structure are changes and available areas allocated for crop production near the diary unit substituted for dairy production. This implies that conversion to organic will require considerable investments to achieve.

Previous studies in smallholder farming systems in Kenya have shown that some of the most common problems associated with animal welfare are lameness, mastitis and poor reproductive performances (Abuom 2006; Nguhiu-Mwangi *et al*., 2008; Odima *et al.*, 1994). To be able to convert the smallholder farms to organic production improvements in dairy cattle welfare may be achieved through reconstruction of animal structures to provide adequate indoor space, re-organization of the production systems to allocate more land for outdoor access and maintaining a clean environment for the dairy cows. Animal based parameters should also be used to identify animal response to the systems and adjust the system to accommodate the needs of the dairy cows.

5.5.5. Conversion Process and Marketing

Only 33% of the farmers had plans to convert their dairy production to organic in the last 1 year and were already receiving advice on the conversion processes from a local COSHEP. The conversion process is dependent on the farmers' decisions and actions in meeting the required standards set for converting to organic. The decision to convert to organic dairy production must be based on knowledge of the requirement and the steps necessary to achieve organic status. However, with all the farmers lacking necessary training on the conversion requirements and processes it would be difficult to achieve organic status for most farms in the near future. Since conversion has financial implications to the farmers and involved structural and management changes at the farm level farmers must evaluate their ability to meet these requirements and the potential benefits resulting from the decision to convert. Indicators regarding conversion process were lowest to the approximation to organic. Consistent efforts to ensure smallholder farmers who are interested in organic production receive relevant information related conversion to organic is essential. Interested farmers should also be provided with technical support and training to initiate organic certification of their farms including trainings on record keeping.

5.5.6. Food Safety and Marketing

The organic standard does not exempt producers from compliance with the general requirements of statutory regulations, such as food safety regulations. The adoption of organic is expected to have a positive implication on the food safety of dairy products. In many countries, the perception that organic products adhere to stringent food safety standards, hygiene and meet the animal welfare has been the major drivers of consumption of these products. All the farmers who reported disease treatment on their farms followed recommendation on the drug withdrawal period after treatments.

Though all the farms are free from notifiable diseases, the level adherent to hygienic-sanitary control of milking equipments and milking practices and milk management pose a great challenge to the health and safety of the milk. The lack of data on the quality of milk produced from the farm also is a source of risk to the health of the consumers. Considering that all the milk produced in these farms is sold directly to consumer, the potential risks of transmitting diseases are high. The existence of an organic market is a good motivation to encourage smallholder farmers to convert. However, to enhance the quality of dairy products incentives should be provided to farmers who adopt organic production. Some of the incentives could include fair and constant prices throughout the year for their products in order to stimulate producers to continue to increase their use of appropriate sustainable production and management techniques (von Borell and Sorensen, 2004)

5.5.7. Organic Livestock Proximity Index

The OLPI makes it possible to the proximity of individual farms to the organic production model in order to identify structural and functional (management) limits and potential to stimulating organic production (Nahed-Toral, 2013). Four of the farms evaluated in the two regions have an intermediate level of compliance with the organic regulations (above 60%). Farms in both regions still have considerable improvements to make to enable them to improve their proximity to organic production. The farms that show considerable compliance with organic regulations also need to make significant changes especially with regard to nutrition management, disease prevention and animal welfare. Despite the intermediate compliance with the organic principles, all the farms need to provide adequate indoor area and make room within the farm for regular outdoor run for the dairy cattle. Any farm that is not able to adjust their structures and create outdoor areas will never be able to comply with the organic regulation since animal welfare play a critical role in contributing to all the other aspect of the production system. A number of farms may be challenged from making these adjustments due to lack of land or financial resources.

5.6. Conclusion

The flexibility of the certification requirement makes it possible for a number of smallholder farms to convert to organic production if management practices within the farms and the structures in some farms are changed. However, it is important to note that each farm is unique and recommendation for conversion must be made based on individual farm assessment.

Conversion of smallholder farming systems to the organic model will require adequate production and supply of organically produced livestock feed, maintaining living conditions that promote animal health and welfare, management of manure so that it does not contribute to the contamination of crops, soil or water and optimises the recycling of nutrients, establishing preventive health care practices and ensuring food safety of all the dairy products from each farm.

CHAPTER 6

IN VITRO ANTHELMINTIC EFFECTS OF CRUDE AQUEOUS EXTRACTS OF *TEPHROSIA VOGELII, TEPHROSIA VILLOSA* AND *CARICA PAPAYA* LEAVES AND SEEDS

6.1. Abstract

Traditional medicinal / herbal plants can offer an alternative to the reliance on chemical anthelmintic drugs. This study evaluated the efficacy of crude aqueous extracts of *Tephrosia vogelii* Hook., *Tephrosia villosa* Pers., and *Carica papaya* Linn. leaves and *Carica papaya* Linn. seeds against gastrointestinal nematodes using *in vitro* egg hatch and larval development inhibition assays. Rectal faecal samples from sheep were subjected to parasitological examination for faecal egg counts (FEC) using the McMaster counting technique. 100g of dried and poultice aqueous leaf extract of *T. vogelii, T. villosa*, *C. papaya* leaves and seeds was blended into liquefaction in 200ml of distilled water then boiled at 90-100^{0}C for 1 hour and cooled. Levamisole and distilled water were used as positive and negative controls respectively in the bioassay. Egg hatch assay revealed more than 95.8% reduction in egg hatch at concentration of 500 mg/ml for dried and poultice paste of *T. vogelii* leaves and *C.papaya* seeds. Larval development inhibition assay results showed that both dried and poultice paste of *T. vogelii* leaves and *C.papaya* seeds extract yielded more than 98% inhibition at a concentrations of 500mg/ml. Based on the LD_{50} dried extract of *C. papaya* seeds was most potent extracts for the inhibition of both egg hatching (49.94mg/ml) and larval development (49.32mg/ml). Both poultice and dried extract for all the plants showed significant and dose dependent egg and larval development inhibition. These findings indicate that the evaluated plants have potential

anthelmintic effect and could provide viable alternatives for the control of gastrointestinal helminths in ruminants.

6.2. Introduction

Helminthosis adversely affects ruminants productivity and welfare in both organic and conventional systems (Silva *et al.*, 2011; Chartier and Paraud, 2012; da Silva *et al*., 2013). It is ranked the highest animal health constraint to the poor especially in tropical and sub-tropical countries (Perry *et al*., 2002). There are a number of approaches used to control helminths in livestock, including nutritional, immunological and biological interventions (Jackson and Miller, 2006). However, most farmers rely on chemical anthelmintic drugs. The cost and non-availability of synthetic anthelmintics to some farmers, emergence of drug resistance, environmental pollution and toxic chemical residues reported in foods derived from livestock are a major cause of concern for many consumers (Jackson and Coop, 2000; Kaplan, 2004; Saddiqi *et al*., 2010; Sutherland and Leathwick, 2011). Therefore, naturally occurring plants with anthelmintic properties could offer alternatives that can overcome some of these problems. This would be both sustainable and environmentally friendly.

Consumers demand more natural and higher quality foods (Casemiro and Trevizan, 2009). This is due to the growing demand for healthy foods for the people and awareness of impact of chemical residues on the environment. There is a worldwide debate about the development of sustainable food production systems, adapted to different farming conditions. Alternative concepts of agroecology and holistic agriculture, that advocate for the use of integrated management strategies, such as target selected treatment, herbal medicine, and the application of other parasite control alternatives, are undergoing resurgence because of their more sustainable appeal (Molento, 2009). Use of medicinal plants could offer possible alternatives that may be important for agroecological production systems, organic or biological – dynamical systems where the use of chemical drugs is limited (Peixoto *et al*., 2013).

Tephrosia vogelii Hook. is widely used across Africa as a fish poison, pesticide and for soil enrichment (Neuwinger, 2004; Mafongoya and Kuntashula, 2005; Sirrine *et al*., 2010; Kamanula et al., 2011). The methanolic leaf extracts have shown *in vitro* anthelminthic activity in goats (Kabera *et al.,* 2014). *Carica papaya.* Linn is popularly used as a dessert or processed into jam or wine, while the green fruits are cooked as vegetables (Samson, 1986; Nakasone and Paul, 1998). *Carica papaya* is among the thirteen plant species used as anthelmintics to combat worm infestation in livestock in Nigeria (Adedapo *et al*., 2002). Aqueous extracts of papaya seeds have shown anthelmintic activity against *Haemonchus contortus*, *Trichostrongylus spp*, *Strongyloides spp* and *Ostertagia spp* in Sheep (Ameen et al., 2010). Kermanshai et al., (2001) identified benzyl isothiocyanate has the predominant or sole anthelmintic agent in papaya seed extracts against *Caenorhabditis elegans*. Among these botanical species, *C. papaya*, (pawpaw) may be preferred as an ethnoveterinary remedy in this part of the tropics because of its adaptability, agro-ecological considerations and availability (Mundy and Murdiati, 1991) and its reported anthelmintic efficacy (Ameen *et al*., 2012).

There is, however, no scientific evidence for the anthelmintic effects of *Tephrosia villosa* Pers. The plants were selected and evaluated based on the indigenous knowledge information about their use by farmers against helminths. The plants are also distributed widely in Kenya and an assessment of their possible efficacies was considered to be of interest.

The study was conducted to evaluate the *in vitro* anthelmintic activity of aqueous extracts of *Tephrosia vogelii* Hook., *Tephrosia vellosa* Pers. and *Carica papaya* Linn. leaves and *Carica papaya* Linn. seeds to validate their use in ethnoveterinary medicine among some farmers in Kenya. These tests are based on the hypothesis that an anthelmintic activity observed *in vitro* would be indicative of a potential *in vivo* activity.

6.3. Materials and Methods

6.3.1. Collection of plant materials

Fresh leaves of *T. vogelii* and *C. papaya* were collected on May 2013 at the Kenya Agricultural Research Institute – National Research Laboratory (NARL) in Nairobi while fresh leaves of *T. villosa* were collected from the Kenya Agricultural Research Institute station in Kiboko. *Carica papaya* Linn. seeds were collected from ripe pawpaw fruits and washed with clean water to remove dirt. The plants were identified and authenticated in the Department of Botany at the National Museums of Kenya, Nairobi and voucher specimens of each species deposited at the University of Nairobi herbarium. The plant materials and seeds were divided into two samples for each plant species. The first samples were ground soon after collection to make a poultice paste of 100g which was blended into liquefaction in 200ml of distilled water then boiled at 90-100^{0}C for 1 hour and cooled. The second set of samples were dried in shade at ambient temperature for 14 days, ground and milled to powder by electrical blender. 100g of the powder was also blended into liquefaction in 200ml of distilled water boiled at 90-100^{0}C for 1 hour and then cooled. Both samples were then centrifuged at 1500 rpm for 5 minutes. The supernatant was filtered through sterile filter papers and stored at 4^0 C in dark tightly closed glass bottles until use. One milliliter of the filtrate contained 0.5 g (500 mg/ml) of the extract.

6.3.2. Preparation of serial dilutions of aqueous extracts

Serial dilutions of stock solution were performed to yield 10ml each of 500mg/ml, 250mg/ml, 125mg/ml and 62.5mg/ml concentrations of the extract.

6.3.3. Recovery and preparation of eggs

Faecal materials (pellets) were collected per rectum from sheep with natural acute/ sub-acute parasitic gastroenteritis due to mixed nematode species. The samples were placed into labeled specimen bottles and transported to the Laboratory at the Department of Veterinary Pathology, Microbiology and Parasitology, Faculty of Veterinary Medicine, University of Nairobi. All the samples collected were processed on the same day.

Faecal Samples were examined for helminths eggs using the modified McMaster technique described by Hansen and Perry (1994). Briefly, approximately 3 gm of faeces were placed in a beaker and 45ml of floatation fluid (saturated Sodium Chloride solution) added. The faeces were broken into pieces and mixed by stirring with a wooden spatula. The mixture was sieved using a tea strainer into another beaker and subsample taken from it using Pasteur pipette while stirring. A McMaster counting chamber was filled with the subsample and the number of eggs counted under a microscope at X40 magnification.

6.3.4. Egg hatch assay

The *in vitro* egg hatch assay method described by Coles et al. (1992) was adopted. A suspension of 20 μl was distributed in three 96 well-flat-bottomed microtiter plates containing approximately 100 fresh eggs per well and mixed with the same volume of plant extract having different concentrations (500mg/ml, 250mg/ml, 125mg/ml, 62.5mg/ml and 31.25mg/ml). Four other similar replicates of the plates were made to evaluate the effect of the plant extracts over a three day period. In the control plates, levamisole and distilled water was added to the egg suspension. Levamisole was used only at one dose level of 3.125mg/ml as a reference drug. The eggs were incubated in this mixture for 48 hours at 27^0C and 70% relative humidity. After 48 hours a drop of Lugol's iodine solution (Reidel de Hae) was added to stop the eggs from hatching. Hatched larvae (dead or alive) and unhatched eggs were then counted under dissecting microscope.

An inhibition percent (%) of egg hatching was calculated for each extract concentration using the following modified formula of Coles et al. (1992):

Inhibition (%) = $100 \times (1 - X_1)/X_2$

where X_1 is the number of eggs hatched in test extracts, and X_2 is the respective number in distilled water control.

6.3.5. Larval development and viability assay

The procedure used was a modification of the technique described by Hubert and Kerbouef (1992). Aliquots of 150 μl of a suspension with about 100 eggs per well and 20 μl of filtrate obtained by faecal washing during egg recovering were distributed to wells of a 96-well flat-bottomed microtiter plates. This suspension was supplemented with 30 μl of the nutritive medium described by Hubert and Kerboeuf (1984) and comprised of Earle's balanced salt solution (Sigma) plus yeast extract (Sigma) in saline solution (1g of yeast extract/90 ml of saline solution) at a ratio of 1:9 v/v. The plates were incubated at 27^0C and 70% relative humidity. After 48 h, 200 μl of the plant extracts at same concentrations as mentioned levamisole and distilled water (control) were added to respective plates. There were four replicates for each extract concentration and control. The plates were further incubated for 5 days (total of 7 days), further development was stopped by addition of one drop of Lugol`s iodine solution. All L1 and L3 larvae in each well were counted under a dissecting microscope. The percentage of development was calculated as the ratio: number of L3/total number of larvae. The percent mortality was calculated from an average of the four replicates.

6.3.6. Statistical analysis

The data from egg hatch assay/test and larval development assay/test were transformed by probit analysis against the logarithm of extract concentration using SPSS for Windows version 14.02 (SPSS Inc., ©1989-2005). The extract concentration required to inhibit 50% (LD_{50}) egg hatching and 50% (LC_{50}) larval development were calculated after correction for natural mortality by probit analysis. The comparisons of mean percentage of egg hatching and larval development inhibition at different concentrations with the control, was done by one way ANOVA. All statistical analyses were performed by SPSS for Windows version 14.02 (SPSS Inc., ©1989-2005). The post hoc statistical significance employed was the least square difference (LSD), the difference between the mean were considered significant at $P < 0.05$.

6.4. Results

6.4.1. Egg hatch assay

The result showed that the crude aqueous extracts of the experimental plants inhibited egg hatch of gastrointestinal nematodes at different concentrations as shown in Table 6.1. At concentrations of 500ml/ml, poultice paste of *C. papaya* seeds and *T. vogelii* leaves and dried leaves of *T. vogelii* and *C. papaya* seeds showed efficacies greater than 95%. The LC_{50} for egg hatch inhibition were highest for dried and poultice paste of *C. papaya* seeds as shown in Table 6.3. Both dried and poultice paste of *C. papaya* leaves showed the lowest egg hatch inhibition among the extracts. Very low effects were recorded for distilled water control group. Increasing the concentration of the extracts caused a dose dependent significant ($P < 0.05$) decrease in egg hatch for all the extracts tested.

Table 6.1: Percentage inhibition of egg hatching ± SD for the different plant extracts compared to levamisole positive control and the distilled water negative control

Concentration (mg/ml)	Percentage Inhibition of Egg hatching (%) ± SD					
	Poultice paste (Set 1)					
	C. papaya leaves	*C. papaya* seeds	*T. vogelii* leaves	*T. villosa* leaves	Levamisole – 3.125mg/ml	Distilled water
500	57.8 ± 3.30	99.5 ± 0.58	95.8 ± 1.71	93.2 ± 0.91	100.00 ± 0.00	1.3±2.03
250	28.0 ± 6.06	83.5 ± 1.29	68.3 ± 2.22	67.3 ± 2.99		
125	16.0 ± 4.97	72.3 ± 4.57	52.3 ± 4.19	55.5 ± 4.44		
62.5	6.2 ± 3.26	58.7 ± 5.03	36.7 ± 5.05	36.1 ± 5.54		
31.25	3.4 ± 2.19	37.8 ± 4.11	24.9 ± 4.12	21.3 ± 2.10		
	Dried (Set 2)					
500	59.5 ± 3.42	99.0 ± 0.82	95.8 ± 1.71	87.0 ± 3.16		
250	32.3 ± 2.99	82.5 ± 2.89	77.8 ± 2.36	60.3 ± 4.57		
125	19.8 ± 5.06	75.3 ± 3.78	66.3 ± 3.60	47.8 ± 2.99		
62.5	9.9 ± 2.47	62.1 ± 3.90	41.3 ± 3.90	28.4 ± 4.97		
31.25	6.9 ± 2.62	35.5 ± 4.79	29.7 ± 6.88	19.9 ± 4.29		

SD = Standard deviation

6.4.2. Larval development inhibition

The average efficacy of the decoctions to inhibit larval development is show in Table 6.2. The larval development inhibition of poultice and dried *C. papaya* and *T. Vogelii* were higher than 98% at concentration of 500mg/ml. There was no significance difference between poultice and dried *C. papaya* and *T. Vogelii* for larval development inhibition at 500mg/ml ($P > 0.05$). The minimum larval development inhibition was recorded for distilled water with a mortality rate of 1.3±4.03%. The LC_{50} for larval development are shown Table 6.3.

Both poultice paste extract and dried extracts showed a dose dependent activity against both egg inhibition and larvae development inhibition for gastrointestinal nematodes. However, the overall performance of the dried extracts was better than that of the poultice paste extracts of the same extract.

Table 6.2: Percentage larval inhibition ± SD for the different plant extracts compared to levamisole positive control and the distilled water negative control

Concentration (mg/ml)	**Percentage Larval Inhibition (%) ± SD**					
	Poultice paste (Set 1)					
	C. papaya leaves	*C. papaya* seeds	*T. vogelii* leaves	*T. villosa* leaves	Levamisole – 3.125mg/ml	Distilled water
500	63.0 ± 2.58	99.5 ± 0.58	99.0 ± 1.41	81.8 ± 2.99	100.00 ± 0.00	1.3±2.03
250	39.5 ± 4.04	78.8 ± 2.22	78.8 ± 2.50	52.8 ± 3.86		
125	23.3 ± 3.59	71.8 ± 2.50	69.3 ± 2.63	41.0 ± 3.65		
62.5	14.9 ± 4.87	54.6 ± 4.92	52.1 ± 4.34	33.4 ± 3.18		
31.25	5.1 ± 4.21	42.1 ± 3.11	35.6 ± 3.92	22.4 ± 2.99		
	Dried (Set 2)					
500	60.1 ± 2.08	98.8±0.50	98.3±0.96	86.8±4.35		
250	38.0 ± 4.97	84.0±3.16	77.5±4.20	59.0±3.16		
125	20.3 ± 3.78	78.5±1.83	68.5 ± 3.11	46.0 ± 2.45		
62.5	11.2 ± 2.99	59.8 ± 5.16	48.9 ± 3.55	28.1 ± 4.78		
31.25	9.3 ± 5.40	47.9 ± 5.23	40.5 ± 6.18	17.6 ± 6.10		

SD = Standard deviation

Table 6.3: LC_{50} and regression values for egg hatching and larval development of the plant extracts

Preparation method	Plant extract	LC_{50} on egg hatching	LCL-UCL on egg hatching	LC_{50} on Larval development	LCL-UCL on Larval development
Poultice paste (Set 1)	*C. papaya* seeds	49.94	22.90 - 76.25	49.32	10.68 - 87.87
	T. vogelii leaves	96.92	49.37 - 167.26	57.94	24.15 - 92.80
	T. villosa leaves	101.45	65.98 - 148.51	159.09	83.59 - 321.35
	C. papaya leaves	431.32	386.74 - 490.73	335.00	271.11 - 440.89
Dried (Set 2)	*C. papaya* seeds	48.81	20.11 - 76.60	38.36	12.98 - 62.36
	T. vogelii leaves	73.32	60.61 - 86.63	56.07	16.73 - 96.80
	T. villosa leaves	131.78	110.40 - 157.90	138.80	116.84 - 165.92
	C. papaya leaves	417.83	327.24 - 584.32	386.54	30.18 - 541.05

LCL – Lower Concentration Limit, **UCL** – Upper Concentration Limit

6.5. Discussion

This study demonstrated the existence of biologically active compounds with ovicidal and larvicidal effects in the plant extracts on gastrointestinal nematodes, even after heating for 1 hour. The lower activity of dried and poultice paste of *C. papaya* leaves on egg hatching and larval development may be attributed to lack of ovicidal or larvicidal action of the metabolites or the alteration of these compounds by heating. Marie-Magdeleine et al. (2009) suggested that heating could potentially denature bioactive molecules, thereby influencing the anthelmintic activity of aqueous extracts of *Cucurbita moschata*. The study also showed that both the poultice paste extracts and the dried extracts of the plants evaluated showed a dose dependent egg hatching and larval development inhibition at tested concentrations. The probable reasons for the observed minor differences between the poultice paste extracts and dried extracts could be due to similarity of the solubility and the bioactive active constituents. Extracts from *C. papaya* seeds and *T. vogelii* leaves showed dose-dependent inhibition at lower concentration compared to other extracts.

In vivo studies have showed the potency of crude aqueous extract of *C. papaya* seeds against helminths in Sheep (Hounzangbe-Adote *et al*., 2001Ameen *et al*., 2010) and Goats (Fajimi *et al.*, 2005) and poultry(Ameen, 2012). Incorporation of *C. papaya* leaves into goat feed resulted in increased feed intake and decrease egg per gram (EPG) in the feaces *in vivo* as well as *in vitro* (Daryatmo *et al*., 2010). Previous *in vitro* studies have showed anthelmintic effect of ethanolic extract of *C. papaya* seeds (Hounzangbe-Adote *et al*., 2005). Other studies on non ruminants have also indicated potential anthelmintic effects of *C. papaya* latex and seeds on helminths in mice, rats, pigs and poultry (Satrija *et al*., 1994; Satrija *et al*., 1995; Sapaat *et al*., 2012; Bi and

Goyal, 2012). The anthelmintic activities of *C. papaya* seeds extracts are associated with the presence of Benzyl isothiocyanate (Kermanshai *et al*., 2001). Toxicity studies show that *C. papaya* seeds and leaves are considered safe for livestock and human consumption due to their low contents of oxalate and alkaloids compared with other commonly consumed food products (Adeniyi *et al*., 2009; Halim *et al.*, 2011).

Crude aqueous extract of *T. vogelii* have shown significant activity against *Ascaridia galli* in indigenous chicken both *in-vitro* and *in-vivo* (Siamba *et al*., 2007). There is no scientific evidence of the *in vitro* or *in vivo* anthelmintic activity of *T.vogelii* or *T. villosa* extract in ruminants. However, anthelmintics effect of these plants could be attributed to the presence of alkaloids, tannins, rotenoids and flavonoids constituents of the leaves (Marston *et al*., 1984; Ekpendu *et al*., 1998; Madhusudhana *et al*., 2010; Ahmad and Khan, 2013). Larvicidal and ovicidal effects of plants with these compounds against gastrointestinal nematodes have been reported in previous studies (Lateef *et al*., 2003; Siamba *et al.*, 2007).

The extraction of plants in *in vitro* condition is not always comparable to those *in vivo* and as a result the outcome of the two assays can differ (Athanasiadou *et al.*, 2001). *In vitro* tests only provide means for rapid screening for potential anthelmintic activities of plant extracts. The results therefore remain indicative and have to be confirmed through *in vivo* studies with experimental nematode infections in target host species. The potential of the plant aqueous extracts in this study to inhibit egg hatch and larval development may provide an alternative low-cost method for helminths control, since the plants are available all-year round in Kenya.

6.6. Conclusion

Based on the result of this study, it can be concluded that *T. vogelii*, *T. villosa*, *C. papaya* leaves and seeds in form of crude aqueous extracts have anthelmintic activity in vitro against gastrointestinal nematodes of sheep. Based on the LC_{50}, the most potent decoction was that of *C. papaya* seeds for both egg inhibition and larval development inhibition. These studies suggest that these plant extracts could form an alternative to commercially available chemical anthelmintic drugs. In view of these findings, further research may be carried out for phytochemical screening and toxicity in order to exploit and verify the use of these plants as crude anthemintic agents. There is need to develop standardized methods for preparations for plants with good anthelmintic activity and formulate best alternative herbal preparation to replace or compliment the chemical anthelmintic drugs currently in use.

CHAPTER 7

GENERAL DISCUSSION AND CONCLUSION

7.1. Background to the research

Organic production in Kenya is dominated by smallholder farmers practicing mixed farming. To date, in Kenya only the crop enterprises are certified as organic all certified farms. Nevertheless, most of such farms have dairy cattle among other livestock to diversify and maximize returns from their limited land and capital, minimize production risk, and provide food security. Organic farming principles demand a holistic production management system on whole farm. However, challenges in integrating organic dairy production into crop farms have reduced benefits of organic production to farmers through failing to meet demand for organic dairy products especially in Nairobi (Kledal *et al*., 2009; Bett and Kiarie, 2013). The result is that emerging organic restaurants and markets offer uncertified "organic" livestock products.

Integration of organic dairy production in crop certified smallholder farms with dairy cattle is one of the ways of achieving a balanced ecosystem within the smallholder farming system and meeting the growing demand for organic dairy products in Nairobi. To effect this integration, its potentials challenges and prerequisites needed assessment and comprehension. Alternative strategies for smallholder farmers to enhance integration of dairy cattle in their farms need to be expressed within the scope of what is possible, among potential practices. Comprehension of the system will enable development of innovative strategies for integrated organic crop-livestock systems.

This thesis addressed four major scientific questions related to integration of dairy production in smallholder farms. They included:

1. What are the challenges that certified crop farmers face in integrating organic dairy production in their farms?
2. How does dairy cattle management, health and welfare in certified organic farms compare to the accepted standards of organic dairy production?
3. What are the possibilities for certified crop farms to fully integrate dairy cattle production into the organic system?
4. Are the plant extracts used by some farmers for the management and control of helminths an effective alternative to synthetic veterinary drugs?

Questions 1, 2, 3 and 4 were answered in chapters 3, 4, 5, and 6, respectively. In this section, therefore the research approach, the discussion of the major findings and their implication on integration of dairy production in smallholder farming systems are highlighted.

7.2. Research approach

The study was based on a participatory approach that involved a close interaction with stakeholders in the organic sector and adopted a strategy where the outcomes of one phase fed into the decision about the details and focus in the next phase. This allowed for a process where stakeholders contributed to decisions made at every stage of the study. Since organic livestock production was not widespread among the stakeholders, participatory research was selected to provide an opportunity for those involved in the research to learn as the research was being conducted. Before the study was conducted, information on certified organic producers was sought from KOAN and COSHEP. Stakeholder meetings were held to explain the objective of the project to the farmers and to ensure that they were involved in the process from the initiation phase. Documentation on the farmers contacts, crops produced, location and registration status were done prior to the field visits.

Next, an exploratory survey was conducted to identify the challenges, practices, conditions and issues of potential importance to dairy production on crop certified organic farms (chapter three). Direct interviews based on a pre-tested questionnaire (annex 1) were used to collect the information. Exploratory survey was effective in collecting the limited information available on organic livestock production systems in Kenya and provided the flexibility needed to explore areas of future research (Polonsky and Waller 2005; Cooper and Schindler 2006). Thus the goal to gain better understanding of production systems of certified farms and provide the background for the longitudinal study was met.

Based on the need to understand the production system in details, available resources and logistical considerations, a longitudinal study was conducted on twenty four farms selected from Kiambu and Kajiado counties (chapter four). The longitudinal study evaluated the management practices, as well as the animal health and welfare in the farms. Information obtained during the longitudinal studies was also used to evaluate the feasibility of converting the smallholder farms to organic production based on the multi-criteria methodology of the Organic Livestock Proximity Index (chapter five). The longitudinal study was designed to allow for the repeated observation of management practices in the farms. A laboratory study to evaluate the efficacy of crude aqueous plant extracts used by farmers against gastrointestinal nematodes was conducted to validate their use in ethno-veterinary medicine among some farmers in Kenya (chapter six).The use of multi-method research design provided qualitative and quantitative data from different sources which added rigour to the research.

7.3. Organic production system

An organic production system is can be defined as "*a holistic production management system, which promotes and enhances agro-ecosystem health, including bio-diversity, biological cycles and soil biological activity. It is based on minimal use of external inputs (off-farm), avoiding the use of synthetic drugs, fertilizers and pesticides and aims at optimizing the health and productivity of interdependent communities of soil life, plants, animals and people*"(EAOPS, 2007). The system is based on an understanding of the ecological processes that promote nutrient cycling, optimize plant and animal health, and increase resource efficiency in agricultural ecosystems. Farming systems that actively follow organic principles are considered organic, even if the agro-ecosystem or the farm is not formally certified as organic (Scialabba, 2007). This study mainly focused on the certified crop enterprises with dairy cattle in two counties in Kenya (Kiambu and Kajiado County).

'Organic production' on the farms studied was only viewed as linked to an enterprise, that is, crop production, and not a way of thinking and organizing the whole production system. The concepts of organic production are defined within the framework of the four principles for organic production: ecology, care, health, and fairness (IFOAM, 2014). These principles are expected to be used as a whole in management of organic farming systems. Based on the definition of organic production in the EAOPS, it is expected that practices within an organic farm should aim at optimizing the health and productivity of interdependent communities of soil life, plants, animals and people. This implies that within an organic production system both the soil, plants, animals and people must be viewed as interdependent communities. The principles of organic production should therefore be used in organizing the whole system and not only a part of the system. Based on this view, a farm with only one enterprise certified as organic cannot be considered organic, since the whole production system is not organic.

In all the farms, only the crop enterprises were certified organic despite the fact that most of the farms had dairy cattle and other livestock. This was because of integration of organic dairy production was a challenge. One of the main reasons identified by the farmers for keeping dairy cattle was to provide manure for the organic farms (chapter three). This was an indication that the dairy cows contributed to the crops within the farms, and that it was beneficial for the farmers to integrate cows into the farming system. Organic farms are built on an idea of closed cycles, which is often challenged by the fact that plant and animal products are exported from the farm to the food market. In this way the animals through manure, contributed to a nutrient balance through consumption of feed resources from outside the farm. On the contrary, as will be seen below, the management of dairy cows was not based on organic principles in many farms (chapter four). If the whole production system is to be considered organic then both the crop and dairy components on the same farm should be managed based on organic principles and guidelines. In the existing systems, they are regarded as entirely different components within the same farm; because one component applies the organic standards while the other (the livestock) does not. Certification of the farms only focussed on inspecting a single enterprise within the farm and hence did not require that crop and livestock within the same farm be managed based on the organic principles.

At the same time, the East African Organic Production Standards contain some paradoxes and compromises, to which some solutions need to be found. For example, the conditions for management of animals used as draught animals in organic crop production are set in a way so that crop land is in risk of being contaminated with acaricides. The plant products from these farms can still be sold as 'certified organic' even though the farming system is not entirely organic. As a result, most of the certified crop farmers may not find it necessary to consider changing management of livestock in their farms to meet the organic principles.

7.4. Integration of dairy cattle in certified crop farms

Integrated agricultural production systems are agricultural systems with multiple enterprises that interact in space and/or time and the interactions result in a synergistic resource transfer among enterprises (Hendrickson *et al*., 2008). In this respect, integration usually occurs when outputs (usually by-products) of one enterprise are used as inputs by another within the context of the farming system. When farming activities are treated as interdependent entities rather than being viewed as isolated enterprises synergies and complementarities among the enterprises can be realized. Mixed farming systems, in which crops and livestock are integrated on the same farm, are widespread in rain-fed agriculture in Sub-Saharan Africa (Lenne and Thomas, 2006). The farms in the study were all mixed farms with certified crop enterprises and dairy production. Most of the land owned by farmers in both counties was allocated to crop production (chapter four) and the land was mainly used to produce high value horticultural organic crop like tomatoes, kales, spinach, and cauliflower. Most of the feed requirements in Kiambu County were met through purchase of feed from other farms (74.1%) while in Kajiado, more of the feed was produced on farm (57.1%) (Chapter four). However, feed purchase became a common feature of farms in both regions during the dry season. Due to small land sizes in both regions it is not possible to meet the feed requirements of the dairy cows from the limited land resources. The farm land sizes were small, partly due to high population density, inter-generational inheritance of land (subdivision and fragmentation), and the rapid growth of the city of Nairobi into these areas (Mabiso *et al*., 2012). This poses a challenge to integration of organic dairy production in smallholder certified farms.

Hall et al, (2008) identified the inability to provide sufficient quantity and quality of feed to livestock on a consistent basis as the main constraint facing small scale farmers in smallholder mixed farming system, pastoral and agro-pastoral production systems in East Africa. Farmers in this study also identified feed as a major challenge to conversion and integration of organic dairy production (chapter three). Integration of organic dairy production in smallholder farms will have implications on the feeding regime and source of feed for the cows. Maintaining access to adequate quantity and quality of organic feed resource is crucial for organic dairy production in smallholder farms. Currently, smallholder farms do not have the capacity to produce all the feed required for dairy production. Feed for organic livestock must therefore be sourced from other organic farms to enable smallholders integrate organic dairy production. Integration of organic dairy production will therefore require a step wise approach that involves setting up systems that guarantee supply of quality organic feeds to converting farmers. One of the solutions to lack of organic feed could be to develop collaboration between organic farms, where one category of farmers produce organically certified feed for smallholder dairy farmers and such farms could also benefit from the smallholder farms by obtaining manure. Other strategies that could guarantee consistent feed supply throughout the year may include widening the feed resource base, increasing acreages of fodder for those with larger pieces of land and promoting feed conservation within the farms to ensure consistent supply of feeds. This may be possible only in a very few farms in the study area.

7.5. Dairy cattle management in smallholder farms

Smallholder farmers intensify dairy production by keeping exotic breeds in zero-grazing units to meet the increasing demands for dairy products and sustain livelihoods from limiting production resources like land, capital and labour (Bebe *et al*., 2008). Smallholder farmers prefer potentially high yielding genotypes (Bebe *et al.,* 2003) despite the policy recommendation for genotypes with reduced nutritional demand, adaptability and high production efficiency in smallholder production systems (Kahi *et al.,* 2000; Wakhungu, 2000). Integration of organic dairy production in smallholder farms will require changes in animal health management. These changes will mainly be characterized by a move to preventive management which will require that breeds with better resistance to diseases with higher incidences within the smallholder production systems. Integration of organic dairy production implies that routine practices like spraying against tick infestation and de-worming that are common in smallholder farming systems in this study will need to be avoided (chapter 4). The greatest challenge in avoiding the use of anthelmintics is that helminths are considered a major constraint to dairy farming among the smallholder dairy farms in Kenya (Gitau *et al*., 1994; Maingi and Njoroge, 2010). Consequently, farmers have resorted to use of plant extracts whose efficacy in controlling worms and ticks are unknown. A validation of study of the *in vitro* anthelmintic activity of aqueous extracts of *Tephrosia vogelii* Hook., *Tephrosia vellosa* Pers. and *Carica papaya* Linn. leaves and *Carica papaya* Linn. seeds which were documented to be used by some farmers showed that these plant extracts could form an alternative to commercially available chemical anthelmintics drugs (chapter six). However, further research is required in order to exploit and verify the use of these plants as crude anthelmintic agents and develop standardized methods for preparations for plants with good anthelmintic activity and formulate best alternative herbal preparation before they can be used to replace the chemical anthelmintic drugs currently in use. Development of alternative and sustainable solution to reduce such risk is required to ensure that losses resulting from pest and diseases are greatly reduced.

Disease prevention in organic livestock production is based on multifaceted approaches that require the farmers to have appropriate knowledge and skills on animal husbandry practices based on the principles. The organic principles recommend that disease management should be based on the choice of appropriate breeds or strains of animals; the application of animal-husbandry practices appropriate to each species, encouraging strong resistance to disease and the prevention of infections; the use of good quality organic feed, regular exercise, and access to pasture or runs in the open air and maintaining an appropriate density of livestock. Despite the fact that the use synthetic veterinary drugs or antibiotics are permitted if preventive and alternative practices are unlikely to be effective in curing sickness or healing an injury, improving the level of animal management and improving the immunity of the animals to disease, many problems can either be prevented or detected in the early stages of development and effectively treated with alternative remedies without the need to routinely use conventional medicines.

Dairy cattle management is smallholder farms should focus on ensuring that the health and welfare of the animals are sustained. This requires considerable management skills and stockmanship. In study of on welfare of dairy cattle in smallholder production systems in Nairobi and its environs, Aleri et al. (2012) reported that farmers and stockmen in smallholder farms had poor perception of animal welfare matters and poor attitudes towards animals. Smallholder farmers will require additional skills on good welfare practices and resources to ensure that animal health and welfare are not compromised. This is because the living condition of the dairy cows is entirely dependent on the decisions made by the farmers and the stockmen. For example, in all the farms studied only one provided bedding for the cows yet the flooring for the most of the units were made of concrete. The presence of comfortable bedding influences cow resting behaviour positively by encouraging them to lie frequently on it and hence reduce the long hours of standing, which subsequently minimizes the risk of lameness (Nguhiu-Mwangi *et al.*, 2008; Rutherford *et al.*, 2009), thus enhancing welfare of the cows.

The farm organization and animal structures within the farm have an impact on animal health and welfare. All the dairy cattle were zero-grazed (chapter four). Most of the structures were small with concrete flooring that did not have bedding and the stocking densities of dairy cows in some farms were high (chapter four). To meet the welfare needs of the dairy cows, the farmer must make changes in the animal structures or build new one to accommodate the natural behaviours of the cows since the restrictiveness of housing types and structures affects the cows' behavioural patterns (Kiellard *et al.*, 2009). The goals of organic principles are that dairy animals should be managed in a way that allows the expression of natural behaviour and according to their natural behavioural needs. The EAOPS permit, bringing fodder to the animal if it is a more sustainable way to use land resources than grazing. Under such conditions regular outdoor runs or possibilities for grazing must be provided for. However, the standard does not provide the details concerning amount of space required for regular outdoor run. The smallholder farms will have to make provisions for regular outdoor run even if zero-grazing will be used to manage the dairy cows. This may require additional land for dairy production if land is available or in cases where more land is already allocate to a crop enterprise then a trade-off between crop production and dairy production need to be made to provide space for regular outdoor run for dairy cattle. To be able to provide space for regular outdoor run farms with very small land sizes may find that conversion is too expensive (land wise) and probably without commensurate returns. Such farms need to make additional investment on more land to be able to comply with the organic dairy production requirement without which conversion in such farms would be impossible. Other factors requiring consideration in most farms include the provision of suitable structures and space for regular outdoor runs to ensure cow comfort.

7.6. Conversion of smallholder farms to organic production

Conversion to organic production is mainly defined through regulation and standards. It involves the application of organic to parcel and animal for a given period set by the certifying agency or organization. During the conversion process each farm unit requires careful assessment of the resources available and the interaction between components of the systems. The transformations during conversion are expected go beyond the technical level and concern farmers' conceptions, values and inscription in social networks (Lamine and Bellon, 2009). The main challenges, if the livestock was to be converted to comply with the organic standards, according to the farmers in both counties covered by the study include; lack of organic input to control pest and diseases, lack of organic feeds and lack of market for organic livestock products (chapter three). During the assessment of the farms to evaluate their proximity to organic production, similar challenges were also observed (chapter five). Therefore, all farms have to make major adjustments to be able to change the whole farm to organic. This implies that conversion of smallholder farms will require major changes on nutrition management, disease prevention, animal welfare management and marketing. To make these changes farmers need awareness of requirements and knowledge for organic principles and rules.

Lack of knowledge on organic dairy production practices was also identified as one of the challenges to conversion and integration of the dairy enterprises (chapter 3). Training is therefore essential because organic dairy production requires complex knowledge that encompasses different components and elements within the system and their interaction. Currently, extension services on organic production in both areas of the study was done by COSHEP and KOAN and mainly focused on crop production. The private and government extension services have not focused on organic production mainly because it is not a priority at the national level. There has also been low demand for such services since the extension policy in Kenya is demand-driven. Extension services fulfil an important role in providing a link between researchers and farmers and help to ensure the relevance of research undertaken and subsequent dissemination of results. There is need for researchers, government extension departments and organic organization to develop extension messages for certified farmers to provide them with information on organic dairy production and the basic requirement for certification of dairy enterprises. This will make it possible for the farmer to consider the changes proposed and make decision on whether to convert their enterprises or not.

7.7. Organic production standards

The organic standards provide the basic requirement for conversion of an agricultural enterprise to organic. In many cases, organic standards are developed to serve the interest of markets most of which are in developed countries where the products are exported.

The EAOPS does not provide the detailed requirements for key parameters that are essential for conversion. For example, the standard does not provide details on the specification for space requirements for organic livestock production and only require that animals have sufficient space for free movement, according to their natural behaviour. However, EnCert, the accredited certifying body for organic products in Kenya, that uses the EAOPS as a basis for certification, gives details on the requirement for conversion of livestock enterprises.

Based on the certification requirements, organic dairy farms are expected to have a maximum of two dairy cows per hectare, indoor areas of $6m^2$ per cow, outdoors areas (exercise area, excluding pasturage) of $4.5m^2$ per cow and feed 60% of dry matter from organic sources (EnCert, 2009). The average size of land in both counties in the study was less than 2 hectares. The same parcel of land was also used for crop production as well as other functions (chapter three and four). It is unlikely that smallholder farms will meet these requirements relating to expected number of dairy cows per hectare and provide the outdoor and indoor space requirements per animal. The organic standard allows animals to be fed on carried fresh fodder if it is a more sustainable way to use land resources than grazing. In situations where feed is carried to the animals, farmers may only need to provide additional $10m^2$ ($6m^2$ for indoor space and $4.5m^2$ for outdoor run) per animal. This additional space is achievable in most smallholder farms provided organic feed for the animal is available. This is because the trade-off between dairy and other activities within the farm that compete for the same land in small. This amount of space probably is still inadequate. The foundations for these details may be derived by certifiers from existing international certifying bodies and consequently require domestication if they are to receive widespread acceptance among smallholder producers.

The EAOPS recognizes that organic agriculture is dynamic and makes provision for revision to incorporate on new knowledge continuously being generated. A review of the standard may need to be done to incorporate some key characteristic of smallholder farming systems that are unlikely to change and make it possible for smallholder dairy farmers to convert to organic dairy production. Such adjustment in the certification requirements must not compromise the principles of organic production.

7.8. Conclusions and recommendations

This study showed that integration of dairy production in smallholder dairy farms provided manure for organic crop production, increased farm income from milk sales and enhance household food security. However, this study also pointed to the following challenges for smallholder farmers to converting their dairy cows to comply with organic standards, and making the integration of certified organic milk an attractive and promising business opportunity for smallholder farmers in Kenya:

- Certified organic feed is currently not available, and most smallholder farms cannot grow enough feed on their farms to provide the cows with home-grown feed. Most farmers relied on feed partly supplied from outside the farm, e.g. purchased feed from other farmers, and feeds sourced from roadsides, which are not organically certified;

- Available housing structures for dairy cattle in most smallholder farms are small and the dairy cattle are not provided with outdoor access to allow free movement for the animals;
- Farmer's lack organically accepted inputs for management of pest and diseases
- Smallholder farmers lack knowledge and skills on organic dairy production practices

The study recommends that;

- Strategies should be put in place to ensure sufficient (quality and quantity) supply of certified organic feed to the farmers integrating organic dairy production in their farms;
- Structural adjustments on the cow housing need to be made on the certified farms to provide for the welfare needs of the animal; certification needs on space and structures need review to enable relevance and domestication.
- More investment should be put in research to develop alternative management strategies or organically accepted inputs for management of pest and diseases which are a major challenge in smallholder farming systems and
- Agencies involved in promotion of organic production should provide training and extension services for farmers to address challenges in the organic value chain

References

Abuom T. O. (2006): Periparturient conditions in smallholder dairy cattle herds in Kikuyu division of Kiambu District, Kenya. Msc Thesis. University of Nairobi, Kenya

Adedapo A. A., Dina O. A., Saba A. B. and Oladipo O. D. (2002): Evaluation of *Telfaria occidentalis* and *Sorghum bicolour* extracts as potent haematinics in domestic rabbits. Nigeria Journal of Animal Production **29 (1):** 88-93

Adeniyi S. A., Orjiekwe C. L. and Ehiagbonare J. E. (2009): Determination of alkaloids and oxalates in some selected food samples in Nigeria. Africa Journal of Biotechnology **8:** 110-112

AFMA (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management). (2011): Production and commercialization of organic milk in Europe. Results of a survey held in August 2011. Retrieved November 27, 2013 from http://www.google.dk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCoQFjAA&url=http%3A%2F%2Fwww.lebensministerium.at%2Fdms%2Flmat%2Fland%2Fproduktion-maerkte%2Ftierische-produktion%2Fmilch%2FBiomilch%2F1111OrganicMilk.pdf&ei=pXBqUvegGMuZ0AXqvoH4Bg&usg=AFQjCNHVJa3NhCUliXndXA28ZHlbX368IA

Agro Eco B. V. and Grolink A. B. (2008): Organic exports—A way to a better life? Retrieved March 17, 2014 from http://www.grolink.se/epopa/Publications/Epopa-endbook.pdf

Ahmad S. and Khan M. (2013): Pharmacognostical and Preliminary Phytochemical Investigation on Stems of *Tephrosia Villosa* Pers. International Journal of Current Pharmaceutical Research **5 (2):** 131-134

Aleri J. W., Nguhiu-Mwangi J., Mogoa E. M. and Mulei C. M. (2012): Welfare of dairy cattle in the smallholder (zero-grazing) production systems in Nairobi and its environs. Livestock Research for Rural Development. Volume 24, Article #159. Retrieved November 5, 2014, from http://www.lrrd.org/lrrd24/9/aler24159.htm

Alroe H. F. and Halberg N. (2008): Development, growth and integrity in the Danish organic sector. A knowledge synthesis on the opportunities and barriers for a continued development and market-based growth in production, processing and sale of organic products. Retrieved April 02, 2014 from http://www.icrofs.org/pdf/synthesis_08.pdf

Altieri M. A. and Nicholls C. I. (2012): Agroecology Scaling Up for Food Sovereignty and Resiliency. Sustainable Agriculture Reviews, pp. 1-29

Ameen S. A., Adedeji O. S., Ojedapo L. O., Salihu T. and Fabusuyi C. O. (2010): Anthelmintic Potency of Pawpaw (*Carica papaya*) Seeds in West African Dwarf (WAD) Sheep. Global Veterinaria **5(1):** 30-34

Ameen S. A., Adedeji O. S., Ojedapo L. O., Salihu T. and Fakorede O. L. (2012): Anthelmintic efficacy of pawpaw (*Carica papaya*) seeds in commercial layers. African Journal of Biotechnology **11(1):** 126-130

Athanasiadou S., Kyriazakis I., Jackson F. and Coop R. L. (2001): Direct anthelmintic effects of condensed tannins towards different gastrointestinal nematodes of sheep: *in vitro* and *in vivo* studies. Veterinary Parasitology **99:** 205-219

Ayantunde A. A., Fernandez-Rivera S. and McCrabb G. (2005): Coping with feed scarcity in smallholder livestock systems in developing countries. Animal Sciences Group, Wageningen UR, Wageningen, The Netherlands, University of Reading, Reading, UK, ETH (Swiss Federal Institute of Technology), Zurich, Switzerland, and ILRI (International Livestock Research Institute), Nairobi, Kenya. pp 306

Baars T., Wagenaar J. P., Padel S. and Lockeretz W. (2004): The role of animals in farming systems: A historical perspective. In M. Vaarst, S. Roderick, V. Lund, and W. Lockeretz (Eds.), Animal health and welfare in organic agriculture (pp. 13–28). Wallingford, UK: CABI Publishing

Badgley C., Moghtader J., Quintero E., Zakem E., Chappell, M. J., Aviles-Vazquez, K., Samulon A. and Perfecto I. (2006): Organic agriculture and the global food supply. Renewable Agriculture and Food Systems **22:** 86–108.

Badgley C., Moghtader J., Quintero E., Zakem E., Chappell M. J., Aviles-Vazquez K., Samulon A. and Perfecto I. (2007): Organic agriculture and the global food supply. Renewable Agriculture and Food Systems **22:** 86–108

Bapst B. (2001): Swiss experiences on practical cattle breeding strategies for organic dairy herds. In breeding and feeding for animal health and welfare in organic livestock systems (ed. M Hovi and T Baars). In Proceedings of the Fourth NAHOWA Workshop, 24–27 March 2001, Wageningen, pp. 44-50

Bebe B. O. (2008): Assessing potential for producing dairy replacements under increasing intensification of smallholder dairy systems in the Kenya highlands. Livestock Research for Rural Development, **20:** 24. Retrieved January 11, 2014 from http://www.lrrd.org/lrrd20/2/bebe20024.htm

Bebe B. O., Udo H. M. J. and Thorpe W. (2002): Development of smallholder dairy systems in the Kenya highlands. Outlook on Agriculture **31(2):** 113-120

Bebe B. O., Udo H. M. J. and Thorpe W. (2008): Characteristics of feeding and breeding practices for intensification of smallholder dairy systems in the Kenya highlands. Livestock Research for Rural Development, **20:** 23. Retrieved April 02, 2014 from http://www.lrrd.org/lrrd20/2/bebe20023.htm

Bebe B. O., Udo H. M. J., Rowlands G. J. and Thorpe W. (2003): Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices. Livestock Production Science **82:** 117-127

Bett E. and Kiarii E. (2013): Analysis of Organic Product Consumption Trends among Urban Consumers in Nairobi, Kenya. Retrieved January 09, 2014 from http://ir-library.ku.ac.ke/handle/123456789/8252

Bett K. E. and Freyer B. (2007): Recognizing and Realizing the potential of Organic Agriculture in Kenya Wissenschaftstagung Okologischer Landbau, Universiät Hohenheim, Stuttgart, Deutschland, 20-23 March 2007. Retrieved April 02, 2014 from http://orgprints.org/9816/1/9816_Bett_Poster.pdf

Bi S. and Goyal P. K. (2012): Anthelmintic effect of Natural Plant (*Carica papaya*) extract against the gastrointestinal nematode, Ancylostoma caninum in Mice. ISCA Journal of Biological Sciences **1(1):** 2-6

Boivin X., Lensink J., Tallet C. and Veissier I. (2003): Stockmanship and farm animal welfare. Animal Welfare **12(4):** 479-492

Casemiro A. D. and Trevizan S. D. P. (2009): Organic Food: Challenges for the Public Domain of a Concept International [Workshop advances in cleaner production]. São Paulo; pp. 1 - 9. São Paulo –Brazil –May 20th-22nd –2009

CGIAR (Consultative Group on International Agricultural Research). (2008): Changing dairy marketing policy in Kenya: The impact of the smallholder dairy project. Science Council Brief. Number 28

Chagunda M. G. G., Msiska A. C. M., Wollny C. B. A., Tchale H. and Banda J. W. (2006): An analysis of smallholder farmers' willingness to adopt dairy performance recording in Malawi. Livestock Research for Rural Development. Volume **18:** 66. Retrieved December 13, 2014 from http://www.lrrd.org/lrrd18/5/chag18066.htm

Chander M., Subrahmanyeswari B., Mukherjee R. and Kumar S. (2011): Organic livestock production: An emerging opportunity with new challenges for producers in tropical countries. Revue Scientifique et Technique-OIE **30(3):** 969

Chartier C. and Paraud C. (2012): Coccidiosis due to Eimeria in sheep and goats: a review. Small Ruminant Research **103:** 84-92

Coles G. C., Bauer C., Borgsteede F. H., Geerts S., Klei T. R., Taylor M. A. And Waller P. J. (1992): World Association for the Advancement of Veterinary Parasitology (W.A.A.V.P.) methods for the detection of anthelmintic resistance in nematodes of veterinary importance. Veterinary Parasitology **44:** 35-44

Conford P. (2002): The Origins of the Organic Movement. Floris Books, Edinburgh.

Cooper D. R. and Schindler P. (2006): Business research methods. 9th edition. New York: McGraw-Hill Irvin

Cooper M. D., Arney D.R. and Phillips C. J. C. (2007): Two- or four-hour lying deprivation on the behaviour of lactating dairy cows. Journal of Dairy Science **90:** 1149-1158

da Silva J. B., Fagundes G. M., Soares J. P. G. and da Fonseca A. H. (2013): Parasitism level by helminths and weight gain of calves kept in organic and conventional grazing. Pesquisa Veterinaria Brasileira **33 (5):** 586-590

da Silva J. B., Soares J. P. G. and da Fonseca A. H. (2012): Gastrointestinal parasites occurrence in dairy cows kept in organic and conventional production system. Semina: Ciências Agrárias **33(6):** 2375-2382

Daryatmo J., Hartadi H., Orskov E. R., Adiwimarta K. and Nurcahyo W. (2010): *In Vitro* Screening of various forages for anthelmintics activity on *Haemonchus contortus* eggs. In Advances in Animal Biosciences. Food, Feed, Energy and Fibre from land – A vision for 2020. Procedure of the Brazilian Society of Animal Science and the Agricultural Research Forum, Belfast India

De Haan C., Steinfeld H. and Blackburn H. (1997): Livestock & the environment: Finding a balance (p. 115). Rome, Italy: European Commission Directorate-General for Development, Development Policy Sustainable Development and Natural Resources. Retrieved January 22, 2014 from http://gis.lrs.uoguelph.ca/agrienvarchives/bioenergy/download/livestock_env_fao.pdf

de Passille A. M. B. P., Marnet G., Lapierre H. and Rushen J. (2008): Effects of twice-daily nursing on milk ejection and milk yield during nursing and milking in dairy cows. Journal of Dairy Science **91:** 1416–1422

Delgado C. L., Rosegrant M. W., Steinfeld H., Ehui S. K. and Courbois C. (1999): Livestock to 2020: The next food revolution (Vol. 61). International Food Policy Research Institute.

Devendra C. (2001): Smallholder dairy production systems in developing countries: characteristics, potential and opportunities for improvement: A review. Asian Australian Journal of Animal Science **14**: 104–113

Diacono M. and Montemurro F. (2010): Long-term effects of organic amendments on soil fertility. A review. Agronomy for Sustainable Development, **30 (2):** 401-422

Duncan I. J. H. (1996): Animal welfare defined in terms of feelings. Acta. Agriculturae Scandinavica. Section A - Animal Science **27:** 29–35

EAOPS (2007) East Africa Organic Product Standards. EAS 456:2007

EC (European Commission). (1991): Council Regulation (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. Official Journal of the European Communities **L198:** 1-15

Ekpendu T. O. E., Obande O. D., Anyogo P. U. and Attah A. D. (1998): Nigerian ethnomedicine and medicinal plant flora, The Benue experience. Journal Pharmaceutical Research and Development **31:** 37-46

EnCert, (2009): EnCert Standards for Organic Livestock Production, EnCert Limited, Nairobi, Kenya

EPOPA. (2008): Organic Exports – A way to a better life? Export Promotion of Organic Products from Africa. Retrieved March 02, 2014 from www.grolink.se/epopa/Publications/epopa-experience.htm

EPZ (Export Processing Zone), (2005): Report on the Dairy Industry in Kenya. Retrieved February 19, 2014 from http://www.epzakenya.com/UserFiles/files/DairyReport.pdf

Fajimi A. K., Taiwo A. A., Oyedeji I. O., Adebowale E. A. and Ogundola F. I. (2005): Pawpaw Seeds as Therapeutic Agent for Parasitic Gastro-Intestinal Helminth of Goats. Asset Series A **5 (1):** 23-29

FAO (United Nations Food and Agriculture Organization). (1999): Codex Alimentarius Commission procedural manual (11th ed.). Rome, Italy

FAO (United Nations Food and Agriculture Organization). (2007): Assessment of the world food security situation**.** Food and Agriculture Organization. CFS: 2007/2. Rome.

FAOSTAT. (2014): Food and Agriculture Organization of the United Nation Statistical Year Book. Retrieved April 02, 2014 from http://faostat.fao.org/site/339/default.aspx

Farnworth C. and Hutchings J. (2009): Organic Agriculture and Women' Empowerment. International Federation for Organic Agriculture Movements (IFOAM), Germany, pp. 86. Retrieved October 28, 2013 from http://community.eldis.org/?233@@.59c4cb31!enclosure=.59c4cb32&ad=1

FiBL and IFOAM, 2013. The World of Organic Agriculture, 2013. Frick and Bonn. Pp 340

Flower F. C. and Weary D. M. (2003): The effects of early separation on the dairy cow and calf. Animal Welfare **12 (3):** 339-348

Frankena K., van Keulen K. A. S., Noordhuizen J. P., Noordhuizen-Stassen E. N., Gundelach J., de Jong D.J. and Saedt I. (1992): A cross-sectional study into prevalence and risk factors of digital haemorrhages in female dairy calves. Preventive Veterinary Medicine **14:**1-12

Fraser A. F. and Broom D. M. (1997): Farm animal behaviour and welfare (3rd ed) CAB International. Wallingford, UK

Gabriel D., Sait S. M., Kunin W. E. and Benton T. G. (2013): Food production vs. biodiversity: comparing organic and conventional agriculture. Journal of Applied Ecology **50 (2)**: 355 – 364

Geier B. (2007): IFOAM and the history of the International Organic Movement. In: Lockeretz, W. (Ed.) Organic farming: an international history. Wallingford: CABI. pp. 175-186

Gillham B. (2005): Research Interviewing: the range of techniques. McGraw Hill Education. Berkshire, England.

Gitau G. K., Aleri J. W., Mbuthia P. G and Mulei C. M. (2010): Causes of calf mortality in peri-urban area of Nairobi, Kenya. Tropical Animal Health and Production **42(8):** 1643-1647

Gitau G. K., McDermott J. J., Waltner-Toews D., Lissemore K. D., Osumo J. M. and Muriuki D. (1994): Factors influencing calf morbidity and mortality in smallholder dairy farms in Kiambu District of Kenya. Preventive Veterinary Medicine **21:** 167-177

Grimm J. W. and Wozniak, P. R. (1990): Basic social statistics and quantitative research methods. Western Kentucky University. Wadsworth publishing Co., Belmont, California.

Grondahl A. M., Skancke E. M., Mejdell C. M and Jansen J. H. (2000): Growth rate, health and welfare in a dairy herd with natural suckling until 6–8 weeks of age. Acta Veterinaria Scandinavic **49:** 16

Halberg N., Peramaiyan P. and Walaga C. (2009): Is organic farming an unjustified luxury in a world with too many hungry people? In: Willer, H. and Kilcher, L., The world of organic agriculture. Statistics and emerging trends 2009, FiBL and IFOAM, 95-100

Halberg N., Sulser T. B., Hogh-Jensen H., Rosegrant M. W. and Knudsen M. T. (2006): The impact of organic farming on food security in a regional and global perspective. In:

Halberg, N., Alrøe, H.F., Knudsen, M.T. and Kristensen, E.S. 2006. Global Development of Organic Agriculture. Challenges and Prospects. CABI Publishing, UK, 277-322

Halim S. Z., Abdullah N. R., Afzan A., Abdul R. B. A., Jantan I. and Ismail Z. (2011): Acute toxicity study of *Carica papaya* leaf extract in Sprague Dawley rats. Journal of Medicinal Plants Research **5:** 1867-1872

Hall A., Sulaiman R. V. and Bezkorowajnyj P. (2008): Reframing technical change: Livestock fodder scarcity revisited as innovation capacity scarcity – A conceptual Framework. System wide Livestock Programme. Retrieved June 10, 2014 from http://www.vslp.org/front_content.php

Hansen J. and Perry B. (1994): The Epidemiology, Diagnosis and Control of Helminth Parasites of Ruminants, A handbook, ILRAD, Nairobi, Kenya, pp 171. Retrieved July 14, 2014 from http://www.fao.org/Wairdocs/ILRI/x5492E/x5492E00.htm

Haynes R. P. (2008): Animal welfare: Competing Conceptions and Their Ethical Implications. Springer, ISBN 978-90-481-8787-4

Hendrickson J. R., Hanson J. D., Tanaka D. L. and Sassenrath G. (2008): Principles of integrated agricultural systems: Introduction to processes and definition. Renewable Agriculture and Food Systems **23(04)**: 265-271

Hermansen J. E. (2003): Organic livestock production systems and appropriate development in relation to public expectations. Livestock Production Science **80:** 3-15

Herrero M., Thornton P. K., Notenbaert A. M., Wood S., Msangi S., Freeman H. A., Bossio D., Dixon J., Peters M., van de Steeg J., Lynam J., Parthasarathy R. P., Macmillan S., Gerard B., McDermott J., Sere C., Rosegrant M. (2010): Smart investments in sustainable food production: revisiting mixed crop-livestock systems. Science **327**: 822-825

Hine R., Pretty J. and Twarog S. (2008): Organic Agriculture and Food Security in Africa. UNCTAD-UNEP report, UNCTAD/DITC/TED/2007/15, Unites Nations Publication, United Nations, New York and Geneva, 2008, pp. 61. Retrieved October 15, 2014 from http://unctad.org/en/Docs/ditcted200715_en.pdf

Hoglund J., Svensson C. and Hessle A. (2001): A field survey on the status of internal parasites in calves on organic dairy farms in southwestern Sweden. Veterinary Parasitology **99:** 113-128

Hounzangbe-Adote M. S., Paolini V., Fouraste I., Moutairon K. and Hoste H. (2005): *In vitro* effects of four tropical plants on three life-cycle stages of the parasitic nematode, *Haemonchus contortus*. Research in Veterinary Sciences **78 (2):** 155-160

Hounzangbe-Adote M. S., Zinsou F. E., Affognon K. J., Koutinhouin B., Adamou-N'Diaye M. and Moutairou K. (2001): Efficacite antiparasitaire de la poudre des graines de papaye (Carica papaya) sur les strongles gastro-intestinaux des moutons Djallonke au sud du Benin. Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux **54:** 225–229

Hovi M., Sundrum A. and Thamsborg S. M. (2003): Animal health and welfare in organic livestock production in Europe: current state and future challenges. Livestock Production Science **80:** 41-53

Hubert J. and Kerboeuf D. (1984): A new method for culture of larvae used in diagnosis of ruminant gastrointestinal strongylosis: comparison with faecal cultures. Canadian Journal of Comparative Medicine **48:** 63–71

Hubert J. and Kerboeuf D. (1992): A microlarval development assay for the detection of Anthelmintic resistance in sheep nematode. Veterinary Records **130:** 442-446

Hughner R. S., McDonagh P., Prothero A., Shultz II C. J. and Stanton J. (2007): Who are organic food consumers? A compilation and review of why people purchase organic food. Journal of Consumer Behaviour **6:** 94–110

ICPALD (IGAD Center for Pastoral Areas and Livestock Development). (2013): The Contribution of Livestock to the Kenyan Economy (ICPALD 4/CLE/8/2013). Retrieved April 12, 2014 from http://igad.int/attachments/714_The%20Contribution%20of%20Livestock%20to%20the%20Kenyan%20Economy.pdf

IFOAM. (2014): Principles of organic agriculture. International Federation of Organic Agriculture Movement. Retrieved May 02, 2014 from http://www.ifoam.org/sites/default/files/ifoam_poa.pdf

ILRI (International Livestock Research Institute). (2007): Markets that work: Making a living from livestock. Annual Report. Retrieved July 21, 2014 from https://cgspace.cgiar.org/bitstream/handle/10568/567/AnnualRep2007_Markets.pdf.pdf?sequence=1

Jackson F. and Coop R. L. (2000): The development of anthelmintic resistance in sheep nematodes. Parasitology **120:** S95–S107

Jackson F. and Miller J. (2006): Alternative approaches to control—Quo vadit? Veterinary Parasitology **139:** 371–384

Jayne T. S., Yamanob T., Weber M. T., Tschirley D., Benfica R., Chapoto A. and Zulu B. (2003): Smallholder income and land distribution in Africa: implications for poverty reduction strategies. Food Policy **28 (3):** 253–275

Kabera J., Tuyisenge R., Ugirinshuti V., Nyirabageni A. and Munyabuhoro S. (2014). Preliminary investigation on anthelmintic activity and phytochemical screening of leaf crude extracts of *Tithonia diversifolia* and *Tephrosia vogelii*. African Journal of Microbiology Research, 8(25): 2449-2457.

Kahi A. K., Thorpe W., Nitter G., Van Arendonk J. A. M. and Gall C. F. (2000): Economic evaluation of crossbreeding for dairy production in a pasture based production system in Kenya. Livestock Production Science **65(1):** 167-184

Kalibwani F. (2004): Africa IFOAM Strategic Plan Draft (II). Outcome of the African planning workshop held in Nairobi, Kenya.

Kamanula J., Sileshi G. W., Belmain S. R., Sola P., Mvumi B. M., Nyirenda G. K. C., Nyirenda S. P. and Stevenson P. C. (2011): Farmers' insect pest management practices and pesticidal plant use in the protection of stored maize and beans in Southern Africa. International Journal of Pest Management **57:** 41–49

Kamaru K. (2013): National Organic Agriculture Policy Development and Implementation in Kenya. Proceeding from East African Organic Conference, Dar Es Salaam on 2nd - 4th July 2013. Retrieved January 20, 2014 from http://www.ifoam.org/sites/default/files/oa_policy_in_kenya_draft_4_010713.pdf

Kaplan R. M. (2004): Drug resistance in nematodes of veterinary importance: a status report. Trends in Parasitology **20:** 477–481

KDB (Kenya Dairy Board). (2009): Kenya Diary Board. Milk consumption in Kenya. Retrieved April 02, 2013 from www.kdb.co.ke/readarticle.php?article_id=8

Kermanshai R., McCarry B. E., Rosenfeld J., Summers P. S., Weretilnyk E. A. and Sorger G. J (2001): Benzyl isothiocyanate is the chief or sole anthelmintic in papaya seed extracts. Phytochemistry 57: 427–435

Kiellard C., Ruud L. E., Zarella A. J. and Osteras O. (2009): Prevalence and risk factors for skin lesions on legs of dairy cattle housed in free stalls in Norway. American journal of Dairy Science **92:** 5487-5496

Kimemia C. and Oyare E. (2006): The status of Organic Agriculture, Production and Trade in Kenya. Report on the Initial background study of the national integrated assessment of organic agriculture sector – Kenya

KIPPRA (Kenya Institute for Public Policy Research and Analysis). 2013: Creating and enabling environment for stimulating investments for competitive and sustainable counties. Kenya Economic Report. Retrieved March 24, 2014 from http://www.kippra.org/downloads/Kenya%20Economic%20Report%202013.pdf

Kledal P. R., Oyiera H. F., Njoroge J. W. and Kiarii E. (2009): Organic Food and Farming in Kenya. In Willer, Helga and Lukas Kilcher (Eds.) (2009). The World of Organic Agriculture. Statistics and Emerging Trends 2009. FIBL-IFOAM Report. Retrieved June 08, 2014 from http://www.organic-world.net/fileadmin/documents/yearbook/2009/world-of-organic-agriculture-2009-small-2009-02-15.pdf

Lamine C. and Bellon S. (2009): Conversion to organic farming: a multidimensional research object at the crossroads of agricultural and social sciences. A review. Agronomy for Sustainable Development **29(1):** 97-112.

Lanyasunya T. P., Wang H. R., Abdulrazak S. A. and Mukisira E. A. (2006): Effect of Supplementation on Performance of Calves on Smallholder Dairy Farms in Bahati Division of Nakuru District, Kenya. Pakistan Journal of Nutrition **5(2):** 141-146

Lateef M., Iqbal Z., Khan M. N., Akhtar M. S. and Jabbar A. (2003): Anthelmintic activity of *Adhatoda vesica* roots. International Journal of Agriculture and Biology **5:** 86–90.

Lenne J. M. and Thomas D. (2005): Addressing poverty through crop–livestock integration: the contribution of past research to future challenges. In Rowlinson, P., Wachirapakorn, C., Pakdee, P., and Wanapat, M., eds, Integrating Livestock–Crop Systems to Meet the Challenges of Globalization , AHAT/BSAS International Conference, 14–18 November, Khon Kaen, Thailand, pp 13–26

Lenne J. M. and Thomas D. (2006): Integrating crop–livestock research and development in Sub-Saharan Africa: option, imperative or impossible? Outlook on Agriculture, **35(3):** 167-175

Lockeretz W. (1990): Major issues confronting sustainable agriculture. In: Sustainable Agriculture in temperate zones. (C. A. Francis, C. Butler Flora and L. D. King). John Wiley; New York, pp 423-438.

Lotthammer K. H. and Wittkowski G. (1994): Fruchtbarkeit und Gesundheit der Rinder. Ulmer Verlag, Stuttgart

Lukuyu B., Franzel S., Ongadi P. M. and Duncan A. J. (2011): Livestock feed resources: Current production and management practices in central and northern rift valley provinces of Kenya. Livestock Research for Rural Development **23:** 112. Retrieved April 20, 2014 from http://www.lrrd.org/lrrd23/5/luku23112.htm

Lund V. (2002): Ethics and animal welfare in organic animal husbandry (Vol. 137)

Lund V. (2006): Natural living-a precondition for animal welfare in organic farming. Livestock Science **100:** 71–83

Lund V. and Algers B. (2003): Research on animal health and welfare in organic farming: a literature review. Livestock Production Science **80**: 55–68

Lyons K. and Burch D. (2008): Socio-Economic Effects of Organic Agriculture in Africa. 16th IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008. Retrieved April 02, 2014 from http://orgprints.org/12071

Mabiso A., Pauw K. and Benin S. (2012): Agricultural Growth and Poverty Reduction in Kenya: Technical Analysis for the Agricultural Sectoral Development Strategy (ASDS)—Medium Term Investment Plan (MTIP). ReSAKSS Working Paper No. 35, International Food Policy Research Institute (IFPRI). Retrieved March 06, 2014 from http://www.resakss.org/sites/default/files/pdfs/agricultural-growth-and-poverty-reduction-in-kenya-50989.pdf

Madhusudhana J., Reddy R. N., Reddy B. A. K., Reddy M. V. B., Gunasekar D., Deville A. and Bodo B. (2010): Two new geranyl flavanones from *Tephrosia villosa*. Natural Product Research **24(8):** 743-749

Mafongoya P. L. and Kuntashula E. (2005): Participatory evaluation of Tephrosia species and provenances for soil fertility improvement and other uses using farmer criteria in eastern Zambia. Experimental Agriculture **41:** 69–80

Maingi N. and Njoroge G. K. (2010): Constraints on production, disease perceptions and ticks and helminths control practices on dairy cattle farms in Nyandarua District, Kenya. Livestock Research for Rural Development **22:** 138. Retrieved January 13, 2014 from http://www.lrrd.org/lrrd22/8/main22138.htm

Marie-Magdeleine C., Hoste H., Mahieu M., Varo H. and Archimede H. (2009): *In vitro* effects of *Cucurbita moschata* seed extracts on *Haemonchus contortus*. Veterinary Parasitology **161:** 99–105

Marley C. L., Weller R. F., Neale M., Main D. C. J., Roderick S. and Keatinge R. (2010): Aligning health and welfare principles and practice in organic dairy systems: a review. Animal **4:** 259-271

Marston A., Msonthi J. D. and Hostettmann K. (1984): On the reported molluscicidal activity from *Tephrosia vogelii* leaves. Phytochemistry 23: 1824–1825

Mburu L. M., Gitu K. W. and Wakhungu J. W. (2007) A cost-benefit analysis of smallholder dairy cattle enterprises in different agro-ecological zones in Kenya highlands. Livestock Research for Rural Development. Volume **19:** 95. Retrieved December 04, 2013 from http://www.lrrd.org/lrrd19/7/mbur19095.htm

Mena Y., Nahed J., Ruiz F.A., Sanchez-Muñoz B., Ruiz-Rojas J. and Castel J. M. (2011): Evaluating mountain goat dairy systems for conversion to the organic model, using a multicriteria method. Animal **6(4):** 693-703

Michelsen J. (2001): Recent development and political acceptance of organic farming in Europe. Sociologia ruralis **41(1):** 3-20.

MoLD (Ministry of Livestock Development). (2007): Housing in a Zero Grazing System. Retrieved April 10, 2013 from http://www.sdcp.or.ke/TRAINING_%20MATERIAL/manuals/Zero%20Grazing%20Housing.pdf

Molento M. B. (2009): Parasite control in the age of drug resistance and changing agricultural practices. Veterinary Parasitology **163(3):** 229-234

Mundy E. M. and Murdiati T. B. (1991): Traditional Veterinary Medicine for Small Ruminants in Java. Bogor, Indonesia

Murage A. W. and Ilatsia E. D. (2011): Factors that determine use of breeding services by smallholder dairy farmers in Central Kenya. Tropical Animal Health and Production **43(1):** 199-207

Muraguri G. R., McLeod A., McDermott J. J. and Taylor N. (2005): The incidence of calf morbidity and mortality due to vector-borne infections in smallholder dairy farms in Kwale District, Kenya. Veterinary Parasitology **130 (3):** 305-315

Muriuki H. G. (2011): Dairy Development in Kenya. Food and Agriculture Organization. Rome. Retrieved October 29, 2013 from http://www.fao.org/docrep/013/al745e/al745e00.pdf

Musalia L., Wangia S., Shivairo R., Okutu P. And Vugutsa V. (2007): Dairy production practices among smallholder dairy farmers in Butere/Mumias and Kakemega Districts in Western Kenya. Tropical Animal Health and Production **39:** 199-205

Nahed-Toral J., Sanchez-Munoz B., Mena Y., Ruiz-Rojas J., Aguilar-Jimenez R., Castel J. M., de Asis Ruiz F., Orantes-Zebadua M., Manzur-Cruz A., Cruz-Lopez and Delgadillo-Puga C. (2013): Feasibility of converting agrosilvopastoral systems of dairy cattle to the organic production model in southeastern Mexico. Journal of Cleaner Production **43:** 136-145

Nakasone H. Y. and Paul R. E. (1998): Papaya. In: Tropical fruits. CAB International, Wallingford. Oxon. UK. pp. 239-269

Nalubwama S, Vaarst M, Kabi F, Kiggundu M, Bagamba F, Odhong C, Mugisha A and Halberg N 2014: Challenges and prospects of integrating livestock into smallholder organic pineapple production in Uganda. Livestock Research for Rural Development. Volume **26:** 113. Retrieved November 6, 2014, from http://www.lrrd.org/lrrd26/6/nalu26113.htm

Nalubwama S. M., Mugisha A. and Vaarst M. (2011): Organic livestock production in Uganda: potentials, challenges and prospects. Tropical Animal Health Production 43 (4) 749-757

Ndugire N. (2010): Scaling up organic agriculture and enhancing its foreign market access: Lessons learned from Eastern Africa. ATPC, Work in Progress, No. 80, UN Economic Commission for Africa. Retrieved February 14, 2014 from http://www.uneca.org/sites/default/files/publications/80.pdf

Ndungu S. K. (2006): The Development of a Consumer awareness and Education Concept Based on A Consumer Survey of Attitudes and Preferences Towards Organic Foods and on the Review of Existing PR Materials in East Africa. Retrieved May 05, 2014 from http://www.ifoam.org/sites/default/files/page/files/ifoam_survey_report.pdf

Ndungu S. K. (2013): Consumer Survey of Attitudes and Preferences Towards Organic Products in East Africa. Retrieved May 55, 2014 from http://www.ifoam.org/sites/default/files/page/files/osea_ii_consumer_survey_final.pdf

Neuwinger H. D. (2004): Plants used for poison fishing in tropical Africa. Toxicology **44:** 417–430

Nguhiu-Mwangi J., Mbithi P. M. F., Wabacha J. K. and Mbuthia P. G. (2008): Factors associated with the occurence of claw disorders in dairy cows under smallholder production systems in urban and peri-urban areas of Nairobi, Kenya. Veterinarski Arhiv **78(4):** 345-355

Njarui D. M. G and Mureithi J. G. (2006): Enhancing maize and fodder production by use of legumes in semi-arid region of eastern Kenya. In: Mureithi J. G., Gachene C. K. K. and Wamuongo J. W. (eds) Enhancing agricultural productivity in East Africa. Development and up-scaling of green manure legume technologies in Kenya. pp. 203-234. ISBN 9966-879-71-4

Njarui D. M. G, Gatheru M., Wambua J. M., Nguluu S. N., Mwangi D. M. and Keya G. A. (2011): Feeding management for dairy cattle in smallholder farming systems of semi-arid tropical Kenya. Livestock Research for Rural Development **23:** 111. Retrieved Septermber 27, 2013 from http://www.lrrd.org/lrrd23/5/njar23111.htm

Northbourne L. (1940): Look to the Land, J. M. Dent, London.

Nyikal R. A. (2007a): Financing smallholder agricultural production in Kenya: an analysis of effective demand for credit. **8th African Crop Science Society Conference** to be held in El-Minia, Egypt, 27- 31 October 2007. African Crop Science Conference Proceedings Vol.8.pp.1261-1264. Retrieved May 23, 2014 from http://www.ruralfinance.org/fileadmin/templates/rflc/documents/Financing__smallholder__agricultural_pdf.pdf

Nyikal R. A. (2007b): Financing smallholder agricultural production in Kenya: production for the market as a gauge of effective demand for credit. African Association of Agricultural Economists (AAAE) in its series 2007 Second International Conference, August 20-22, 2007, Accra, Ghana. Conference Proceedings: 193-197

Odima P. A., McDermott J. J. and Mutiga E. R. (1994): Reproductive performance of dairy cows on smallholder dairy farms in Kiambu district, Kenya: Design, Methodology and Development Constraints. The Kenya Veterinarian **18(2):** 366

Onono J. O., Wieland B. and Rushton J. (2013): Productivity in different cattle production systems in Kenya. Tropical Animal Health and Production **45(2):** 423-430

Organic Denmark. (2012): Organic Market Memo. Retrieved November 10, 2013 from http://www.organicdenmark.dk/media/2093224/organic%20market%20memo%202012.pdf

Owen E., Kitalyi A., Jayasuriya N. and Smith T. (2005): Livestock and Wealth creation: Improving the husbandry of animals kept by resource poor people in developing countries. 1st Edition. Nottingham University press.

Paull J. (2006): The farm as organism: the foundational idea of organic agriculture. Journal of Bio-Dynamics Tasmania **80**: 14-18

Paull J. (2009): A Century of Synthetic Fertilizer: 1909-2009. Journal of Bio-Dynamics

Paull J. (2011): Attending the first organic agriculture course: Rudolf Steiner's agriculture course at Koberwitz, 1924. European Journal of Social Sciences **21(1):** 64-70

Peden D., Tadesse G. and Misra A. K. (2007): Water and livestock for human development. In: Molden, D., Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture, London: Earthscan, and Colombo: International Water Management Institute., 485-514. Retrieved December 16, 2013 from http://www.iwmi.cgiar.org/assessment/Water%20for%20Food%20Water%20for%20Life/Chapters/Chapter%2013%20Livestock.pdf

Peixoto E. C. T., de Andrade A., Valadares F., da Silva L. P. and da Silva R. M. G. (2013): Phytotherapy in the control of helminthiasis in animal production. African Journal of Agricultural Research **8(21):** 2421-2429

Perry B. D., Randolph T. F., McDermott J. J., Sones K. R. and Thornton P. K. (2002): Investing in Animal Health Research to Alleviate Poverty. ILRI (International Livestock Research Institute), Nairobi, Kenya, pp 148

Phillips C. J. C. and Morris I. D. (2000): The locomotion of dairy cows on concrete floors that are dry, wet or covered with a slurry of excreta. Journal of Dairy Science **83:** 1767-1772

Pimentel D. (1996): Green revolution agriculture and chemical hazards. Science of the Total Environment **188:** 86–98.

Pimentel D., Hepperli P., Hanson J., Douds D. and Seidel R. (2005): Environmental, energetic, and economic comparisons of organic and conventional farming systems. BioScience **55:** 573-582

Polonsky M. J. and Waller D. (2005): Designing and managing a research project: A business student's guide. Thousand Oaks USA. Sage Publications, Inc

Powell J. M., Pearson R. A. and Hiernaux P. H. (2004): Crop-livestock interactions in the West African drylands. Agronomy Journal **96:** 469-483

Radostitis O. M. (2001): Herd Health – Food Animal Production Medicine. 3rd edition. Philadelphia, PA: W. B. Saunders Co

Reed M. (2010): Rebels for the soil: The rise of the global organic food and farming movement. London, UK

Reinhardt V. and Reinhardt A. (1981): Natural sucking performance and age of weaning in zebu cattle (Bos indicus). Journal of Agricultural Science **96:** 309–312

Republic of Kenya. (2004): Strategies for Revitalizing Agriculture, 2004-2014. Ministry of Agriculture and Ministry of Livestock and Fisheries Development. Pp 124

ResearchMoz. (2013): Global Organic Food and Drink Market 2012-2016: Industry Analysis, Size, Share, Growth, Trends and Forecast Research Report

Roderick S. and Hovi M. (1999): Animal health and welfare in organic livestock systems: identification of constraints and priorities. A report to MAFF. Pp 65

Rozzi P., Miglior F. and Hands K. J. (2007): A total merit selection index for Ontario organic dairy farmers. Journal of Dairy Science **90:** 1584-1593

Rubaire-Akiiki C. M., Okello-Onen J., Musunga D., Kabagambe E. K., Vaarst M., Okello D., Opolot C., Bisagaya A., Okori C., Bisagati C., Ongyera S. and Mwayi M. T. (2006): Effect of agro-ecological zone and grazing system on incidence of East Coast Fever in calves in Mbale and Sironko Districts of Eastern Uganda. Preventive Veterinary Medicine **75(3):** 251-266

Rutherford K. M. D., Langford F. M., Jack M. C., Sherwood L., Lawrence A. B. and Haskell M. J. (2009): Lameness prevalence and risk factors in organic and non-organic dairy herds in the United Kingdom. The Veterinary Journal **180:** 95 -105

Saddiqi H. A, Iqbal Z., Khan M. N. and Muhammad G. (2010): Comparative resistance of sheep breeds to *Haemonchus contortus* in a natural pasture infestation. International Journal of Agriculture and Biology **12:** 739 -743

Sahota A. (2014): The global Market for organic food and drink. In Willer, Helga and Julia Lernoud (Eds.) (2014). The World of Organic Agriculture. Statistics and Emerging Trends 2009. FIBL-IFOAM Report. Retrieved July 13, 2013 from https://www.fibl.org/fileadmin/documents/shop/1636-organic-world-2014.pdf

Samson J. A. (1986): Tropical fruits (2nd Ed). Longman Scientific and Technical, New York. pp. 256-269

Sapaat A., Satrija F., Mahsol H. H. and Ahmad A. H. (2012): Anthelmintic activity of papaya seeds on *Hymenolepis diminuta* infections in rats. Tropical Biomedicine **29(4):** 508-512

Satrija F., Nansen P. and Murtini S. (1995): Anthelmintic activity of papaya latex against patent *Heligmosomoides polygyrus* infections in mice. Journal of Ethnopharmacology **48:** 161 – 164

Satrija F., Nansen P., Bjorn H., Murtini S. and He S. (1994): Effect of papaya latex against *Ascaris suum* in naturally infected pigs. Journal of Helminthology **68:** 343 – 346

Scialabba N. E. (2007): Organic Agriculture and Food Security. In: International conference on Organic agriculture and food security , 3-5 May, 2007, Food and Agriculture Organization of the United Nation, Italy. (OFS/2007/5). Retrieved January 29, 2014 from www.fao.org/organicag

Siamba D. N., Okitoi L. O., Watai M. K., Wachira A. M., Lukibisi F. B. and Mukisira E. A. (2007): Efficacy of *Tephrosia vogelli* and *Vernonia amygdalina* as anthelmintics against *Ascaridia galli* in indigenous chicken. Livestock Research for Rural Development 19**:** 176. Retrieved April 29, 2014 from http://www.lrrd.org/lrrd19/12/siam19176.htm

Silva J. B, Fagundes G. M. and Fonseca A. H. (2011): Dynamics of gastrointestinal parasitoses in goats kept in organic and conventional production systems in Brazil. Small Ruminant Research **98:** 35-38

Simm G., Villanueaseva B., Sinclair K. D. and Townsend S. (2004): Farm Animal Genetic Resources, Nottingham University Press, Nottingham.

Singh R. B. (2000): Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India. Agriculture Ecosystems and Environment **82:** 97–103

Sirrine D., Shennan C. and Sirrine J. R. (2010): Comparing agroforestry systems' ex ante adoption potential and ex post adoption: on-farm participatory research from southern Malawi. Agroforestry System **79:** 253–266

Solano J., Orihuela A., Galina C. S. And Aguirre V. (2007): A note on behavioral responses to brief cow–calf separation and reunion in cattle (*Bos indicus*). Journal of Veterinary Behaviour **2:** 10–14

Somers J. G. C. J., Frankena K., Noordhuizen-Stassen E. N. and Metz J. H. M. (2003): Prevalence of claw disorders in Dutch dairy cows exposed to several floor systems. Journal of Dairy Science **86:** 2082-2093

SPSS (Statistical Procedures for Social Sciences). 2005. SPSS version 14.02 for windows. IBM Corporation

Steinfeld H., Wassenaar T. and Jutzi S. (2006): Livestock production systems in developing countries: Status, drivers, trends. Revue scientifique et technique - Office international des épizooties **25(2):** 505-156

Sundrum A. (2001): Organic livestock farming: a critical review. Livestock Production Science **67:** 207–215

Sutherland I. A. and Leathwick D. M. (2011): Anthelmintic resistance in nematode parasites of cattle: a global issue? Trends in Parasitology **27:** 176–181

Taylor A. (2006): Overview of the current state of organic agriculture in Kenya, Uganda and the United Republic of Tanzania and the opportunities for regional harmonization. UNEP-UNCTAD Capacity Building Task Force on Trade, Environment and Development. Retrieved February 03, 2013 from http://www.unep.ch/etb/pdf/cbtfOA_study_text.pdf

Tebug S. F., Kasulo V., Chikagwa-Malunga S., Wiedemann S., Roberts D. J. and Chagunda M. G. G. (2012): Smallholder dairy production in Northern Malawi: production practices and constraints. Tropical Animal Health and Production **44 (1):** 55 – 62

Tittonell P., Vanlauwe B., Leffelaar P. A., Rowe E. C. and Giller K. E. (2005): Exploring Diversity in Soil Fertility Management of Smallholder Farms in Western Kenya I. Heterogeneity at Region and Farm Scale. Agriculture, Ecosystem and Environment **110**: 149-165

Tulachan M. P., Partap T. and Maki-Hokkonen J. (2000): Livestock in the mountains and highlands of Asia, Africa and South America: An overview of Research and Development Issues and Challenges, pp. 3-31 In: Tulachan P. M., Saleem M. A. A., Maki- Hokkonen J, Partap T. (Editors), Contribution of livestock to mountain livelihoods: Research and Development Issues, International Centre for Integrated Mountain Development (ICIMODD), Kathmandu, Nepal

UNEP- UNCTAD. (2008): Organic agriculture and food security in Africa. UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development. Retrieved May 11, 2013 from www.unctad.org/en/docs/ditcted200715_en.pdf

UNEP-UNCTAD and CBTF. (2010): Organic Agriculture: Opportunities for Promoting Trade, Protecting the Environment and Reducing Poverty – Case Studies from East Africa. Retrieved March 15, 2014 from http://www.unep.ch/etb/publications/Organic%20Agriculture/OA%20Synthesis%20v2.pdf

Vaarst M. (2010) Organic Farming as A Development Strategy: Who are Interested and Who are not? Journal of Sustainable Development **3 (1):** 38 – 50

Vaarst M. and Alroe H. F. (2012): Concepts of animal health and welfare in organic livestock systems. Journal of Agriculture and Environmental Ethics **25(3):** 333-347

Vaarst M. and Thamsborg S. M. (1994): Nematode infections in organic dairy cattle herds in Denmark. Proc. Baltic-Scandinavian Symposium on Parasitic Zoonoses and Ecology of Parasites, Vilnius, Lithuania, 7–8 September, 1994. In: Bulleting of Scandinavian Society of Parasitology **5:** 54–55

Vaarst M., Roderick S., Byarugaba D. K., Kobayashi S., Rubaire- Akiiki C. and Karreman H. J. (2006): Sustainable veterinary medical practices in organic farming: A global perspective. In: Halberg, N., Alrøe, H.F., Knudsen, M.T and Kristensen, E.S. (eds.), Global Development of Organic Agriculture, Challenges and Prospects, (CABI Publishing), 241-276

Vaarst M., Roderick S., Lund V. and Lockeretz W. (2004): Combining ethological thinking and epidemiological knowledge to enhance the naturalness of organic livestock systems. In BGS/AAB/ COR 2004 conference, BGS occasional symposium No. 37 (pp. 87–91), Organic Farming

Valerian J., Domonko E., Mwita S. and Shirima A. (2011): Assessment of the Willingness to Pay for Organic Products amongst Households in Morogo Municipal. Report to sustainable agriculture in Tanzania. Retrieved August 30, 2014 from http://kilimo.org/WordPress/wp-content/uploads/2012/01/Assessment-of-the-Willingness-to-Pay-for-Organic-Products-amongst-in-Morogoro-Households-in-Morogoro-Municipal.pdf

Van den Ban A. W. (1998): Support farmers' decision-making processes in agricultural extension. Journal of Extension Systems **14:** 55-57

Verhoog H., Lund V. and Alroe H. F (2004): Animal welfare, ethics and organic farming. Animal Health and Welfare in Organic Agriculture. In Vaarst M., Roderick S., Lund V. and Lockeretz W. ed. CABI Publishing, Wallingford, UK

Verhoog H., van Bueren E. T. L., Matze M. and Baars T. (2007): The value of 'naturalness' in organic agriculture. NJAS–Wageningen Journal of Life Sciences **54(4):** 333–345

Vogt G. (2007): The Origins of Organic Farming. In: Lockeretz, W. (Ed.) Organic farming: an international History.Wallingford: CABI. pp. 9-29

von Borell E. and Sorensen J. T. (2004): Organic livestock production in Europe: aims, rules and trends with special emphasis on animal health and welfare. Livestock Production Science **90:** 3- 9

Wagenaar J. P. and Langhout J. (2007): Practical implications of increasing 'natural living' through suckling systems in organic dairy calf rearing. Netherlands Journal of Agricultural Systems **54:** 375-386

Wagner K., Barth K., Palme R., Futschik A. and Waiblinger S. (2012): Integration into the dairy cow herd: Long-term effects of mother contact during the first twelve weeks of life. Applied Animal Behaviour Science **141 (3–4):** 117-129

Waiblinger S., Baumgartner J., Kiley-Worthington M. and Niebuhr K. (2004): Applied ethology: The basis for improved animal welfare in organic farming. In Vaarst M., Roderick S. Lund V. and Lockeretz W. (Eds.), Animal health and welfare in organic agriculture (pp. 117–161). CABI Publishing. Wallingford, UK

Waithaka M. M., Thornton P. K., Herrero M. and Shepherd K. D. (2006): Bio-economic evaluation of farmers' perceptions of viable farms in western Kenya. Agricultural Systems **90 (1):** 243-271

Wakhungu W. J. (2000): Dairy cattle breeding policy for Kenyan smallholders: an evaluation based on demographic stationary state productivity model. PhD Thesis, College of Agriculture and Veterinary Sciences, University of Nairobi, Kenya, pp. 164

Wambugu S., Kirimi L. and Opiyo J. (2011): Productivity Trends and Performance of Dairy Farming in Kenya. Tegemeo Institute of Agricultural Policy and Development. WPS 43/2011. Retrieved August 12, 2013 from http://www.tegemeo.org/documents/work/WP43-Productivity-Trends-and-Performance-of-Dairy-Farming-in-Kenya.pdf

Webster J. (1994): Animal welfare: A cool eye towards Eden (1st edition). Oxford: Wiley-Blackwell.

Wesonga F. D., Kitala P. M., Gathuma J. M., Njenga M. J. and Ngumi P. N. (2010): An assessment of tick-borne diseases constraints to livestock production in a smallholder livestock production system in Machakos District, Kenya. Livestock Research for Rural Development **22:** 111. Retrieved March 04, 2013 from http://www.lrrd.org/lrrd22/6/weso22111.htm

Willer H. and Kilcher L. (2009): The world of organic agriculture. Statistics and emerging trends 2009, (Eds.) IFOAM, Bonn, and FiBL, Frick, TC, Geneva. Retrieved April 02, 2014 from http://www.organic-world.net/fileadmin/documents/yearbook/2009/world-of-organic-agriculture-2009-small-2009-02-15.pdf

Willer H., Lernoud J. and Schlatter B. (2014): Current Satatistics on Organic Agrculture Worldwide: Organic Area, Producers and Market. In; FiBL and IFOAM (2014): The World of Organic Agriculture, Statistics and Emerging Trends. . Retrieved June 12, 2014 from https://www.fibl.org/fileadmin/documents/shop/1636-organic-world-2014.pdf

Willer H., Maren R. and Wynen E. (2009): The world of organic agriculture. Statistics and emerging trends 2009, (Eds.) IFOAM, Bonn, and FiBL, Frick, TC, Geneva. Retrieved May 15, 2013 from http://www.organic-world.net/fileadmin/documents/yearbook/2009/world-of-organic-agriculture-2009-small-2009-02-15.pdf

Zilberman D., Otte J., Roland-Holst D. and Pfeiffer D. (2011): Health and Animal Agriculture in Developing Countries (Vol. 36). Springer

Annexes

Annex 1: Exploratory Survey Questionnaire

QUESTIONNAIRE

Introduction

Certified organic farmers in Kenya face major challenges with regard to harmonization and successful integration of organic animal husbandry into the whole organic production system. However, the inclusion of livestock forms an integrated system with harmony between the land, the animals, and the people especially among the certified smallholder farmers who do not require external inputs for organic crop production. This survey aims at evaluating the challenges and opportunities of organic dairy production within the local context and evaluating the conditions, knowledge, attitudes and constraints to adoption of organic livestock production practices in certified organic farms.

The information generated during this survey will be used to develop sustainable strategies to enhance the integration of organic milk production in certified organic farms. This will enable livestock and crops to be produced within a coordinated framework to enhance farm productivity.

This survey is part of a PhD study and the result obtained during the study will be communicated back to the stakeholders at the end of the study. The study is part of the ProGroV project whose major objective is to increase agricultural productivity and development of agribusiness for economic growth, improved livelihoods and sustainable development in Africa.

A) IDENTIFICATION

Questionnaire number: ………………**Date:** …………. **Time of interview:** …………………

GPS of household: Lat……………Long…………………District: ………………………….........

Location: ……………………..….Sub-location: ………………….. Village: …………………….

Name/ Contact of farmer: ………………………………………………………………………

B) DEMOGRAPHIC AND HOUSEHOLD INFORMATION

No	**Questions**	**Coding categories**	**Skip to**
1	Gender	Female: ……………………………1 Male: ………………………………2	
2	Position in the household	Household head: …………………...1 Spouse: …………………………….2 Daughter: …………………………..3 Son:……………………………………4 Other……………………………….5 (Specify)	
3	Marital status	Single: ……………………………...1 Married: ……………………………2 Divorced: ……………………......3 Widow/widower: …………………..4 Other: ………………………………5	

		(Specify)	
4	Age	Age in years: ………………………..	
5	Level of education	None: ……………. ………………..1 Primary: ……………………………2 Secondary: …………………………3 Tertiary: ……………………………4 University: ……………………..….5	
6	What is your main source of income?	Farming: …………………………...1 Employed: ………………………....2 Business other than farming: ……...3	
7	Family Size	1-3person(s)………………………..1 4-6persons…………………………2 7 or more…………………………...3	
8	Age in years of family members	**Males** Less than 18 ………………………1 18-35………………………………2 36-50………………………………3 Over 50……………………………4	
		Females Less than 18 ………………………1 18-35………………………………2 36-50………………………………3	

		Over 50……………………………4	

C) ORGANIC CERTIFICATION

No	Questions	Coding categories	Skip to
9	Is your farm certified as Organic?	Yes: ………………………………..1 No: ……………………………….....2	
10	When was your farm inspected for the time?	Date: ………………………..............	
11	Were you certified as an individual organic producer or as a group?	Individual: …………………………1 Group: ……………………………...2	
12	If certified as a group, what is the name of your group?	Group Name: ………………………..	
13	What is the size of your farm that is certified organic?	Size of farm in acres: ……………….	
14	What changed in you farm after you were certified? **Record in detail** .... …………………………………………………………………………………….. …………………………………………………………………………………….. …………………………………………………………………………………….. ……………………………………………………………………………………..		

D) FARM CHARACTERISTICS

No.	Question	Coding category	Skip to
15	Location of the farm	Rural…………………….…………1 Peri-Urban……………………....2 Urban…………………………..….3	
16	Land ownership	Own: ……………………………1 Lease: …………………………..2 Other: …………………………...3 (Specify)	
17	Topography of the land	Flat………………………………1 Undulating………………………2 Steep……………….…………..3 Very steep………………………4	
18	Total Farm size (acres)	Number	
19	Total land proportion under crop production	a) Own land …………………... b) Rented land……………………	
20	Total land proportion under livestock production	…………………………….............	
21	Total grazing land	a) Not cleared……………………. b) Natural pastures………………. c) Improved pastures…………….	

22	Do you grow improved pastures?	Yes……………………………1 No…………………………..…2	
23	If Yes, What types and species, List in order of importance.	Grass (names ………………………………….. ………………………………….. ………………………………….. Legumes or forbs (names) …………………………………… …………………………………… ……………………………………	
24	Which multipurpose trees are included in your farming system?	Calliandra…………………..…..1 Gliricida…………………….…...2 Sesbania……………………..…..3 Mulberry………….……………..4 Albizia…………………………..5 Ficus(Mutuba)……….……..... ....6 Others…………………………...7 (Specify)	
25	How do you finance your farming activities?	Own capital: ……………………1 Finance institutions: ……………2 Relative: ……………...………3 Other: (Specify) ...………………4	

26	What is your main source of labour	Family: ………………………….1 Casuals: ………………………...2 Permanent staff: ………………..3	
27	Do you have any livestock on your farm?	Yes: …………………………….1 No: ……………………………..2	
28	For how many years have you practiced crop-livestock integration in your farm?	< 2years…………………………1 2-4 years………………………...2 5-7 years………………………...3 Others….…………………………4 (Specify)	
29	What are the main reasons for integration of crops and livestock in your farms? **Record in details** ……………………………………………………………………………………………. ……………………………………………………………………………………………. …………………………………………………………………………………………….. ……………………………………………………………………………………………..		
30	What problems/challenges do you experience (have you experienced) in livestock production?	Parasites and diseases: ....1 Lack of rain/ water: ....2 Lack of feeds: ....3 Low production: ....4 Lack of market for product: ....5 Labour scarcity: ....6 Lack of inputs: 7	

		Breeding failure..8 Lack of knowledge to improve management…..........9 Others (specify)………………...............................10	
31	How are you addressing the challenges above?		

Challenge/ Problem	**Solution (s)**

E) LIVESTOCK PRODUCTION, MANAGEMENT, PRICES

i) Livestock numbers and herd structure

32 Which species of livestock do you keep on your farm?

Species	**Numbers**				**Type**	**Reasons for keeping livestock**
	Local	**Cross-breed**	**Exotic**	**Total**	**Organic (O) or not organic (NO)**	**Sale (s), home consumption (H) or both (SH)**
Cattle						
Goat						
Sheep						
Pigs						
Chicken						
Turkey						
Rabbits						
Others						

33	What is the number of the different category of livestock on your farm?

Species	Number for each category	No. lost since January 2012
Cattle	Bulls .... Heifers.................... Milking cows......... Dry cows................ Calves..........................	
Goat	Boars................... Does.................... Kids.....................	
Sheep	Male .... Females............ Lambs................	
Pigs	Boars.............. Gilts................. Sows................ Piglets.............	
Chicken	Hens (i) Layers: .... (ii)Broilers: .... Cocks .... Pullets...................... Cockerels................	
Rabbits	Bucks.............................. Does............................... Young rabbits................	
Others......................		

34	What are the levels of production of the various livestock enterprises?

Livestock product	Production e.g. litre/day,	Amount sold	Unit price
Milk			
Beef			
Live cattle			
Goat meat			
Pork			
Eggs			
Whole chicken			
Mutton			
Other (…………….)			

35	Who owns the livestock on the farm? : ....

36	Gender roles in livestock production activities (tick where appropriate)		

Livestock production activity profile	**Gender**			
	Women	**Girls**	**Men**	**Boys**
Land preparation and fodder planting				
Collection of feeds/fodder				
Feeding animals				
Collection water for animals				
Watering animals				
Cleaning animal house/shed				
Milking, record keeping				
Marketing				
Spraying and washing animal				
Involvement in crop production				

37	How do you breed your animals?	Natural service....................................1 Artifical Insemination..........................2	
38	What is the cost of the breeding service?	...............................Shillings.	
39	How do you select a male for breeding purposes? **Record in details** ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ………………………………………………………………………………………		

iii) Feeds, feeding and housing			
40	What grazing system do you practice on your farm?	Free range: ....1 Herding: ....2 Confinement/Zero-grazing: ....3 Tethering..4 Others...5 (specify)	
41	Which type of feed do you give your animals?	Natural pastures: ....1 Improved pastures e.g. Napier grass: ..2 Pasture legumes: ....3 Specify: .... Crop residues ....4 Specify... Agro industrial by products.................5 Specify.. Commercial concentrates.....................6	
42	Do you conserve feed for your farm animals?	Yes..1 No...2	
43	If yes, which conserved feeds do you produce on your farm?	Hay bales..1 Standing hay.......................................2 Silage..3 Fodder banks.......................................4	

44	If no, why		
45	Where do you source your feed from? **Record in detail**		
46	What are the sources of water for your animals on your farm?	Spring water..1 Tap water...2 Dam..3 Bore hole...4 Others..5 (specify)	
47	How often do your animals access water for drinking?	Once a day..1 Twice a day...2 Others..3 (specify)	
48	Do you house your animals?	Yes..1 No...2	

49	If yes, where do you house them?	Temporary shelter...............................1 Permanent shed/house..........................2 Others..3 (specify)	
iv) Disease management			
50	How frequent do these diseases occur on your farm?		
	Infectious diseases	Every month ....1 Twice a year..2 Once a year..3 Others..4 (specify)	
	Parasites	Every month ....1 Twice a year..2 Once a year..3 Others..4 (specify)	
	Nutritional/metaboloc disorders	Every month ....1 Twice a year..2 Once a year..3 Others..4 (specify)	
	Genetic disorders	Every month 1	

		Twice a year..2 Once a year..3 Others..4 (specify)	
51	Which specific diseases/conditions have your livestock experienced in the last 1 year?	Mastitis...1 East coast fever...................................2 Swine fever..3 Newcastle disease................................4 Mange/skin infection............................5 Hoof/craw problems.............................6 Milk fever...7 Tick/fleas infestation...........................8 Others..9 (specify)	
52	How do you manage the diseases?		

Disease/condition	**Treatment/remedies used**

v) Record Keeping			
53	Do you keep records on your farm?	Yes…………………….………1 No………………….……….2	
54	If yes, which type of records do you keep?	Visitors book………………1 Farm diary…………………..2 Financial records……………3 Livestock inventory records...4 Production records………….5 Treatment records…………..6 Breeding records……………7 Others………………………..8 (specify)	
55	How do you use the records kept at the farm? **Record details**		
56	If no, why ? **Record details**		

F) EXPERIENCE WITH AND PERCEPTION ON INTEGRATING LIVESTOCK WITH CROP PRODUCTION

No.	Question	Coding categories	Skip to
57	How does livestock contribute to your crop production?	Manure for the crop………………….……...1 Crop wastes for animal feed…..…………..2 Others…………………….……………3 (specify)	
58	What challenges do you face in managing livestock at the same time managing organic crops on the farm? **Record details** ………………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………		
59	What measures do you have in place to ensure that the livestock rearing system does not affect organic crop production on your farm? **Record details** ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………		
60	Have you considered managing your livestock using organic practices? (based on organic principles)	Yes:……………...………...1 No: ………………..………2	
61	What challenges do you foresee in adopting organic	Lack of organic livestock	

	livestock production on your farm?	knowledge ……….……...1 Small land size………...….2 Livestock feeding……...….3 Diseases……..……….……4 Lack of training………..….5 Lack of market ………..….6 Others……..………….…...7 (specify)	

G) ORGANIC FARMING KNOWLEDGE

No	Question	Coding categories	Skip to
62	What is the source of your organic farming knowledge?	Fellow farmers..1 Government worker..................................2 NGO..3 TV programmes.......................................4 Radio programmes...................................5 Others...7 (specify)	
63	What were the reasons for converting to organic	Fetch better/ premium prices: ……….......1 Protect environment …………...….....2 Influence from neighbor…...…..…..….....3 Hobby……………..…………….…...4 Others…... ……………….……...…5 (specify)	

64	Which organic animal management practices are you familiar with?	Selecting appropriate type and species of livestock..1 Natural breeding.......................................2 Non- use of feed additives.........................3 Provision of organic feeds.........................4 Use non-synthetic remedies.......................5 Provision of proper housing and space......6 Proper waste management.........................7 Non-use of antibiotics and other conventional drugs....................................8 Record keeping...9 Others...10 (specify)	
65	What would you focus on to make your livestock production organic? **Record details**		
66	In what aspects can researchers work more closely with the farmers to improve		

	organic agriculture production? **Record details**	

Annex 2: Baseline Farm Characteristics

Farm(er): …………………………….................... **Contacts:** ……………………………… **Date:** ……………………………..

Number of livestock in the farm at the beginning of the longitudinal study

Category	**Number**	**Other livestock**	**Number**
Lactating			
Dry cows			
Calves			
Bulls			

Farm size and layout (sketch farm layout and map other farming activities)

Farm size: ……………………..Number of pieces: ……………………………………….

<u>Farm layout (sketch)</u>

List other farming activities and land allocation:

………
………
………

Farm structures (Document the structure used for the cattle**)**

Document the Dairy Unit (Pictures of unit as well as other structures are necessary**).**

	Lying area:
	Number of cubicles: ……………………
	Flooring of cubicles: ☐ concrete ☐ wood ☐ sand ☐ soil
	Calve rearing area:
	Calving area available? ☐ yes ☐ no
	Type of bedding: ☐ straw ☐ other: ....
	Sick pen:
	Sick pen available? ☐ yes ☐ no
	Type of bedding: ☐ straw ☐ other: ....
	Milking area:
	Milking available? ☐ yes ☐ no
	Measure and dimension of farm structures
	(see table below)
	Mutilations
	Horns? ☐ all horned ☐ all dehorned ☐ partly horned- Number horned: ………………
	Other mutations? (Document): ....
	Feeding/ watering places
	Number of feeding places: ……………………..
	Size of feeding trough ………………………….X……………………..**m**
	Number of watering places: ……………………..
	Size of watering trough ………………………….X……………………..**m**
	Document further observation on the feeding and watering places ....

Structure	**Length (m)**	**Width (m)**
Lying area		
Calve rearing area		
Sick pen		
Milking area		

Annex 3. Longitudinal study Questionnaire

DAIRY MANAGEMENT QUESTIONNARE

Farm: ………………………………………… **Date of visit:** ………………………

	Production		Milk quality						
Cow's ID	**Am**	**Pm**	**CMT(+/-)**	**Density**	**BCS**	**D. Heat**	**D. Treated**	**Treatment against**	**Observation on the animal**

Animal dynamics

		Entry		Exit	
Category	**No.**	**Births**	**Purchases**	**Deaths**	**Sales**
Calves					
Dry cows					
Lactating cows					
Bulls					

Comments/ additional notes

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

Structure Cleanliness

1	Current state of lying area:	☐ clean	☐ slightly dirty	☐ dirty	☐ none
2	Current state of calf lying area:	☐ clean	☐ slightly dirty	☐ dirty	☐ none
3	Current state of sick pen:	☐ clean	☐ slightly dirty	☐ dirty	☐ none
4	Current state of milking area:	☐ clean	☐ slightly dirty	☐ dirty	☐ none
5	Current state of feeding trough:	☐ clean	☐ slightly dirty	☐ dirty	☐ none
6	Current state of water trough:	☐ clean	☐ slightly dirty	☐ dirty	☐ none

Feed / concentrates on offer

Type	**Amount on offer**	**Source**	**Price (if bought)**	**Grazing/ Outdoor run**	**Remarks**

Milking management

	Washing of hands before milking: ☐ yes ☐ no
	Washing of equipment before milking ☐ yes ☐ no
	Does the farmer perform foremilking? ☐ yes ☐ no
	Washing of udder before milking? ☐ yes ☐ no
	Order of foremilking/ udder cleaning routine ☐ foremilking before cleaning ☐ cleaning before foremilking ☐ irregular ☐ just foremilking ☐ just cleaning ☐ nothing
	Post-dipping of teats after milking? ☐ no ☐ spray ☐cup .Detail what is used: ....
	Is post-dipping applied correctly? ☐ yes (at least 2/3 of the teat-length is covered) ☐ no
	Have you changed the milkers (since our last visit)? ☐ yes ☐ no Reason for changing milker…………………..

<u>Record details based on observation</u>

……
……
……
……......
....

Annex 4: Daily Milk and Farm Occurrences Record

Name of farmer: …………………………**Area:**……………………**Month:** ………………

Cows Name/ No: ……………………. **Date calved:** ………………………………………….

DAYS	AM	PM	TOTAL	Daily Concentrate	Total Sales/ day
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					

GENERAL HEALTH RECORD

DATE	SYMPTOMS	DIAGNOSIS	TREATMENT GIVEN	REMARKS

VACCINATIONS

DISEASE	DATE	DATE	DATE	DATE	DATE	DATE
FOOT AND MOUTH						
BRUCELLOSIS						
RINDERPEST						
ANTHRAX						
LUMPY SKIN DISEASE						
RIFT VALLEY FEVER						
MASTITIS						
……………………………						
……………………………						
TREATMENT (De-wormer)	**DATE**	**DATE**	**DATE**	**DATE**	**DATE**	**DATE**