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FARMER CHARACTERISTICS AND ADOPTION RATES OF KEY PRODUCTION TECHNOLOGIES IN DAIRY VALUE CHAIN IN BUNGOMA COUNTY, KENYA

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Abstract

The study investigated the adoption rates of technologies in dairy sector in Bungoma County.This study was anchored on Porter's Value Chain theory. The study adopted cross-sectional research design. Target population consisted of 13 Dairy Cooperative Societies with a total membership of 10,062 livestock farmers, eight (8) Livestock Officers from the eight (8) sub-counties, 13 managers of Dairy Cooperative Societies and other licensed milk vendors. The study used semi-structured questionnaires, key informant interview schedules, focus group discussion and observation schedules to collect primary data. A Pilot study was carried in Kimilili Sub-County and then sets of data analyzed using Cronbach alpha method which yielded an alpha value of 0.824. Validity of research instruments was tested using content, construct and face validity. The data obtained was analyzed using descriptive and inferential statistics. The study found out that the adoption rates of dairy technologies like Artificial Insemination (AI), internet and e-dairy, silage making techniques, daily milk yield recording devices, milk conductivity indicators, automatic temperature recording devices and lactometers, hay making techniques, bloodless castration and hot iron dehorning among farmers in Bungoma County was low. Among the factors that negatively affected their adoption included years of experience, gender, age, farm size, cost of veterinary services, and type of dairy breeds. The study recommended designing of policies and programs like farm advisory programs that will enhance dairy production, thus transforming dairy value chain for food security and sustainable development in Bungoma County. These findings will be vital to the Ministry of Agriculture and Livestock Development and other policy makers in enforcing measures for achieving food security in Bungoma County, Kenya and Africa as a whole.

Key words*:* Adoption Rates of Technologies, Dairy Sector, Transformation of the Dairy Value Chain, Food and Nutrition Security and Sustainable Development

1. INTRODUCTION

The U.S. dairy industry has experienced significant structural change during the last few decades. Statistics indicate that an average U.S. herd size per capita was 19 cows in 1970, rising to 120 in 2006 (MacDonald *et al*., 2007). Over that period, average milk produced per cow doubled and milk produced per farm increased twelvefold (MacDonald *et al*., 2007). Trends show that the larger, more efficient operations are continually increasing their share of the milk cow inventory and milk production, while numbers of smaller operations are declining. The very large operations with 2,000 or more cows doubled in number between 2000 and 2006 (MacDonald *et al*., 2007).

Current trends in the U. S. dairy industry show an increase in milk cows per farm and milk production per cow, though the total number of milk cows in the industry is declining. This increase in productivity is attributed to advancements and adoption of modern dairy technologies. Breeding technologies are one of the important components of this structural change (Khanal, 2010). The story in BungomaCounty is quite different. The county has more Zebu cattle (259,940) compared to the dairy animals (102,183) and this could explain why the milk productivity in the County is low, thus relying on the neighbouring counties like Trans-Nzoia, Uasin Gishu and Nandi for supply of milk. The county has milk deficit of 104,294,168 litres/year (see Appendix 1). These statistics point out the dire need of dairy transformation in Bungoma County through adoption of technologies in dairy sector, thus addressing food and nutrition security and sustainable development.

A study by Khanal (2010) on the adoption of breeding technologies in the U.S. dairy industry and their influences on farm profitabilityshowed that the adoption decision is affected by different farm and farmer attributes such as age, education, off-farm work, farm size, and specialization. The embryo transplants and/or sexed semen technology adoption decision was also influenced by the farmer's planning horizon.Both artificial insemination (AI) and embryo transplants and/or sexed semen (ETSS) technologies are found to have significant and positive influences on net returns over total and net returns over operating costs per hundredweight of milk produced. Results also suggest that a higher allocated cost is associated with ETSS adoption. Relatively younger, more highly educated farmers and larger and more specialized farms received higher net returns.

Johnson and Ruttan (1997) found breeding technologies as the most significant factor contributing to farm productivity in the livestock sector since the 1940s. Dairy was the first livestock sector to accept the concept of commercial breeding (Johnson and Ruttan, 1997). The dairy industry has experienced a substantial increase in milk produced per cow, mostly attributed to innovations in breeding and feeding systems (MacDonald *et al*., 2007).Modern dairy cows with higher production potential have been developed through genetic selection. This is consistent with the findings of Short (2004), who indicated a relatively large proportion of farms used genetic selection and breeding programs to improve herd quality.

According to Shook (2006), genetics has accounted for about 55% of gains in the yield traits and about one-third of the change in the time interval required to conception. Thiscan be accomplished through artificial insemination (AI), embryo transplants (ET), sexed semen and/or traditional breeding methods. Application of ET technologies results in an increase in the reproductive rate of females (Khanal, 2010).Arendonk and Bijma (2003) also illustrated that factors such as genetic scheme and genetic merit between available semen and embryos as well as the purchase price of semen and embryos determine a farmer's decision to inseminate a cow with semen from a progeny tested sire or to implant the embryo.This study focused on the adoption rates of technologies in dairy sector in Bungoma County. The question was, to what extent has technology been adopted in the dairy sector in Bungoma County?

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Artificial insemination has become one of the most important techniques for genetic improvement of farm animals. Literature has shown the significant impact of AI in dairy cattle (Barber, 1983; Hillers *et al*., 1982). Artificial insemination has made maximum use of superior sires, allowing a good economic return (Hillers *et al*., 1982).

Embryo Transplant is a technique by which embryos are collected from a donor female and are transferred to recipient females. Recipients do not have genetic influence on the embryo. Multiple eggs may be obtained from a cow via hormone administration, even with young heifer calves. These “superovulated,” generally more valuable donor cows are then inseminated and embryos are allowed to grow for 4-5 days prior to their being transferred to relatively less valuable recipient cows (Tyler and Ensminger, 2005). Application of ET results in an increase in the reproductive rate of females. An increase in such rate is an opportunity to reduce the number of dams that need to be selected for the next generation (Arendonk and Bijma, 2003).

Sexed semen technology comprises the separation of sperm into male/Y bearing and female/X bearing sperm cells and then artificially inseminating with the desired sexed-sorted semen. Sexed semen technology lets dairy producers increase the supply of replacement heifers, resulting in lower purchase cost of heifers. Using sexed semen, a calf of specific sex can be produced (De Vries, *et al*., 2008); however, slower sorting speed and lower conception rate (35 to 40% with sexed semen as compared with 55 to 60% for unsexed semen) are the main limitations (Weigel, 2004). Similarly, research has shown that use of sexed semen will lead to higher genetic merit of the new-born calf (Arendonk and Bijma, 2003).With the use of sexed semen and better utilization of genetic markers, cost of progeny testing and ET will be lower (De Vries et al., 2008). According to Weigel (2004), early adopters of this technology capture economic benefits because adopters will get an increased supply of (extra) replacement heifers and the chance to expand rapidly from within a closed herd.

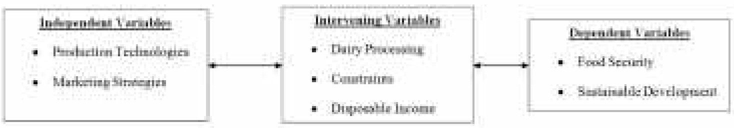
Herbst *et al*. (2009) studied the effects of sexed sorted semen on Southern dairy farms. The study showed that the use of sexed-sorted semen over unsorted semen made available the surplus replacement heifers to sell. The positive results of more heifer calves should compensate the higher cost of sexed-sorted semen to have application of this technology in farms (Herbst *et al*., 2009).

Adoption of breeding technologies such as AI, ET, and sexed semen has significant economic value in dairy performance (De Vries et al., 2008; Seidel 1984). Despite their influence on productivity, a number of factors cause the rate of adoption of these technologies to be different across dairy farms.Abdulai *et al.* (2008) examined the decision of dairy farmers to acquire information and adopt technology in the presence of uncertainty in Tanzania. They found that human capital and scale of operation were positive and significant in the adoption decision. Increases in education,age and herd size, and an expectation of higher profitability from the technology were found to have positive effects on adoption intensity.

Studies have also shown that inferior genetics, low quality feeds, and disease incidence are limiting factors for production per cow (Khanal, 2010). El-Osta and Morehart (2000) showed that the chance of a farmer being in the lowest quartile of production performance is lower with the adoption of capital or management intensive technology.

The current poverty index level standing at 53% and the cyclical shortage of milk supplies in the months of January, February and March is indicative enough that the transformation could not be far from the target. Therefore, the current study is designed to examine the extent of transformation of the dairy value chain in Bungoma County, Kenya, for food and nutrition security and sustainable development.

1.1 Theoretical framework



In this study production technologies and marketing strategies in the value chain are independent variables and it was hypothesised that these variables had positive and direct influence on food security and sustainable development (dependent variables) among dairy farmers in Bungoma County. The relationship between the independent variables (production technologies and marketing strategies) and food security and sustainable development, as dependent variables was intervened by variables like dairy processing, constraints and disposable income. Production technologies and marketing strategies can affect and be affected by dairy processing, constraints and disposable income. Similarly, dairy processing, constraints and disposable income can affect and be affected by food security and sustainable development. This portrays a cyclic relationship among these key study variables that happen in nature. The directions of the arrows show the interrelationships between the key variables of the study.

MATERIALS AND METHODS

The study adopted cross-sectional survey research design. Cross-sectional studies also known as cross-sectional analyses, transversal studies, prevalence study form a class of research methods that involve observation of all of a population, or a representative subset, at one specific point in time. Multi-stage random sampling was used to group the 10,062 farmers spread in the eight sub-counties, then followed by selecting a sample within each chosen cluster. Multi-stage random sampling involves selecting a sample in at least two stages. In the first stage, large groups or clusters are selected (Rahmantya, 2009).

The sample size of farmers in the fourteen (14) managers of Dairy Cooperative Societies was obtained using coefficient of variation. Nassiuma (2000) asserts that in most surveys or experiments, a coefficient of variation in the range of 21% to 30% and a standard error in the range of 2% to 5% is usually acceptable.

$$S = \frac{N(Cv)^2}{(Cv)^2 + (N-1)e^2}$$

Where S = the sample size
N = the population size
Cv = the Coefficient of Variation
e = standard error

Therefore, the sample size will be:

$$S\,(10{,}062) = \frac{10{,}062(0.21^2)}{0.21^2 + (10{,}0621)\,0.02^2} = 110.129 \qquad = 111 \text{ farmers}$$

Where S = 10,062 ; N = 111 Farmers

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Purposive sampling technique will be used to select the thirteen (13) managers of the Dairy Cooperative Societies and nine Agricultural Livestock Officers from the nine sub-counties. The milk vendors, transporters and consumers will be obtained through simple random sampling technique.

The table below is a summary of the sample frame for the study.

Table 2.1: Study Sample Frame

Study Population Unit	**Target Population**	**Sampling Method**	**Sample e**
Dairy Farmers	8,662	Multistage random	101
Cooperative Officers	48	Census	48
Credit & Saving encies	17	Census	17
Managers of the Dairy operative Societies	07	Purposive	07
Livestock Officers	09	Purposive	09
Milk Vendors	345	Simple random	84
Transporters	1302	Simple random	102
Consumers	1,499,400	Simple random	110

3. RESULTS AND DISCUSSION

3.1 Introduction

The aim of the chapter was to present the results on the determination of the adoption rates of technologies in dairy sector in Bungoma County. The study used a Statistical Package for Social Sciences (SPSS version 20) for entering the data and analyzed data by use of descriptive statistics like cross tabulation tables, the mean, standard deviation, frequencies and percentages.

3.2 Background Information of the Respondents

The first section of the questionnaire sought to establish the background information of the respondents. This included their gender, category of respondent, age and educational level. The results were as discussed below:

3.2.1 Gender of the Respondents

The respondents were asked to indicate their gender. The results were as shown in Table 4.2.From these results, 87.5% of the respondents were male while the remaining 12.5% were female. This illustrated that there was a highly significant ($p<0.000$) variation in the gender distribution among the respondents ($\chi^{2}_{1,0.0} = 8.385$).This implied that there were more male respondents as compared to the female who participated in this study.

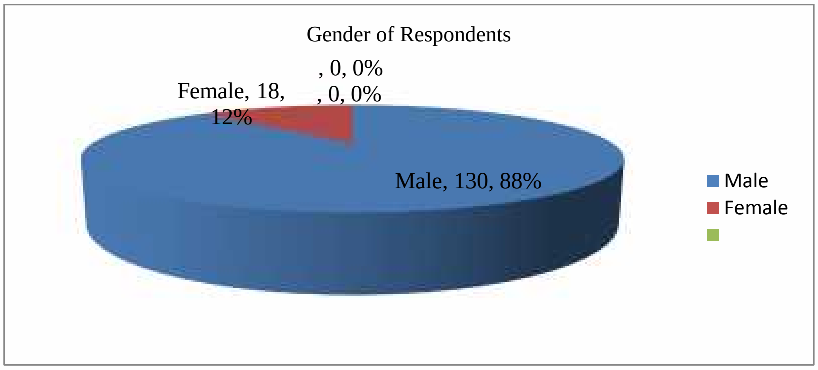

Figure 3.1: Gender of the Key Stakeholders in Dairy Sector in Bungoma County
Source: Field data, 2015

This can be attributed to more male employees than female employees. However, both male and female participated in the study. The results from the focus group discussions, key informant interview, observations and secondary data all confirmed that there were more male employees than female employees.

3.2.2 Category of Respondents

The questionnaires were supplied to managers of the dairy co-operative societies and Agricultural livestock officers. The second background information sought to find out their categories. The results are as shown in Table 4.4. From the results, farmers contribute 73.6% of the respondents, managers of the Dairy Co-Operative Societies were represented by 9.5%, 6.1% were Livestock Officers, while Veterinary Officers and Cooperative Officers, each represented by 5.4%. There was a significant ($p<0.05$) difference in the category of respondents.

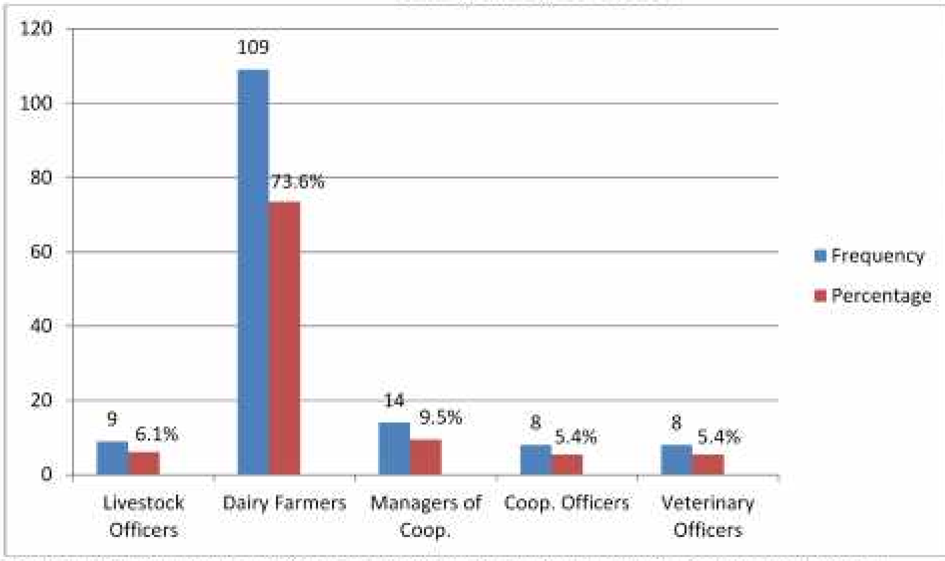

Figure 3.2: Category of Key Stakeholders in Dairy Sector in Bungoma County
Source: Field data, 2015

The secondary data revealed more key value chain actors in the dairy value chain in Bungoma County to include the following: licensed milk vendors, milk hawkers, product consumers, County Trade and Industry executives, banks & microfinance and insurance companies, transporters, NGOs, dairy input suppliers, Quality Standards Officers, Kenya Dairy Board, Public Health Officers, Managers of Youth polytechnics and producers of Animal feeds.

3.2.3 Age

The third question sought to establish the age of the respondents. The results are as shown in Table 4.5.

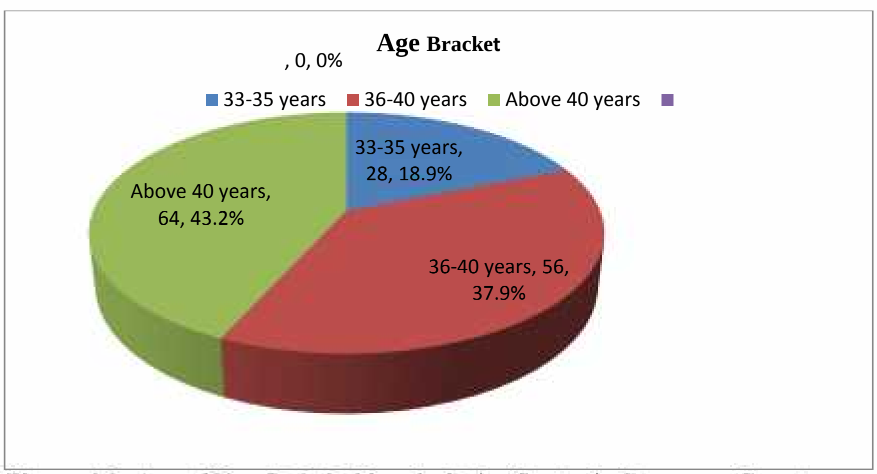

Figure 4.3: Age of Key Stakeholders in Dairy Sector in Bungoma County

Source: Research data (2015)

From the results, 18.9% of respondents were in the age bracket of 31 to 35 years, 37.9% of the respondents were in the age bracket of 36 years to 40 years while the remaining 43.2% of the respondents were in the category of above 40 years. Majority of the respondents were above 35 years. A Chi Square test conducted on the age of the respondents revealed that there was a highly significant ($p<0.048$) variation in the age of the respondents among the respondents ($\chi^2_{2,0.00} = 6.077$).

3.2.4 Level of Education

The last question was to establish from the respondents their highest level of education. The results are as shown in Table 4.6.

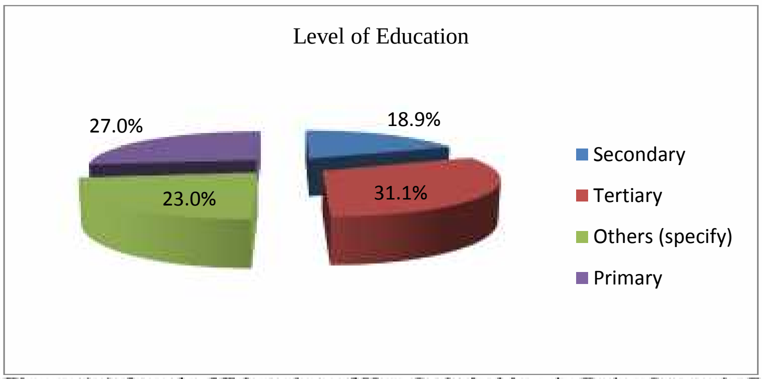

Figure 4.4: Level of Education of Key Stakeholders in Dairy Sector in Bungoma County
Source: Research data (2015)

From the results, 31.1% of the respondents had attained tertiary education, 27% primary education, 23% others including class six, seven and other professional courses while the remaining 18.9% had attained secondary education level. A Chi Square test conducted on the education levels of the respondents illustrated that there was a highly significant ($p<0.01$) variation in the education levels among the respondents($\chi^2_{3,0.00} = 66.00$).

3.3 Descriptive Statistics on Adoption Rates of Technologies in Dairy Sector in Bungoma County, Kenya.

Table 3.1: Descriptive Statisticson Adoption Rates of Technologies in Dairy Sector

S/N	Variables	Mean (m)	Std. Deviation (SD)	Variance (v)
a)	Please state your gender	1.2609	0.44898	0.202
b)	Please indicate your age bracket	1.6522	0.77511	0.601
c)	Years of experience in Dairy farming	1.9565	1.26053	1.589
d)	Please indicate the level of your education	3.0870	0.51461	0.265
e)	Farm size	1.3478	0.57277	0.328

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f)	Veterinary Expenses	2.4783	0.73048	0.534
g)	Markets	3.6522	1.19121	1.419
h)	Dairy breed	2.4348	0.50687	0.257
i)	Internet and e-dairy	1.3478	0.48698	0.237
j)	Artificial Insemination	1.3913	0.49901	0.249
k)	Embryo Transfer/transplant	0.0000	0.00000	0.000
l)	Milking machines	0.1364	0.35125	0.123
m)	Silage making techniques	1.5652	0.58977	0.348
n)	Hay making techniques	2.0870	0.73318	0.538
o)	Automation technology	0.6667	0.57735	0.333
p)	Milk conductivity indicators	1.3043	0.55880	0.312
q)	Automatic estrus detection monitors	0.3529	0.60634	0.368
r)	Automatic temperature recording devices	1.3043	1.01957	1.040
s)	Pedometers	0.4211	0.69248	0.480
t)	Lactometers	1.2000	0.76777	0.589
u)	Daily milk yield recording devices	1.6190	0.80475	0.648
v)	Daily body weight measurement devices	0.9000	0.96791	0.937
w)	Milk dispensers (Milk ATMs)	0.4500	0.82558	0.682
x)	Surgical Castration	0.8000	1.05631	1.116
y)	Bloodless castration	2.2174	0.73587	0.542
z)	Hot iron dehorning	2.2609	0.44898	0.202

Key: *High = 3, Average = 2, Low = 1 & None = 0, applicable for variables from i to z*

Table 1above illustrates descriptive statistics on the adoption rates of technologies in dairy sector in Bungoma County, Kenya, based on the three point Likert Scale where, High = 3, Average = 2, Low = 1 and None =0. The data was obtained from126 farmers, 24 Veterinary Officers and fourteen (14) managers of the Dairy Cooperative Societies. From the results seven (7) of the variables had scores of less than one (i, o, q, s, v, w and x); seven (7) had scores of more than one (1) but less than two (2) (i, j, m, p, r, t and u), giving a clue that the adoption rate of technology in the dairy sector in Bungoma County is low. These translate to 77.8% (14 out of 18 total technologies). Therefore, statistics meant low use of AI,internet and e-dairy, silage making techniques, daily milk yield recording devices, milk conductivity indicators, automatic temperature recording devices and lactometers. The Chi-Square tests conducted among these seven variables were insignificant (Asymptotic significance was >0.05).

Three (3) had scores more than two (2) but less than three (3) (n, y and z) which indicated that the adoption rate of technology was average. That meant that hay making techniques, bloodless castration and hot iron dehorning were averagely practised among farmers in dairy sector in

Bungoma County. Findings from the observation checklists do confirm that hay making techniques were on the increase among the farmers. The Chi-Square tests on these three variables do indicate significant differences($p<0.01$): hay making techniques($\chi^2_{2,0.00} = 2.435.00$), bloodless castration($\chi^2_{2,0.00} = 2.696.00$) and hot iron dehorning($\chi^2_{2,0.00} = 5.261.00$).

The variable K, on embryo transfer had a mean of 0.0000 and standard deviation of 0.00000. This is attributed to the fact that this is a relatively new technology in Bungoma County to the farmers, Veterinary Officers and managers of the Dairy Cooperative Societies. The respondents were of the views that the technology was also expensive to offer and this explains why the variable had a score of zero.According to Moore and Thatcher (2006); Mapletoft and Hasler (2005), embryo transfer and sexed semen is among a range of reproductive technologies that have been developed over the last number of decades.

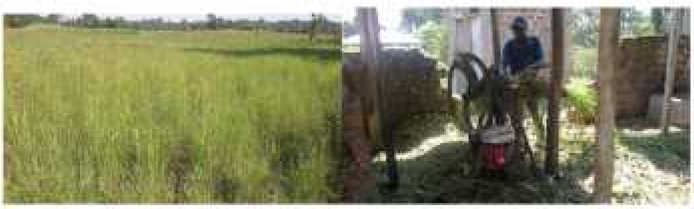

Plate 1 &2: Increase in Fodder Crop Production in Munyiri Farm, in Bumula Sub-County

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3.4 Determinants of Adoption Rates of Technologies in Dairy Sector in Bungoma County

Models		Unstandardized Coefficients		Standardized Coefficients	t	Sig. Level (p-value)
	Factors	Regression coefficient, b	Std. Error	Correlation coefficient, r		
1	Age	-0.066	0.140	-0.102	-0.471	<0.05
2	Gender	-0.078	0.242	-0.071	-0.324	<0.05
3	Years of experience	-0.046	0.086	-0.116	-0.536	<0.05
4	Education level	0.037	0.211	0.038	0.176	<0.05
5	Farm size	-0.295	0.179	-0.339	-1.650	<0.05
6	Veterinary Expenses	-0.277	0.158	-0.405	-1.748	<0.05
7	Markets	0.060	0.095	0.142	0.628	>0.05
8	Type of dairy breed	0.095	0.237	-0.096	-0.399	<0.05

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a. Dependent Variable: Mean of Adoption rate of dairy technologies

Inferential statistics sought to establish the effect of years of experience, gender, age, education level, farm size, veterinary expenses, markets and type of dairy breed on the rate of adoption of dairy technologies in Bungoma County, Kenya. Therefore, the means of these individual variables were regressed against the mean of Adoption rate of dairy technology (obtained from the means of 18 variables, i to z). The results do signpost that out of these eight factors only two were positively corrected with adoption of dairy technologies: Education level (b =0.037, r = 0.038, t = 0.176; $p<0.05$, significant)and markets (b =0.060, r = 0.142, t = 0.628; $p>0.05$, insignificant). Findings from most of the dairy farmers interviewed on the marketability of their milk products said that there were no ready markets for their fresh milk. Some had to travel long distances in search of the markets for the milk and in the process their milk went bad. This has really discouraged the farmers investing more in dairy animal production. Even the Dairy Cooperative Societies that buy milk from the farmers occasionally take long to pay the dairy farmers. The rest of the six factors had negative and significant ($p<0.05$) associations on the adoption of dairy technologies.

For example, age was negatively associated with adoption rate of dairy technologies (b = -0.066, r = -0.102, t = -0.471; $p<0.05$). It was established that relatively older farmers were found to be much less likely to use dairy technology than younger age cohorts. This could be attributed to the fact that younger farmers may be better educated and therefore more aware of the benefits of dairy technologies and also older farmers may be more conservative, less flexible and more sceptical about the benefits of dairy technology utilisation as also observed by Howley, Donoghue and Heanue (2012).

The strong cultural beliefs among the Luhyas on the usage of these dairy technologies militate against their adoption. For example, it is believed that the use of AI could lead to the indigenous breeds being unable to give calve down due to large sized calves leading to death of their animals. The Luhya community would prefer keeping indigenous breeds like Zebu because they are resistant to diseases and are cheaper to use during dowry negotiations than exotic and crosses that are expensive to buy and maintain. Moreover, these dairy technologies like Internet and e-dairy, milking machines, silage making techniques, hay making techniques, pedometers and lactometers are also expensive to the farmers and require high management skills. The Internet and e-dairy were dependent on availability of electricity and internet connectivity which most farmers did not have. These have been supported by Kaaya *et al*. (2005) who established that the factors negatively associated with adoption and use of AI technology included farm level cost of AI services, farming experience, herd size and breed of animals.

Consistent with these findings, Khanal and Gillespie (2011) report that in the US where the dairy sector is specialised, younger, more educated farmers are more likely to adopt advanced breeding technologies such as AI, sexed semen and embryo transplants. An analysis of the use of AI for Ugandan dairy farmers revealed that the age of the farmer, years of awareness of the AI technology, total farm milk production and sales, extension visits per year, and quality of AI services provided to the farmers were positively associated with adoption and use of AI technology.

It was also noted that the farmers who used dairy technologies like AI, milking machines, silage making techniques, hay making techniques, pedometers and lactometers in any given year continue with their use in the subsequent years. Therefore it can be seen that experience with these dairy technologies was positively associated. It could be that once farmers have any experience with these

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dairy technologies then the process becomes much easier in subsequent years thus making them more likely to continue with their use. This could also be due to the fact that use of these dairy technologies had positive effect on the farm business thus making farmers more likely to continue with their application, as also suggested by Howley, Donoghue and Heanue (2012).

4. CONCLUSION AND RECOMMENDATION

4.1: Conclusion

The adoption rates of dairy technologies like AI, internet and e-dairy, silage making techniques, daily milk yield recording devices, milk conductivity indicators, automatic temperature recording devices and lactometers, hay making techniques, bloodless castration and hot iron dehorning among farmers in Bungoma County was found to be low. Among the factors that negatively affected their adoption included years of experience, gender, age, farm size, veterinary expenses, and type of dairy breeds.

4.2: Recommendations

It was recommended that Veterinary Officers be empowered to reach out to dairy farmers and educate them on the vital role of the dairy technologies in Bungoma County. Education has previously been found to have a positive association with the adoption of new technologies. It is hoped this study will better equip policymakers to design policies and programs like farm advisory programs that will enhance dairy production, thus transforming dairy value chain for food security and sustainable development in Bungoma County.

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