ORIGINAL ARTICLE

Dairy product consumption behaviour of Addis Ababa city households: A multivariate probit model approach

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ABSTRACT

Although Ethiopia is holding one of the largest dairy cattle herds in the world, the per capita consumption of dairy products is low. Moreover, the dairy marketing system in the country from where the consumers obtain dairy products is dominated by the informal market that supplies raw milk which can be a risk factor for zoonotic disease transmission. Using primary data collected from 384 sample households of Addis Ababa city, determinants of dairy products purchase decision was investigated. Descriptive statistics and multivariate probit (MVP) model were used to analyse the data. The results showed that raw milk, pasteurized milk, powdered milk, cottage butter, cottage cheese, factory cheese, cottage yoghurt and factory yoghurt were purchased by 46%, 73%, 12%, 94%, 64%, 9%, 11% and 26% of the sampled households, respectively. The MVP model results indicated the interdependence of decisions to purchase different dairy products. The result of the model further revealed that religion, age and education of household head, family size, presence of children in household, and consumption value variables such as taste, price, social values (influence of friends and families), emotional values (the perception that dairy products offer pleasure and good feeling), conditional value (availability), and epistemic value (habit of trying new products) had a significant impact on dairy product purchase decision of the respondents. Therefore, addressing demographic, socio-economic and consumption value variables, and acknowledging the interdependence of decisions consumers make while purchasing multiple dairy products, would all be important factors to consider when designing policies to improve the consumers' nutritious food consumption and zoonotic diseases control.

Keywords: Consumption values, multivariate probit, dairy products, purchase decision

INTRODUCTION

Consumption of dairy products is important to meet the recommended intake levels of nutrients to support the body immune system (Huth *et al*., 2006; Thorning *et al*., 2016). Recognizing this importance, 87 of the 90 countries (96%) with food-based dietary guidelines (FBDG) across the globe include dairy products in their FBDG (Herforth *et al*., 2019). Although the recommended daily per capita intake varies across countries, at least half a litre of liquid milk equivalent is widely recommended. However, some countries such as Latvia in European Union has higher FBDG recommendations (500-750ml/day) (WHO, 2003). From the African countries, 1-2 servings of dairy products composed of 125gram yoghurt, 20gram powder milk, 50gram local cheese, and 85gram concentrated milk per day was specified in the Benin FBDG prepared in 2015 (FAO, IFAD, UNICEF, WFP and WHO, 2020).

Despite its nutritional importance, the global average per capita milk consumption between 2014 and 2018 was 84kg/year with a wide gap between the per capita consumption of developed and developing countries. The top three countries with the highest average annual per capita consumption in the world were Montenegro, Finland and Albania with 355kg, 353kg and 311kg, respectively during the same period. In contrast, the average annual per capita consumption in developing countries is low. The annual per capita consumption of East African countries namely Uganda, Ethiopia, Djibouti and Rwanda was only 38kg, 30kg, 26kg and 14kg, respectively, during 2014-2018 and this is by far lower than the recommended intake, except for Sudan and Kenya with higher annual per capita milk consumption of 95kg and 76kg, respectively during the same time period (FAOSTAT, 2020). For Ethiopia, this is a paradox as the country is one of the top ten countries holding dairy cow population in the word in 2020 (FAO, 2022a) yet one of the low dairy product consuming countries in the world in 2019 with 28kg/year/person while the highest per capita consumption in the same period was 353kg/year in Montenegro (FAO, 2022b). Developed countries consume processed while developing countries mainly consume unprocessed dairy products (OECD/FAO, 2020) which are associated with a higher risk of zoonotic diseases such as bovine tuberculosis (Rowe and Donaghy, 2008; LeJeune and Rajala-Schultz, 2009; Costard et al., 2017).

Given the importance of dairy product consumption for human nutrition, it is vital to understand the factors affecting purchasing (consumption) behaviour of dairy product consumers in developing countries where there is insufficient intake of dairy products and where unprocessed dairy products with high risk for zoonotic diseases transmission are common. Ethiopia is a good example of such countries to investigate dairy product consumers' behaviour. It is characterized by a low per capita dairy consumption (FAOSTAT, 2020). Research findings have reported a high prevalence of bovine tuberculosis (bTB) in the country (Firdessa *et al*. (2012) and Mekonnen *et al*. (2019)), which highlight the high risk of zoonotic disease transmission implications associated with raw dairy product consumption. Consuming processed dairy products helps to reduce such risks (Holsinger *et al*., 1997). Hence, Ethiopia is an interesting case to investigate dairy consumers' behaviour in detail.

Dozens of studies have been conducted on dairy products consumption around the globe. Some of the most relevant studies from both developed and developing countries are Melesse and Beyene **(**2009), Kuma (2010), B. Kuma *et al*. (2012), Abegaz *et al*. (2018), D'Haene *et al.* (2019) and Minten *et al*. (2020) from Ethiopia, Njarui *et al*. (2011) from Kenya, Aidoo *et al*. (2009) from Ghana, Fuller *et al*. (2007) and Bai *et al*. (2008) from China, Hsu and Kao (2001) from Taiwan, Thapa *et al*. (2020) from Nepal, Hoque and Hossan (2020) from Bangladesh, Alwis *et al*. (2009) from Sri Lanka, Hatirli *et al*. (2004), Akbay and Tiryaki (2008) and Tiryaki and Akbay (2008) from Turkey, Rahnama and Rajabpour (2017) from Iran, Kurajdová *et al*. (2015) from Slovakia, Fu *et al*. (2014) and Fu and Florkowski (2016) from Poland and Cornick *et al*. (1994) from the United States. The main findings from the past studies suggested a large set of variables affecting dairy product consumption. Examples of these are household background variables such as age, education, family size and presence of children in the family, economic variables such as income and wealth, and product-related variables including the consumption value variables which include taste, price, social influences, availability, and other related variables. However, the past studies have mainly focused on fluid milk or few milk products, and do not sufficiently investigate the interdependence of the decision-making process when buying multiple dairy products.

Another limitation of the past studies is that they rarely disaggregated dairy products when identifying the determinant factors of purchasing or consumption decisions. However, there are different dairy products in reality and hence factors affecting the purchase decision of each can also vary accordingly. The exception was observed in the works of Cornick *et al*. (1994), Fu and Florkowski (2016) and Fu *et al*. (2014) who acknowledged the interdependence of decision-making when purchasing dairy products and tried to disaggregate the dairy products when identifying factors affecting consumption of each product but failed to include consumption value variables to factors affecting dairy products. To the best of our knowledge, only Rahnama and Rajabpour (2017) explored the importance of consumption value variables but also failed to disaggregate dairy products. However, these works were done in developed nations and rarely reflect the dairy consumers' decision-making behaviour in multi-category dairy products in the context of developing countries.

This study focuses on a developing country in Africa because of the current emerging food system transformation, population growth and urbanization

in Africa that target high nutritional foods including dairy products (Tschirley *et al*., 2014; Badiane and Makombe, 2015). Specifically, it was conducted in Ethiopia, one of the fast-growing economies in the world which has an implication on the demand for dairy product consumption (ADB, 2020). To the best of our knowledge, a comprehensive study that examined factors affecting purchasing and consumption decisions of several dairy products simultaneously with interdependence decision making in Ethiopia as well as in most of the developing countries. This study aimed to fill this knowledge gap by applying an econometric model appropriate to address the interdependence of decisions when purchasing dairy products in Ethiopia that well represents most of the developing countries dairy consumption behaviour.

The contribution of this work to the existing literature is two-fold. First, we applied the MVP model which is appropriate when a decision-maker decides to 'pick-any' product among the multiple products that are often interrelated using several dairy products in a developing country. Second, we exhaustively included available (seven) dairy products in the dependent variables of the MVP model, unlike the past studies that addressed a maximum of four products. This can better represent the real-world decision-making process of dairy consumers. Therefore, this study was conducted to investigate the determinants of dairy consumers' purchase decisions.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Addis Ababa city, the capital city of Ethiopia and home of several important organizations such as the African Union. It is also the city where many diplomatic, embassy and consular institutions are located. The city is in the centre of the country which makes it economically important. The total population of the city in 2018 was estimated to be three million (Addis Ababa city Mayor Office, 2018). The city is divided into ten sub-cities which are further divided into 117 districts (also known as Woredas). This study covered four sub-cities, namely Bole, Kirkos, Kolfe Keraniyo and Gulele and 10 districts, three districts each from Bole and Kolfe Keraniyo and two districts each from Kirkos and Gulele (Figure 1). Addis Ababa city was purposively selected due to three reasons. First, Addis Ababa city is a metropolitan city where high potential for dairy products consumption is expected from the demand side. Second, there is a high supply of dairy products in the city from domestic production of urban and peri-urban dairy producers of the Addis Ababa milk-sheds and there are dairy processing industries in the city. Third, dairy products importing companies are available in the city.

Sample size determination

To obtain a representative sample size of the dairy product consumers, the sample size determination formula by Kothari (2004) was used:

$$N = \frac{Z^2 pq}{e^2} = \frac{(1.96)^2 (0.5)(0.5)}{0.05^2} = 384 \quad (1)$$

Where N is the sample size needed, Z is the inverse of the standard cumulative distribution that corresponds to the level of confidence, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population and q = 1-p. The value of Z is found from the statistical table which contains the area under the normal curve of 95% confidence level. In the determination of sample size, setting the value of p=0.5 and hence q=0.5 yields the maximum optimum sample size while any other combination of the values of p and q yields less sample size using the Kothari formula. Therefore, using 0.5 for the values of p and q and e =0.05 and inserting the Kothari formula gives a total of 384 samples to sufficiently represent the dairy product consumers' population in the selected study areas assuming a 95% confidence level and ±5% precision.

Sampling procedure: Multi-stage stratified random sampling procedure was used in this study. The city was stratified into four strata using the population density, geographical location and the level of development of the sub-cities. Based on this, Bole was selected to represent the eastern, north-eastern and south-eastern sub-cities stratum composed of three sub-cities, sparsely populated and highly developed sub-city whereas Kirkos was selected from the central part representing four sub-cities, less developed and highly populated sub-city. Kolfe Keraniyo was selected from the south-western and western sub-cities representing two sub-cities with a medium level of both development and population density. Finally, Gulele sub-city was selected from the northern part of the city having medium level of development and population density. After the selection of the four sub-cities, the number of districts to be selected was determined based on the number of districts available in each sub-city. Since ten or more districts are available in each sub-city, the districts and sample households were randomly selected from each district using systematic random sampling from the households list available in each district. The allocation of the number of samples for each district was based on probability proportional to population size. Table 1 presents the details of the sample size in the selected districts.

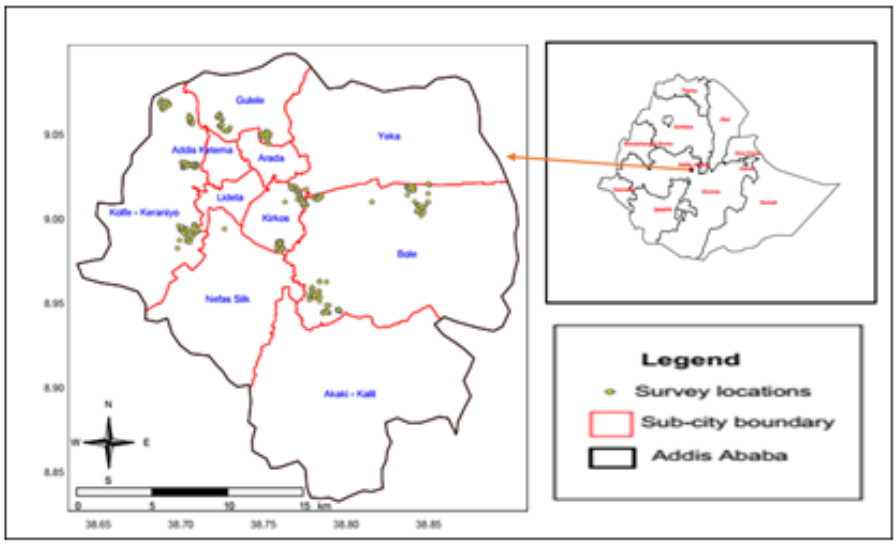

Figure 1: Map of Addis Ababa city, sub-cities and the study area.

Source: Developed by Tesfaye Solomon using R software for the study purpose.

Table 1. Description of the sample households by sub-city and districts

Sub-city	District	Number of households in the districts	Sample size	Percent
Bole	Woreda 4	5166	39	10.2
	Woreda 8	6013	42	10.9
	Woreda 12	12120	53	13.8
	Sub total	23299	134	34.9
Kirkos	Woreda 3	3341	34	8.8
	Woreda 8	3230	32	7.9
	Sub total	6571	66	17.2
Gulele	Woreda 4	2529	30	7.8
	Woreda 9	2041	28	7.3
	Sub total	4570	58	15.1
Kolfe kerani yo	Woreda 5	8605	49	12.8
	Woreda 10	6024	44	11.5
	Woreda 15	3935	33	8.6
	Sub total	18564	122	31.8
Total			384	100

Source: Office of the respective sub-cities of Bole, Kirkos, Gulele and Kolfe Keraniyo.

Data collection

Well-trained and experienced enumerators having university first degree were recruited and given training on the content of the questionnaire and on how to approach sample households. The questionnaire was pretested before the actual data collection was conducted. The questionnaire included household's, socio-economic and demographic characteristics, awareness, and perception on dairy products consumption, detailed dairy product purchase and consumption practices such as place, frequency, quantity and reason of buying dairy products and average annual price of each dairy products they purchase. Data collection was performed using CAPI (computer aided personal interview) laden with Census Survey Processing System (CSPro 7.1) in January and February 2019.

Data analysis

Both descriptive statistics and econometric model were used to analyse the data. Descriptive statistics were used to describe the socio-demographic characteristics of the sample households. In addition, multivariate probit model was used to analyse the determinants of dairy products purchase and consumption decisions.

Conceptual framework and empirical model

The conceptual basis for choosing an appropriate econometric model to analyse the determinants of

dairy products purchase decisions is the random utility theory (McFadden, 1974). The idea behind this theory is that a consumer is a rational decision-maker and has perfect information to make decisions of choosing an alternative that offers him the highest utility from the choice set. To express this theory in analytical form, dairy product consumer *i* chooses a particular alternative *j*, if and only if the expected utility U_{ij} derived from the product choice made, is greater than the expected utility U_{ik} that can be obtained from another alternative product *k* in the choice set. However, utility cannot be directly observed while only the action of the decision-maker is observed through the choice he or she made. Following (Greene, 2012), the linear random utility model for the two choices can be specified as:

$$U_{ij} = W'\beta_j + Z_j'\gamma_j + \varepsilon_j \text{ and } U_{ik} = W'\beta_k + Z_k'\gamma_k + \varepsilon_k \quad \forall j \neq k \qquad (2)$$

Where W is a vector of observable explanatory variables, Z_j and Z_k are attributes (features) of the two choices that might be choice specific, ε_j and ε_k are the random terms that represent the stochastic elements that are specific to and known only by the individual, but not by the observer (analyst). Assume that Y=1 is the consumer's choice of alternative *j*, it can be inferred from Y=1 that $U_{ij} > U_{ik}$. The choice (outcome) is eventually derived by the random element in the utility functions, the probability that a consumer chooses the jth dairy product conditional on W and Z can be expressed as:

$$\text{Prob}(Y = 1|W, Z_j, Z_k) = \text{Prob}(U_{ij} > U_{ik}) \qquad (3)$$

$$= \text{Prob}[(W'\beta_j + Z_j'\gamma_j + \varepsilon_j) - (W'\beta_k + Z_k'\gamma_k + \varepsilon_k) > 0|W, Z_j, Z_k]$$

$$= \text{Prob}[(W'(\beta_j - \beta_k) + Z_j'\gamma_j - Z_k'\gamma_k + \varepsilon_j - \varepsilon_k) > 0|W, Z_j, Z_k]$$

$$= \text{Prob}[(X'\beta + \varepsilon > 0|X] = F(X'\beta)$$

Where $X'\beta$ captures all the observable elements of the difference of the two utility functions and ε denotes the difference between the two random elements, $F(X'\beta)$ is the cumulative distribution function of ε evaluated at $X'\beta$. The distribution of F depends on the distribution of ε.

In this study, the dairy product consumers made the choice to purchase and consume among eight common dairy products available in the market. These are: 1) raw milk, 2) pasteurized milk, 3) powdered milk, 4) factory yoghurt, 5) cottage yoghurt (is also known as *ergo* in Amharic[1] stands for naturally fermented (sour) milk and prepared at home), 6) cottage cheese (is also called *ayib* in Amharic. It is prepared from defatted milk left after the butter has taken out, locally known as *arera* after gently heating the defatted milk), 7) cottage butter (is the immediate output of churning cottage yoghurt at home using clay pot or Jerry cans) and) 8) factory cheese. However, the proportion of the consumers who bought factory cheese was small (9%) and only the remaining seven dairy products that were purchased and consumed by more than 10% of the households were considered to model the purchase behaviour of the dairy product consumers.

The fact that several dairy products are available to be chosen from by a consumer, leads to the use of multiple-category (polychotomous) responses or dependent variables to model consumer's dairy product choice behaviour (Gujarati and Porter, 2009). Multinomial logit (MNL), multinomial probit model (MNP), multivariate logit (MVL) and MVP are among such models that are appropriate to estimate such unordered multinomial response. However, MNL and MNP models based on the assumption that a consumer 'pick-any' product (choice is independent and mutually exclusive) at a time which is not work in the real world (Walsh, 1995; Dube, 2004). In reality, consumers usually 'pick any' product (multiple products that can be interdependent) at a time (Chandukala *et al*., 2007; Kim *et al*., 2007; Mehta, 2007; Mehta and Ma, 2012; Aurier and Mejia, 2014).

Therefore, when alternatives are not mutually exclusive and correlated error terms of the alternatives are expected, the appropriate econometric model are the MVL and MVP models, but the MVP model is widely used in literature. In this study, households can purchase more than one dairy product (meaning alternatives are not mutually exclusive) and the decision to purchase one dairy product can be correlated with the purchase decision of other dairy products or the error terms can be correlated which means the unobserved factors that determine choice can be correlated. Hence, the MVP is more appropriate and was used to investigate determinants of dairy products purchase decision of the sample households. The limitation of this model is that it needs computers with high processing capacity for several equations. In this study seven equations were dealt with and hence it took several hours to run in Stata 15 software. Based on Greene (2012), the MVP model can be specified as:

$$Y_m^* = X_m'\beta_m + u_m, Y_m = 1 \text{ if } Y_m^* > 0, 0 \text{ otherwise}, m = 1, \ldots M$$

$$E[u_m|X_1, \ldots, X_M] = 0$$
$$\text{Var}[u_m|X_1, \ldots, X_M] = 1$$
$$\text{Cov}[u_j, u_m|X_1, \ldots, X_M] = \rho_{jm},$$
$$(u_1, \ldots \ldots \ldots u_M) \sim N_M[0, R] \qquad (4)$$

[1] Ethiopian federal official language which is one of the most commonly spoken languages of the 83 languages in the country

Where Y_m^* and Y_m are the latent dependent variables and actual observations relating to the latent dependent variables, respectively, X_m' is a matrix of covariates, β_m are matrix of unknown parameters to be estimated, u_m are error terms, $\mathbf{R}$ is the variance-covariance matrix and ρ_{jm} are the off-diagonal elements in correlation matrix that represent the unobserved correlation between the stochastic component of the jth and mth options.

The joint probabilities of the observed events $[y_{i1}, y_{i2}, \ldots y_{iM} | \mathrm{X}_{i1}, \mathrm{X}_{i2}, \ldots \mathrm{X}_{iM}]$, *i* =1, ..., n, that forms the basis for the likelihood function are the M-variate normal probabilities Green (2012) is given by:

$$L_i = \Phi_M(q_{i1}\mathrm{X}_{i1}'\beta_1, \ldots \ldots, q_{iM}\mathrm{X}_{iM}'\beta_M, \mathbf{R}^*), \quad (5)$$

Where,

$$q_{iM} = 2y_{iM} - 1$$
$$R_{jM}^* = q_{ij}q_{iM}\rho_{jm}$$

Where ρ_{jm} is the correlation between ϵ_j and ϵ_m. The distributions are independent if and only if ρ_{jm} = 0. If that is the case, one can use a binary probit model for each equation instead of MVP.

The simulated maximum likelihood (SML) methods of the Geweke–Hajivassiliou–Keane (GHK) simulator was used to estimate the above system of equations because of the numerical complexity of estimating integrals under the multivariate normal (Gates, 2006).

Description of variables used in the econometric model

Based on economic theories, related literature and past findings, description of explanatory variables along with their expected signs is given in Table 2. The data analysis was performed using Stata version 15 software.

RESULTS AND DISCUSSION

Characteristics of the sampled dairy product consumers

Table 3 presents the descriptive results of variables included in the econometric model. The result shows that the average age of the household head, who makes household level decisions, was 48 years. The sample households were on average composed of 3.6 family members (converted into consumption unit). The result further indicated that only 10% of the households had a monthly income of 8,000ETB ($289 at 0.036 average exchange rate of 2018) or more per household, 27% had completed 12th grade education level, 43% had children of age seven years or below, and 77% were aware that consuming raw milk is a risk factor for zoonotic diseases in general. The result presented in Table 2 also indicated that the majority of the sampled households followed the religion of Orthodox Christianity which accounted for 78.9%, followed by Muslims (13.8%), Protestant (6.8%) and the rest 0.5% were Catholic.

Table 2. Description of explanatory variables included in the MVP model

Variables	Description and measurement	Expected sign
Religion-orthodox	Dummy variable (Yes=1; No=0)	-
Age of household head	Age of household head (measured years)	+/-
Education grade ≥12	Dummy variable (Yes=1; No=0)	+
Children < 7 years	Dummy variable (Yes=1; No=0)	+
Family size	Number (measured in consumption unit*)	+
Income >8000 Birr	Dummy variable with a monthly income (Yes=1; No=0)	+/-
Aware of risk	Aware of the risk of consuming raw milk (Yes=1; No=0)	+/-
Functional value: price	Expressed in statements indicating price	+
Functional value: taste	Expressed in statements indicating taste	+
Social value	Expressed in statements indicating social values	+
Conditional value	Expressed in statements indicating conditional values	+
Emotional value	Expressed in statements indicating emotional values	+
Epistemic value	Expressed in statements indicating epistemic values	+

** Conversion factor to consumption unit is given in Appendix Table 2. Note: all consumption value variables are measured in 1-5 Likert scale with 1=strongly disagree, 2=disagree, 3=indifferent, 4=agree, and 5=strongly agree.*

In terms of the consumption values that the respondents attribute for dairy products (using the Likert scale), the result indicated that functional values (taste and price), social value, emotional value, conditional value, and epistemic value received average scores of 3.9, 4.4, 3.0, 4.0, 2.7 and 3.4 points, respectively, implying that the sample households tended to agree to the consumption value indicators of functional values of taste and price, and emotional value. On the other hand, the sample households were found to be neutral on the indicator for social value and did slightly disagree on conditional value with an

average value of 2.7. On epistemic value, the average sample households did slightly agree (score 3.4) and that was also the case for the overall consumption value (score 3.7).

Determinants for purchase decision of dairy products

Factors affecting the decision to purchase different dairy products in Addis Ababa city were assessed using the MVP econometric model. Table 5 shows the model estimates and the correlation coefficient matrix. The overall fitness of the model was assessed using appropriate tests. First, using the Wald Chi-square statistic, the explanatory variables included in the model were tested for their significance and the result showed that the variables jointly explained the model at 1% level of significance (Wald chi2 (91) = 195.83, p = 0.000). Second, the goodness-of-fit of the MVP model was verified through the likelihood ratio test that the null hypothesis of independence between the dairy products purchase decision was rejected (Chi^2 (21) = 74.87, p = 0.000). This implies that estimating a separate binary probit model for each of the seven dairy products is inappropriate and leads to biased estimates. Overall, these specification tests justify the appropriateness of the MVP model to identify determinants of dairy products purchase decision of the sample consumers.

Dairy products purchasing and consumption practices

Cottage butter was bought by most of the surveyed households followed by pasteurized milk, cottage cheese and raw milk in Addis Ababa while factory cheese was purchased only 9% of the surveyed households (Table 4). The average annual per capita dairy products consumption converted in liquid milk equivalent (LME)[2] was 89litres/CU. In terms of the quantity of annual per capita consumption of specific dairy products, raw milk was the highest followed by butter and powdered milk while the lowest was cottage cheese. Cottage butter was purchased by the majority of the households followed by pasteurized milk, cottage cheese, and raw milk whereas factory cheese was purchased only by 9% of the sampled households.

The result further indicated the existence of differences in dairy product purchase decisions among the sample dairy products consumers as indicated in the likelihood ratio statistic presented in Table 4. The correlation coefficient (ρ_{ij}) measures the correlation between a pair of dependent variables. The correlation coefficients between pasteurized milk and raw milk (ρ_{21}), cottage butter and pasteurized milk (ρ_{72}), cottage butter and powdered milk (ρ_{73}) and cottage and factory yoghurts (ρ_{54}) were found to be negative and significant at different probability levels. An explanation to ρ_{21} and ρ_{54} is that the two milk products (pasteurized and raw milk) and the two types of yoghurt (cottage and factory) are substitute products. From the consumers' point of view, these products are quite similar and one can substitute for the other. However, from a zoonotic risk perspective, pasteurized milk and factory yoghurt are safe to consume as they are expected to pass through adequate high-temperature treatment that destroys bacteria. However, the significant negative correlation coefficients between butter and the two factory processed milk products (pasteurized and powdered), can be explained by a possible trade-off between pasteurized/powdered milk consumption and butter due to shortage of disposable income to purchase all at a time as all these products are relatively expensive as explained in the descriptive analysis part.

On the contrary, the correlation coefficients between pairs of seven dairy products, namely powdered milk and raw milk (ρ_{31}), cottage yoghurt and raw milk (ρ_{51}), factory yoghurt and pasteurized milk (ρ_{42}), cottage cheese and pasteurized milk (ρ_{62}), cottage yoghurt and powdered milk (ρ_{53}), cottage butter and factory yoghurt (ρ_{74}) and cottage butter and cottage cheese (ρ_{76}) were positive and significant. A positive and significant correlation coefficient between powdered milk and raw milk indicated the supplementary or substitution effect between the two products. This is especially true when there is a shortage or an interruption of raw milk supply. Specially, households who have children less than seven years old depend on powdered milk as their second alternative to supplement any supply shortage of raw milk because milk is an important diet for children (Wiley, 2005; Dror and Allen, 2014).

[2] LME conversion factor is given in Appendix Table 1.

Continuous variables	Mean	Std. Dev.
Age of the household head (years)	48	15.3
Family size (consumption unit or CU in short*)	3.6	1.6
Consumption values using the following statements (1-5 Likert scale)**	3.7	0.4
Functional value - taste: 'dairy products taste good'	3.9	1.0
Functional value - price: 'dairy products are expensive'	4.4	0.8
Social value (average of the following two statements): 'Most people important to me, think that I should buy dairy products'; 'Buying dairy products because of my family/friends' consumption'	3.0	1.1
Emotional value (average of the following four statements): 'Dairy products consumption is interesting'; 'Dairy products consumption makes me and my family feel good'; 'Dairy products consumption gives me and my family pleasure'; 'Dairy products consumption makes me and my family feel relaxed'	4.0	0.5
Conditional value: 'I would buy dairy products when available'	2.7	1.2
Epistemic value (average of the following two statements): 'I would acquire a great deal of information about the different makes and models before buying the product'; 'I like to search for the new and different goods in general'	3.4	0.9
Dummy variables (Frequency and % of Yes)	**Freq.**	**%**
Children < 7 years	165	43.0
Religion_ Orthodox Christian[3]	303	78.9
Other religions [(Muslim (13.8%), Protestant (6.8%), Catholic (0.5%)]	81	21.1
Income ≥8000 ETB***	37	10.0
Education ≥12 grade	102	27.0
Aware of risk of consuming raw milk	295	76.8

Conversion factor for CU is given in Appendix, **1=certainly disagree, 2=disagree, 3=indifferent, 4=agree, and 5=certainly agree, and *** which is considered as an average household income per month in Ethiopia (salaryexplorer.com).

Table 4. Buyers' preferences for and volume of purchases of specific dairy products, 2018

	Buyers of dairy products		Volume purchased and consumed in LME (L/CU)	
Dairy product types	**N**	**%**	**Mean**	**Std. Dev.**
Cottage butter	361	94	31.6	27.2
Pasteurized milk	283	73	17.8	24.5
Cottage cheese	245	64	9.8	14.5
Raw milk	175	46	18.1	31.5
Factory yoghurt	99	26	4.9	13.0
Powdered milk	47	12	3.3	12.0
Cottage yoghurt	44	11	1.8	7.5
Factory cheese	36	9	1.8	7.5
Total dairy products	**384**	**100**	**89.2**	**65.0**

[3] Most of the dairy products considered here are perishable except the cottage butter that can be processed into ghee (*niter kibe*) and hence cannot be stored for a long time. Therefore, the purchase of these products is immediately followed by consumption. As a result, the effect of fasting by Orthodox Christians is expected to have a direct consequence on the purchase of such products.

Similarly, a positive correlation coefficient between cottage yoghurt and raw milk (ρ_{51}) also indicated the supplementary nature of the two products. This is because both of the products are consumed in different forms. Likewise, a positive correlation coefficient between two factory products - factory yoghurt and pasteurized milk (ρ_{42}) - showed the supplementary nature of the two dairy products. Furthermore, a positive correlation coefficient between cottage cheese and pasteurized milk (ρ_{62}), cottage yoghurt and powdered milk (ρ_{53}), cottage butter and factory yoghurt (ρ_{74}), and cottage butter and cottage cheese (ρ_{76}) revealed the supplementary or complementary nature of these products. The positive interdependence between different dairy products is due to the fact that different dairy products are consumed for different purposes and in different forms in Ethiopia (Yilma et al., 2011).Using MVP model that accounts for the interdependence of decisions is important when there are correlations among multiple-choice equations instead of regressing a separate binary probit model for each dairy product purchase decision. The model results confirmed that dairy product consumers decided to purchase a bundle of dairy products that have complementary, supplementary or substitution nature that offered them higher utility in combination as observed from the significant correlation coefficients between different dairy products.

The MVP model showed that the estimated probabilities of the sampled consumers' decision to purchase dairy products had a likelihood of 45% for raw milk, 73% for pasteurized milk, 12% for powdered milk, 26% for factory yoghurt, 11% for cottage yoghurt, 64% for cottage cheese, and 94% likelihood for cottage butter. That is, the probability of purchasing cottage butter was the highest, followed by pasteurized milk and cottage cheese while that of purchasing cottage yoghurt was the lowest followed by powdered milk. The likelihood of the consumers to jointly choose all the seven dairy products was only 0.31% whereas the joint probability of failure to choose (not purchasing) all the seven products simultaneously was 0.37% implying that the probability of purchasing all the seven dairy products or none of the dairy products in a year was very low.

The MVP model result presented in Table 5 further showed that most of the explanatory variables included in the econometric model had a significant effect on the probability of the households' purchasing decision of one or more dairy products. The result indicated that Orthodox Christian households were more likely to purchase raw milk, but less likely to purchase pasteurized milk and cottage cheese compared to other religion followers. The explanation for this can be the fact that the fasting seasons of Orthodox Christians occur in several periods and these consumers may prefer to consume fresh (raw) milk after the fasting seasons as dairy consumers believe that raw milk is more original (more organic) than processed milk. A recent study conducted in Ethiopia on the effect of religion on milk consumption confirmed that Orthodox Christians fasting adversely affects milk consumption in Ethiopia (D'Haene et al., 2019).

Older household heads were less likely to buy pasteurized milk, but more likely to buy cottage butter. In contrast, younger household heads preferred factory processed fluid milk that might be related to changes in the lifestyle. Older household heads tend to prefer cottage butter which might be related to their long-term habits. This result is consistent with the findings by Akbay and Tiryaki (2008) who reported a negative impact of age of the household head on preference of pasteurized milk and the findings of Yayar (2012) who also reported its negative impact on the probability of consuming packed fluid milk in Turkey. It is also congruent with the finding by Fu and Florkowski (2016) who reported a positive impact of age of the household head on the likelihood of butter consumption in Poland.

Educated household heads were more likely to purchase cottage cheese and factory yoghurt. This might be because more educated household heads could acquire more knowledge of the health benefits of processed dairy products, be able to understand health information and generate higher disposable income to buy cheese and yoghurt compared with less educated household heads. The implication is that education helps to reduce the likelihood of consuming unsafe dairy products (made from raw milk) and hence reduce the risk of getting infected with zoonotic diseases such as bTB. This result is consistent with the finding of Bashir (2011) who reported a positive impact of education on cheese and yoghurt consumption in Turkey. Similarly, Rossini *et al*. (2015) also observed that the educational level of the household head had a positive effect on both the probability of consumption and the quantity of cheese consumed in Argentina. Likewise, Fu and Florkowski (2016) also found that education was positively associated with the likelihood of consuming yoghurt in Poland.

Another important result of this study is that the presence of children less than seven years old in the household was found to increase the probability of purchasing raw milk, powdered milk, and cottage butter. These households fed their children with the raw milk usually after boiling and the powdered milk in liquid form after shaking with water. This result is akin to the findings by Fu *et al*. (2014) and Fu and Florkowski (2016) who found a positive and significant relationship between the presence of children and the likelihood of consuming whole milk, yoghurt, low-fat milk, and butter.

Larger family had higher likelihood of purchasing processed products such as pasteurized milk, cottage cheese and cottage butter. One explanation for this is that there is a probability of more family members earning income which leads to enhanced purchases of the family as they have higher purchasing power of expensive dairy products. However, in households where there is a single earner, the purchasing power would likely be lower and the purchasing decisions generally made after considering important needs first and then go for

more expensive (processed) dairy products based on their priorities. Another reason might be related to the diversified knowledge of the family members on the importance of processed dairy products. That is, in a larger family, there might be a probability that some of the family members have awareness on the importance of consuming processed dairy products to reduce the risk of zoonotic disease impact.

Previous findings on the relationship between household size and processed dairy products are mixed and location specific. The findings by Cornick *et al*. (1994) indicated that household size had a positive impact on the expenditure on skimmed milk, fat-reduced milk and whole milk in the United States. Similarly, Davis *et al*. (2010) reported a positive impact of household size on processed cheese, whole milk, canned milk and Sherbet/ice milk in the United States. Rossini *et al*. (2015) also found that household size had a positive impact on the quantity of cottage cheese purchased in Argentina. Hsu and Kao (2001) also saw a positive relationship between household size and the purchase decision of flavoured milk and yogurt drinks in Taiwan.

However, our finding contradicts the finding by Akbay and Tiryaki (2008) who found a negative impact of household size on pasteurized milk preference, Yayar (2012) who reported a negative impact of household size on the consumption of packed dairy products in Turkey and the finding by Fu and Florkowski (2016) who reported a negative relationship between family size and butter consumption in Poland. The contradiction might be due to cultural differences and/or differences in other consumption factors in those countries.

Households with higher income had higher probability of purchasing raw milk. The explanation for this can be related to the raw milk marketing system in Ethiopia that is usually purchased on a monthly contractual basis from producers who prefer to sell their raw milk to consumers who purchase it continuously (Asfaw, 2009). This needs consumers to allocate permanent budget for raw milk purchase whereas other processed dairy products can be purchased at supermarkets at any time when extra income is earned. The implication is that households with higher income can permanently allocate budget for raw milk. However, if the purchased raw milk is infected with zoonotic pathogens and not heat treated, there is a risk of getting zoonotic diseases by consuming it. This result is concurrent with previous similar studies. For instance, Alwis *et al*. (2009) attested the positive impact of household income on consumption of fresh milk (raw milk in their context) in Sri Lanka. It is also in line with the finding of Quang (2019) who reported the positive impact of income on the probability of participation and volume of consumption of fresh milk (raw milk) in Vietnam. Similarly, Njarui *et al*. (2011) found that consumers with higher income group were positively associated with raw milk consumption in Kenya. Similar result has been reported in Ethiopia which showed that increased income results in increased consumption of dairy products by 50% (Abegaz et al., 2018).

All the consumption value indicators had a significant impact on the likelihood of purchasing one or more dairy products. In general, functional values (taste and price) were found to decrease the probability of purchasing and consuming processed dairy products while all other consumption value indicators were positively associated with the probability of purchasing either processed or unprocessed dairy products. Specifically, households with higher score of functional value taste were less likely to purchase four of the seven dairy products, namely: pasteurized milk, powdered milk, cottage yoghurt, and cottage cheese. This suggests that the taste of unprocessed dairy products, such as raw milk, is an important factor when dairy consumers in Addis Ababa are purchasing dairy products.

Households who perceived that 'dairy products are expensive' (functional value price) were less likely to purchase processed dairy products such as pasteurized milk, factory yoghurt, cottage yoghurt and cottage butter. This likely means that consumers are price sensitive, and their probability of purchasing would be higher if dairy products would be cheaper. This price sensitive behaviour for dairy products could also be due to the low level of household income as only 10% earned greater than 8000 Ethiopian Birr (Table 2). This observation aligns with the finding of Abegaz *et al*. (2018) who reported own price elasticity of dairy products to be (-0.45), which implies that an increment of the price of dairy products by one unit would lead to a decrement of consumption by 0.45 in Ethiopia. This result agrees with other similar study results previously reported on the impact of price of dairy products (Ares *et al*., 2010; Cerjak and Tomic, 2015; Rahnama and Rajabpour, 2017).

The social value indicator was found to increase the probability of buying and consuming pasteurized milk, factory yoghurt and cottage cheese, implying that social influences like expectation and opinion of families, friends and neighbours had positive effect on purchasing processed dairy products. As these products are relatively safe to consume compared to the unprocessed raw milk, this consumption behaviour has positive effect on reducing zoonotic diseases transmission. This finding is consistent with result reported by Rahnama and Rajabpour (2017) who found a positive relationship between social value and certain dairy products (yoghurt, milk, cheeses, cream, butter, and doogh) consumption in Iran.

Another consumption value variable that had a significant positive effect on the probability of purchasing dairy products was emotional value. Households, who thought that consuming dairy products is interesting, makes them feel good, relaxed, and gives them pleasure, were more likely to purchase dairy products such as raw milk, pasteurized milk and cottage cheese. The positive relationship between dairy product consumption and emotional value has also been confirmed by the previous finding reported by Rahnama and Rajabpour (2017) for Iranian dairy product consumers and by Johansen *et al*. (2011) who reported that emotions like cheers up, cope up with

stress, and feel good had a significant positive impact on choosing dairy products.

Conditional value (availability) was positively associated with a higher probability of purchasing and consuming pasteurized milk which is safe to consume as compared to raw milk. Therefore, increasing the availability of pasteurized milk would increase the probability of shifting dairy product consumers from raw milk (which is associated with a higher transmission risk of zoonotic disease) to pasteurized milk. Moreover, increased production of pasteurised milk might also reduce the price which would also drive the consumption. Previous findings also confirmed that conditional value is positively associated with dairy products that are safe for human health. For instance, the finding published by Johansen *et al*. (2011) reported a positive association between the conditional value of consumers and motivation for the choice of calorie-reduced dairy products that are perceived to be healthier than whole milk. Similarly, a study conducted by O'Connor *et al*. (2005) found a positive relationship between conditional value and the level of acceptance of a hypothetical genetically modified dairy spread that reduces cholesterol by Irish consumers.

Epistemic value (knowledge) was positively associated with a higher probability of purchasing processed dairy products such as powdered milk and factory yoghurt. That is, households with higher epistemic value tended to purchase dairy products that are safer to consume than raw milk products. This result agrees with the finding of Rahnama and Rajabpour (2017) who found a positive relationship between epistemic value and consumption of dairy products in Iran.

CONCLUSIONS

In this study, dairy product consumption behaviour of Addis Ababa city households was investigated using cross-sectional data collected from randomly selected sample households. Determinants of dairy product purchase decisions were investigated. The result shows that cottage butter, pasteurized milk, cottage cheese and raw milk were the most common dairy products purchased and consumed by the majority of Addis Ababa consumers.

The multivariate probit model results confirmed the interdependence of decisions made by consumers when purchasing and consuming dairy products that have different risk levels for consumers. This interdependence was due to the fact that the dairy products purchased in Addis Ababa were either of complementary or substitution nature. Therefore, rather than focusing on a single dairy product, such as raw milk, it is important to take into consideration that consumers go for a bundle of decisions when they purchase dairy products, and this may have implications on how to design policies for zoonotic disease control that should aim to improve quality and safety of dairy products in Ethiopia. The model results further showed that demographic variables such as religion, age and education of the household head, presence of children and family size; economic variables such as income; and consumption value variables including functional, social, emotional, conditional, and epistemic values had a significant impact on dairy product purchase decision taken by consumers in Addis Ababa.

The result of this study may have implications for authorities who are concerned about public health, for the dairy industry at large and for consumers, among others. The implication for the authorities is that raw dairy products are still widely purchased and consumed despite the risk associated with consuming such dairy products. Therefore, public health policies that target to control zoonotic diseases such as bTB can focus on two policy options. First, awareness creation on risk of consuming raw milk and consumption of milk after boiled at an appropriate temperature, at least as a short-term policy option. Second, awareness creation to traders handling milk products and to consumers. The long-term policy direction should focus on shifting consumers to processed dairy products that serve as a substitution for raw dairy products as one of the policy directions. This can be achieved by shifting milk marketing from informal to formal milk marketing. In this study, the proportion of consumers who were already purchasing pasteurized milk was higher than for those who are purchasing raw milk.

Table 5. Multivariate probit results on determinants of dairy products purchase decision

Variables	**Raw milk**	**Pasteurized milk**	**Powdered milk**	**Factory yoghurt**	**Cottage yoghurt**	**Cottage cheese**	Cottage butter
	Coeff. (SE.)	**Coeff. (SE.)**	**Coeff. (SE.)**	**Coeff. (SE.)**	**Coeff. (SE.)**	**Coeff. (SE.)**	Coeff. (SE.)
Religion (orthodox)	0.34 (0.169)**	-0.351 (0.193)*	-0.194 (0.207)	-0.129 (0.180)	-0.064 (0.229)	-0.387 (0.178)**	-0.498 (0.346)
Age of head	-0.005 (0.005)	-0.011 (0.005)**	-0.002 (0.007)	0.001 (0.005)	0.007 (0.007)	0.008 (0.005)	0.021 (0.009)**
Education of head	-0.115 (0.169)	0.104 (0.185)	0.214 (0.215)	0.356 (0.173)**	0.172 (0.216)	0.443 (0.173)**	0.108 (0.268)
Children	0.51 (0.15)***	-0.099 (0.161)	0.63 (0.194)***	-0.042 (0.158)	-0.116 (0.201)	-0.186 (0.151)	0.439 (0.239)*
Family size	0.015 (0.045)	0.107 (0.052)**	-0.005 (0.063)	-0.072 (0.050)	0.011 (0.062)	0.099 (0.047)**	0.146 (0.082)*
Income	0.71 (0.25)***	0.012 (0.278)	0.145 (0.324)	-0.284 (0.272)	0.122 (0.308)	-0.140 (0.258)	3.23 (104.7)
Awareness	-0.102 (0.161)	0.034 (0.173)	-0.033 (0.218)	-0.202 (0.172)	0.022 (0.225)	0.080 (0.165)	0.042 (0.245)
Functional value-taste	0.007 (0.073)	-0.21 (0.079)***	-0.159 (0.093)*	-0.022 (0.078)	-0.27 (0.107)***	-0.309 (0.08)***	-0.089 (0.120)
Functional value-price	0.058 (0.085)	-0.204 (0.098)**	0.014 (0.108)	-0.147 (0.088)*	-0.314 (0.11)***	-0.083 (0.090)	-0.315 (0.185)*
Social value	0.064 (0.065)	0.238 (0.068)***	-0.087 (0.084)	0.181 (0.071)**	0.082 (0.094)	0.109 (0.065)*	-0.044 (0.101)
Emotional value	0.28 (0.14)**	0.258 (0.142)*	-0.20 (0.179)	0.205 (0.155)	-0.114 (0.179)	0.259 (0.141)*	0.074 (0.221)
Conditional value	0.032 (0.058)	0.133 (0.062)**	0.003 (0.075)	-0.021 (0.063)	-0.063 (0.080)	-0.0001 (0.058)	-0.105 (0.096)
Epistemic value	0.061 (0.083)	0.093 (0.087)	0.232 (0.120)*	0.166 (0.092)*	0.179 (0.121)	0.082 (0.083)	0.101 (0.128)
Constant	-2.26 (0.8)***	0.361(0.830)	-0.535 (0.982)	-1.417 (0.858)*	0.486 (1.040)	-0.171 (0.790)	1.881 (1.322)
Pred. probability	0.45	0.73	0.12	0.26	0.11	0.64	0.94

Correlation matrix

Rho	Estimate (SE)	Rho	Estimate (SE)	Rho	Estimate (SE)	Rho	Estimate (SE)
ρ_{21}	-0.3 (0.1)***	ρ_{32}	-0.09 (0.11)	ρ_{43}	0.09 (0.09)	ρ_{64}	0.06 (0.09)
ρ_{31}	0.18 (0.10)*	ρ_{42}	0.23 (0.09)***	ρ_{53}	0.26 (0.11)**	ρ_{74}	0.27 (0.14)*
ρ_{41}	-0.06 (0.09)	ρ_{52}	-0.18 (0.11)	ρ_{63}	0.07 (0.09)	ρ_{65}	0.16 (0.10)
ρ_{51}	0.32 (0.1)***	ρ_{62}	0.31 (0.08)***	ρ_{73}	-0.28 (0.15)**	ρ_{75}	-0.03 (0.17)
ρ_{61}	0.04 (0.08)	ρ_{72}	-0.23 (0.13)*	ρ_{54}	-0.19 (0.11)*	ρ_{76}	0.39 (0.12)***
ρ_{71}	0.05 (0.13)						

Model fit

Likelihood ratio test of independence $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{51} = \rho_{61} = \rho_{71} = \rho_{32} = \rho_{42} = \rho_{52} = \rho_{62} = \rho_{72} = \rho_{43} = \rho_{53} = \rho_{63} = \rho_{73} = \rho_{54} = \rho_{64} = \rho_{74} = \rho_{65} = \rho_{75} = \rho_{76} = 0$, Chi2(21) = 74.87, Prob > chi2 = 0.0000, Joint probability (success) = 0.0031, Joint probability (failure) = 0.0037. Observation =384, Wald chi2(91) = 195.83 ***, Log likelihood = -1169.85***, Joint probability (success) = 0.0031, Joint probability (failure) = 0.0037

Note: Each coefficient is named based on the following codes: 1=raw milk; 2=pasteurized milk; 3=powdered milk; 4=factory yoghurt; 5=cottage yoghurt; 6=cottage cheese; 7=cottage butter

***, **, and * means statistically significant at 1%, 5%, and 10% level of significance, respectively.

This is because the urban dairy consumers in Addis Ababa have more access to pasteurized milk supply.However, the opposite is true for urban and peri-urban dairy producers where only 10% purchased pasteurized milk (Tilaye *et al*., 2022). This has a clear implication for the dairy processing industries and for investors who like to expand or invest in milk pasteurization plants. Finally, to avoid consumption of unprocessed dairy products by shifting towards consumption of safer dairy products is in the hands of many consumers. Such a shift can have an impact on their health but may not be prioritised unless these safer products are available at a relatively fair price. The information generated by this study can help the Ministry of health and the public health institute policymakers to design more effective policies on dairy product consumption that target to promote new nutritional policies useful for healthier life nationwide. It may also help the Ethiopian dairy industry to design effective marketing strategies to modernize dairy marketing by recognizing the driving forces behind dairy product consumption. Finally, the finding in this research may help as a basis for policy formulation in other developing countries that share similar socio-demographic, economic characteristics, and levels of dairy development with Ethiopia.

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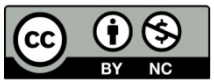

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