The potential of milk production and consumption for improving nutrition of smallholder dairy households in Ethiopia

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Abstract

Evidences on potential of milk consumption in preventing malnourishment vis-à-vis market-oriented/intensifying smallholder dairy-producing areas are scant. Hence, this study explored the consumption habits of fresh bovine milk in the dairy-producing households. Data were collected from a survey of 200 dairy households and key informant interviews. The results revealed that the amount of self-consumed fresh milk per farm and day by producer families varied from 0.5 to 5 liters per day. The majority consumed and traded milk at the same time. The practice of treating milk before consumption differed significantly across production systems. Eighty four percent of the dairy producers boiled milk prior to consumption, and 8.5 % of the respondents did not consume fresh but rather fermented/sour milk (*ergo*) as most of them had symptoms of lactose intolerance. Based on United States Department of Agriculture recommendations, the daily requirement is 10-15 cups if on average five of the family members are drinking milk. Hence, there was a lack of 1.40-2.85 liters of milk, which is insufficient to satisfy the nutrition requirement from dairy foods. However, there are ample experiences of dairy farming, local availability, milk production, and culture of milk consumption. There is scope to improve nutrition through consuming sufficient quantities of milk by the milk-producing households and balancing the staple foods (*teff* and wheat) in the area. Improving milk productivity will increase the levels of milk consumption, which in turn would have great potential as a cost-effective and sustainable household food production strategy for malnourished children.

Key words: Bovine milk, intensive milk production systems, smallholder dairying, household consumption/nutrition, sustainable diets

Introduction

Producing bovine milk is one of the most efficient ways to convert plant biomass into animal protein [1]. Smallholder dairying is cost-effective and a key source of nutrition and income to 300 million farm families globally [2], plays an important social role in developing countries, and is considered an important means of alleviating poverty [3, 4]. It will also contribute to achieving food security and improved nutrition, which is one of the goals of the Post Millennium Development Goals (Sustainable Development Goals).

An increase in household income does not necessarily translate into increased household food security and/or nutritional wellbeing [5, 6]. Although direct links between increased income and improved nutrition remain controversial [7], there is some evidence that cash income can provide certain consumer groups with the flexibility to purchase quality food to which they otherwise would not have access and thus add nutritional value to their diets [8]. However, income gained through milk sale might be spent on non-food item expenditure desired by the dairy households. The low consumption of milk leads to health problems/malnutrition especially among growing children and pregnant women in many developing countries.

To this end, there is concern in protein-energy malnutrition [9] in the household diets of farming community and also interest in agriculture-nutrition linkage [10, 11, 12, 13]. In this regard, the linkage between household nutrition and dairy farming is becoming another agenda of intensifying/market-oriented dairy food production systems. Therefore, research and development for agriculture and food-based approaches to improved nutrition face the challenges of enhancing the food and nutrition security of poor people [14]. Evidences on potential of milk consumption in preventing undernourishment in the face of market-oriented/intensifying smallholder dairy-producing areas are limited. If addressed, this could provide useful insight when designing programs connecting dairy production and human nutrition as well as cross-sectoral interventions.

However, many people in low and middle-income countries suffer from micronutrient deficiencies. An important factor contributing to these deficiencies is the consumption of mainly plant-based diets that are low in micronutrients [15]. Food-based strategies and consumption of foods rich in specific nutrients are believed to be more sustainable and culturally-acceptable than supplementation or fortification [16, 17]. An additional advantage is that several micronutrient deficiencies can be alleviated simultaneously without the risk of antagonistic interactions or nutrient overload [16]. Cow's milk products have a central role in treatment of under nutrition in low-income countries, and the intro-

duction of products with a high milk content has resulted in marked improvements in weight gain, linear growth, cognitive function and reduction in mortality in undernourished children [18, 19, 20, 21]. Milk protein has a high quality score and contains many peptides and other bioactive factors, which might have special effects on recovery from under nutrition. Milk is an important source of minerals supporting growth and the high lactose content also seems to support growth due to a prebiotic effect and improved absorption of minerals. There is consensus that children with under nutrition should be treated with products with high milk content [22]. Therefore, regular consumption of milk is an easy way for one to help ensure the adequacy of nutrition as it is by far the best single food available to man [23].

Results from a limited survey in two dairy business hub sites in Kenya show that increased milk production at household level translates into increased milk consumption by children and therefore improved nutrition [24]. Milk interventions in developing countries (for example, school feeding programs) had nutritional outcomes [25, 26, 27], but this is not local/household production-based and may not be sustainable. Systematic analyses of the relationship between dairy production and consumption at household level are scarce [24]. Research and knowledge gaps in Ethiopia need to be bridged in addressing the following questions: How can dairying be more nutrition-sensitive without compromising market-orientation? What is the relationship between milk trade and milk consumption? What is the effect of changes in production systems on household nutrition? How about the potential of livestock agricultural strategies to improve the nutrition and health of women and young children?

In the Ethiopian highlands, the Ada'a district of the Oromia region is an area with a fast-growing smallholder dairy production and with strong milk marketing cooperatives and private dairy processors [28]. Besides its production potential, the milk shed of Ada'a is also witnessing increasing opportunities at the market of Addis Ababa, where dairy industries and supermarkets are rapidly growing [29, 30]. Hence, driven by human population/land pressure and urbanization/dairy marketing options, dairy producers are intensifying their milk production practices. To this end, children under the age of 15 account for nearly half (45 % of the total population), while only about 4 percent of Ethiopians are over age 65. Malnutrition as a major public health problem in Ethiopia, with 48 % of children at the age of 24-35 months being stunted, 10 % wasted and 24 % underweight. These figures for Oromia were 36.5, 10.6 and 22.5 %, respectively [31], being one of the highest prevalence in the country. However, evidence is still sparse about the potential contribution of intensifying dairy production to family nutrition through milk consumption. These dairy production systems are market-oriented and there have been some uptake of improved dairy practices though little institutional support. Thus, the knowledge gap needs to be filled in the areas of dairy farming and household nutrition in order to devise strategies for integrated/interdisciplinary approach in eradicating malnutrition through dairy food production systems. Understanding how local dairy production improves nutrition is essential if sustainable nutritional benefits especially for vulnerable women and children are to be put into practice. Therefore, the objective of the present study was to investigate household consumption habits of bovine fresh milk and its implication for improved nutrition in the market-oriented smallholder dairy producing households of Ada'a district.

Materials and methods

Study area:

The study was conducted in the Ada'a district, one of the districts of the East Shewa zone of the Oromia regional state. It has 32 *kebeles* (lowest administrative unit). The district is located about 45 km south-east of Addis Ababa. It lies between longitudes 38°51' to 39°04' East and latitudes 8°46' to 8°59' North covering land area of 1750 km2. Most of the land (90%) is plain highland ranging between 1600 to 2000 m above sea level. The district is characterized by sub-tropical climate and receives 860 mm rainfall/annum. Mean annual temperature ranges from about 8–28 °C [32]. These agro ecological conditions provide a favorable environment for dairy production.

Total cultivated land accounts for 64412 ha. Out of this, 64088 ha are rural and 324 ha are urban [28]. Human population is 386523 [33]. The economy of Ada'a district is characterized by crop and livestock farming, mainly smallholder agriculture. The district is fairly well-endowed with development infrastructure. It is one of the leading producers of *teff* and wheat as well as various types of pulses (mainly chickpea) [34] and therefore, *injera* made from *teff* and bread from wheat are the most common human food. There are two cropping seasons in the area, *belg* (short rainy season) from March to April and *meher* (main rainy season) from June to September [28].

The area hosts a fast growing smallholder dairy production system [28]. Cattle population of the area is estimated to be 160697 [35]. There are high numbers of crossbred dairy cattle (indigenous x exotic breeds/ mainly Holstein Friesian) and other dairy development interventions in the district. Based on Workneh et al. [36] and DAGRIS [37], the indigenous animals can be classified as Large East African Zebu/Arsi.

Bishoftu is the capital of Ada'a. In terms of religious distribution, 87.8 % of the total populations of the town are Orthodox, 6.9 % Protestant, 0.6 % Catholic, 4 % Muslims and 0.7 % Wakefeta believers (a traditional Oromo religion, including praising by gathering around water bodies) [34]. Different institutions mandated with livestock related activities (Ethiopian Meat and Dairy Technology Institute, College of Veterinary Medicine and Agriculture, National Veterinary Institute, and Debrezeit Agricultural Research Institute) are situated in the town.

Studied households:

Most of smallholder dairy producers in the study area were selling milk either to Ada'a cooperative or private milk processors in the formal marketing channel. During the survey, there were 100 actively-participating members in the dairy cooperative and they were taken as a benchmark and chosen for household survey purposively. Similarly, non-members who sell milk to private processors were randomly selected from lists of 300 of dairy producers at milk collection centers. Accordingly, a total of 200 households from Ada'a dairy cooperative members and non-members were sampled for the study.

Data collection and data analysis:

Data types include both secondary and primary data sources. The primary data include farm household characteristics (i.e. those of household head) – age, religion, level of education, dairy experience, marital status, family size and composition, land size, cattle breeds kept, labor availability, milk marketing, major income source, dairy training, water source, milk production, and milk consumption level. The primary data is complemented with in-depth analysis of documents (secondary sources) including journals, books, reports/papers, national policies directives of line ministries, statistics, etc. [5, 38, 28, 22, 23, 24, 34, 39, 40, etc.].

Field data were collected through questionnaires, surveying on household-level. It was supplemented with key informant interviews, on-spot observation and document analysis. Enumerators/translators who can speak the local languages (Amharic and Oromo) were selected and given orientation. The questionnaire was pretested with three testers

before administered.

Data were coded and entered into the Statistical Package for Social Science (SPSS) software (Version 20) [41]. Household socioeconomic data, daily milk yield, volume of milk sold and consumed were analyzed using descriptive statistics and mean comparisons. Least significant differences were used to separate means at $P < 0.05$ and $P < 0.001$.

The statistical model used was the form:

$$Yi = \mu + X1 + X2 + X3 + X4 + X5 + X6 + \ldots\ldots\ldots Xi + ei$$

Where *Yi* is the dependent variable; μ = Overall mean; *Xi* is the independent variable and *ei* = effect of random error.

Daily milk yield, volume of milk consumed and milk sold were considered as dependent variables. Independent variables were selected based on established and researchers' knowledge. It was believed that the independent variable (dairy household characteristics) would predict the value of dependent variable, which address the objective/outcome of the study. Therefore, the following independent variables were chosen to evaluate dependent variables.

Daily milk yield, volume of milk sales, family size, household members, household head-age, religion, and education level, time to collection center, land size, labor supply, dairy cooperative membership, frequency of drinking milk, and state of milk consumed were tested for their effects on household milk consumption level.

Dairy cooperative membership, dairy production systems, feed type, feeding frequency, dairy cow water consumption level, watering frequency, labor supply, land size, household head-education, dairy experience, veterinary service delivery and dairy training were tested for their effects on daily milk yield, and volume of milk sold.

Results and discussion

Socio-economic characteristics of the study households:

Two hundred dairy-producing households were included in the study. Percentage of age category of the producers were 0.5 % (15-24 years); 11.5 % (25-34 years); 30 % (35-44 years); 24 % (45-54 years) and 34 % (>55 years). Average family and land sizes were 5.82 and 0.48 ha, respectively. The family size is larger than the national average (4.7) [39]. The total number of household heads and their family members was 1163. Most (50.5 %) of the producers were at secondary education level. About eighty nine percent were married. The religion of the majority (90 %) of participants was Orthodox Christianity (Table 1).

Milk production:

The results revealed that mean daily milk yield per cow obtained from the crossbred dairy cows was 13.89±4.41 liters (Table 2). There was a significant difference across production systems ($P<0.001$), which was also evidenced by variations in terms of feed type, labor input, education level of household head, dairy experience, veterinary service delivery and cow breed. Higher daily milk yield was found in urban production system (15.42±4.35 liters) followed by 13.39±3.96 and 11.68±3.86 liters peri-urban and rural dairy system, respectively (Figure 1). The mean lactation yield was 10.01±0.88 months. The maximum yield (27 liters) indicated that there could be a potential for increasing milk productivity. A possible elucidation for the variation in milk yield between urban and rural dairy production systems could be that there was only a moderate tendency of dairy intensification in the rural setting including lower number of improved dairy cows, lower accessibility of alternative (government and private) veterinary and artificial insemination provisions, and relatively lower utilization of concentrate feed though more accessibility of roughage feed and forage crops than the urban setting. The latter was accessible for information/education, and dairy producers had more years of dairy experience.

There were various reports from Ethiopia and elsewhere concerning average daily milk yield. Azage et al. [43] reported 10.2-15.9 kg per cow per day for crossbred dairy cows in urban and 9.5 kg per cow per day peri-urban dairy systems. 15.5 kg per day per cow in urban and 13.7 kg per day per cow in peri-urban dairy production systems of Adama were stated by Nigusu and Yoseph [44]. In rural Vietnam and Mexico, 13 and 13.9 liters of milk per cow per day were recorded in smallholder dairy systems [45, 46]. These reports are in line with the present study. On the contrary, average daily milk yield of Friesian x local/crossbred cows was 8.4 liters per cow in urban and peri-urban of Bahir Dar and Gondar areas [47]. Another study in the Holleta area of Ethiopia [48] reported 11.1 kg and 9.28 kg per day per cow in urban and peri-urban areas, respectively. Daily milk yield of crossbred (Kenana with Friesian) was 9.77 ± 0.30 liters in Sudan [49]. The mean milk yield per cow per day was 6.47 liters and mean lactation length was 7.67 months in Kenya [50]. In the same country, 9 liters was also reported [51].

Household milk consumption and trading:

The amount of fresh milk self-consumed per farm per day by producer families varied from 0.5 to 5 liters per day (mean= 1.5 liters; total= 200.5 liters) (Table 2), which is around 6.03 % of the mean daily milk yield. The consumption level differed with household religion and consumption frequency ($P<0.001$). This could be due to the religion of the majority of studied households was Orthodox Christianity, who were not consuming milk during fasting days. Within the household. 85 % of children consumed milk as did 81.5 % of wives and 78.5 % of husbands. Adults (husband and wife) mostly consumed some milk in tea/coffee and in the form of fermented milk (ergo). The daily volume of milk for sale was higher (mean= 23.43 liters; total= 4686 liters) (Table 2) and varied among production systems ($P<0.001$). These were 25.77 ± 16.13, 13.09 ± 7.07, and 28.39 ± 17.95 liters in peri-urban, rural and urban dairy production systems, respectively. The more market share of urban dairy system is due to the intensifying/market oriented smallholder dairy farms, which are mainly concentrated adjacent to urban consumers in addition to the variation in daily milk yield. Milk sale provides 77 % and 20 % of the households' major income source for urban and peri-urban dairy producers, respectively. It was also supplementing the household income of other dairy farmers.

Much of milk produced per farm per day (94.2 %) (Table 2) was sold

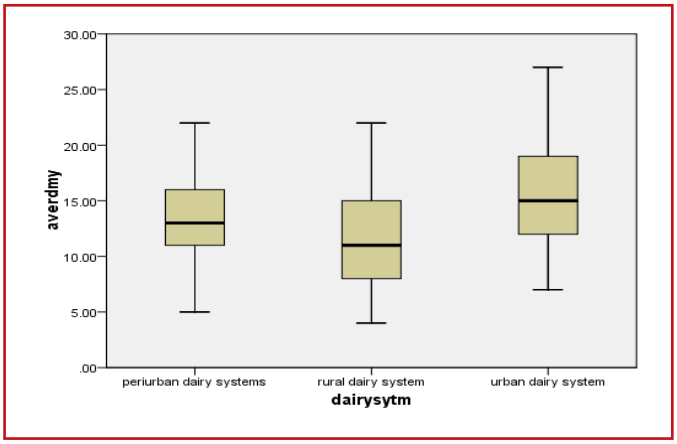

Figure 1: Boxplot of average daily milk yield (y-axis; averdmy: average daily milk yield (liters)) versus dairy production systems (x-axis; dairysytm: dairy production systems)

Table 1: Socio-economic characteristics of the study households (n=200)

Variables	Description	Dairy systems			Significance
		Peri-urban dairy systems (n=46)	Rural dairy systems (n=57)	Urban dairy systems (n=97)	
Household head-age [a]					0.000**
	15-24 (%)	0	1.8	0	
	25-34 (%)	23.9	12.3	5.2	
	35-44 (%)	52.2	28.1	20.6	
	45-54 (%)	13.0	31.6	24.7	
	>=55 (%)	10.9	26.2	49.5	
Family size					0.001*
	number/ household	5.54 (±2.08)	6.68 (±2.38)	5.43 (±1.89)	
Land size					0.000**
	ha/ household	0.10 (±0.16)	1.53 (±1.11)	0.05 (±0.05)	
Cattle herd size					0.009*
	head/ household	7.57 (±3.82)	10.51 (±3.93)	8.62 (±5.87)	
Cattle breed composition					0.000**
	Crossbred (%)	87.0	29.8	99.0	
	Crossbred and local (%)	13.0	70.2	1.0	
Household head-education level					0.072
	Illiterate (%)	19.6	19.2	20.6	
	Primary (%)	21.7	40.4	18.6	
	Secondary (%)	56.5	38.6	54.6	
	Tertiary (%)	2.2	1.8	6.2	
Dairy as major income sources					0.000**
	Yes (%)	41.3	7.0	77.3	
	No (%)	58.7	93.0	22.7	
Marital status					0.031*
	Single (%)	8.7	3.5	4.1	
	Married (%)	80.4	94.7	89.7	
	Widow (%)	4.4	1.8	6.2	
	Divorce (%)	6.5	0.0	0.0	
Household religion					0.278
	Orthodox (%)	84.8	98.2	87.6	
	Muslim (%)	4.3	0.0	4.1	
	Protestant (%)	10.9	1.8	7.3	
	Jehovah's witnesses (%)	0.0	0.0	1.0	
Dairy experience					0.000**
	< =5 years	23.9	77.2	8.2	
	6-10 years	43.5	12.3	25.8	
	>10 years	32.6	10.5	66.0	
Dairy training					0.043*
	Yes (%)	89.1	70.2	82.5	
	No (%)	10.9	29.8	17.5	
Water source					0.000**
	Tap water (%)	100	57.9	100	
	Well hand pump (%)	0.0	42.1	0	
Labor input					0.000**
	number/ household	2.33 (±0.76)	3.32 (±0.85)	2.47 (±0.87)	

[a]WHO (2015) age category
*P<0.05, **P<0.001

Table 2: General descriptive statistics of milk yield, consumption and sale

Variable	N	Mean	Std. Deviation	Minimum	Maximum	Sum (total)
Daily milk yield/farm/day (liters)	418 cows	24.88	16.41	4	93	4975
Daily milk yield/cow/day (liters)	418 cows	13.89	4.41	4	27	2778
Volume of milk consumed/ household/day (liters)	200 households	1.51	0.86	0.50	5	200.50
Volume of milk sold/household/day (liters)	200 households	23.43	16.49	4	85	4686

to dairy cooperative and private milk processing plants that process milk and supply to urban consumers through retailers- supermarkets, shops, etc. The earnings from milk sales were mainly used to cover feed costs. Much lower milk sales were reported in Kenya. For instance, according to Mutua-Kiio and Muriuki [52], about 35 percent of total milk produced was consumed on farm by the calves and the farmer's family while the balance (65 %) was available for sale. In the same country, another study found that about 55% of the milk produced by farmers entered the market [53].

Different figures on milk consumption levels were reported. Muia et al. [54] calculated a daily milk consumption of 1 to 3 liters for dairying households in Kenya. In rural Kenya, farmer households consumed about 1.5 liters a day and there was positive relation between milk consumption and level of education [38]. Children in high-intensity households (milk yield >6 liters milk per day) received more milk than children in medium-intensity households [55]. The same authors disclosed that daily household milk consumption was in the range between 1.8±1.2 and 4.9±1.9 liters. Another study in Kenya compared members of a dairy cooperative with non-members and found that women and school-age children (5–14 years old) from member households consumed more bovine milk than non-members [56].

The majority (66.5 %) consumed milk, of which 63.1 % drank it once a day, 25.4 % more than once a day, 6.2 % three to six times per week, and 5.4 % once or twice per week. The practice of treating milk before consumption differed significantly across production systems ($P<0.001$). 84 % of the dairy producers boiled milk prior to consumption, which is important to reduce health/ risk of disease transmission. The remaining small proportion used in both raw and boiled forms, especially in rural production system.

8.5 % of the respondents did not consume fresh but rather fermented milk ('*ergo*'). The majority of these respondents showed symptoms of lactose intolerance (82.35 % get vomiting upon consuming milk, 17.67 % feel abdominal pain). The percentage of occurrence of lactose intolerance found in this study is believed to affect the milk consumption of milk-producing households in the area.

According to USDA [40], the daily dairy requirement is 2-3 cups depending on age. Milk consumption level in the present study would be 1500 ml or 6.25 cups (taking 1 cup = 240 ml) and daily requirement of 10-15 cups if on average five of the family members were drinking milk (8.5 % lactose intolerant members deducted). Therefore, 1.40-2.85 liters per day of milk were deficient to satisfy the nutrition requirement from dairy foods.

The maximum milk yield obtained by smallholder producers in the present study showed that there is a room to improve milk production through support services and interventions, particularly for women or wives who have great role in dairy activities, taking care of children and food preparation. As dairy households increase milk production, there will be higher probability of keeping milk for home consumption as well as supplying to non-dairy producer urban consumers.

Conclusion

The results revealed that the majority of dairy producers consumed and traded milk at the same time. 84% of the dairy producers boiled milk prior to consumption. However, the amount of milk self-consumed per farm per day by producer families is deficient to satisfy the nutrition requirement from dairy foods of intensive milk producing households. To this end, there is room to improve nutrition through consuming sufficient quantities of milk by the milk- producing households and complementing the staple foods (*teff* and wheat).

In this regard, the ample experiences of dairy farming, local availability/access and culture of milk consumption are untapped potentials to prevent malnutrition. Improving milk productivity (sustainable household milk production) through dairy extension will increase the level of milk consumption, which in turn would be great prospective as cost-effective household food production strategies/food access to enhance micronutrient intakes or as a complementary to the staple foods for undernourished children in sub-Saharan Africa. Furthermore, empowering women and promoting through agriculture and health extension services are needed to increase awareness of the nutritional value and recommended consumption level of milk in the diet of the dairy and non-dairy households. Thus, balancing both livelihood security through creating jobs/income generation from milk sales and improved nutrition through milk consumption, particularly mothers and children will sustain dairy food production systems. External interventions targeting improved food and nutrition security need to build on dairy farmers' best practices (potential) and challenges driven by intensifying production systems.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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