Consumption of functional dairy foods in Northern Tamil Nadu: Pattern and key drivers

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Abstract

The study conducted in the northern parts of Tamil Nadu has analysed the consumers' consumption pattern and the factors moderating consumption of functional dairy foods (FDFs) based on the data collected from 220 respondents (160 consumers and 60 sale points). The study has used tabular and frequency analyses for consumption pattern and double-hurdle model along with tobit model (for comparison) for factors moderating consumption analysis. It has found that 84 per cent of respondents were aware of FDF foods, with television advertisements being their primary source of information. The average monthly per capita consumption was 3.6 litres in terms of milk equivalent quantity which was 33.43 per cent of the total per capita milk availability in Tamil Nadu. The FDFs are still in the early stages of adoption, with fortified milk showing the highest potential. It has also found that factors like income, price, occupation, dietary habits, family size and location significantly influence the consumption expenditure on FDFs. Addressing these factors could facilitate broader adoption and integration of FDFs into consumers' diets.

Key words: Functional dairy foods, double-hurdle model, tobit model, probiotic foods, fortified foods, Tamil Nadu, consumption pattern

JEL codes: D10, J10, M30, Q18

Introduction

Now-a-days, the food serves purposes beyond hunger satisfaction and provision of essential nutrients; it is also designed to prevent nutrition-related diseases and enhance physical and mental well-being of consumers. The evolving dietary patterns, rise in the per capita availability of milk, expansion in the demography of individuals with elevated income levels and the increasing awareness among Indian consumers have led to the diversification of the dairy sector. The consumers now look beyond basic products such as pouched milk and occasional butter or cheese spreads, prompting a growing emphasis on value addition in dairy products. This shift has fostered the development of a functional dairy food industry in the country.

The functional foods (sometimes referred to as physiologically functional foods, nutraceuticals, designer foods or pharmafoods) are those food items or food components that enhance healthcare by regulating or influencing certain physiological processes, besides ensuring the essential nutrition to human beings (Grujić and Grujčić, 2023). The term 'functional food' was introduced in Japan in the mid-1980s for food products fortified with special constituents that produce advantageous physiological effects (Robu *et al*., 2022). In 1994 the Institute of Medicine's Food and Nutrition Board defined functional food as: "Any

food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains".

The dairy industry plays a significant role in the development of functional foods. The functional dairy products primarily originate from milk that has been adequately shown to positively impact one or more specific functions in the body. This goes beyond basic nutritional effects, significantly improving health and well-being, and/or lowering the risk of diseases (Rani *et al*., 2022). Nowadays, consumers focus on nutritional content and health benefits of functional dairy foods, including vitamin/mineral enriched milk, milk containing omega-3 fatty acids, probiotic cheese or yogurt, and low-fat milk products (Peng *et al*., 2006). Several studies have demonstrated various health benefits of these products, including a reduced risk of hypertension (Alonso *et al*., 2005; Toledo *et al*., 2009), *Diabetes mellitus* (Liu *et al*., 2006), and coronary heart diseases (Hu *et al*., 1999). Globally, the functional dairy food market, valued at USD 44 billion, is projected to experience a Compound Annual Growth Rate (CAGR) of 4.5 per cent from 2023 to 2033, potentially reaching USD 67.1 billion by 2033 (Choudhury, 2023). In India, the functional dairy food market is anticipated to grow at a rate of 5.7 per cent from 2022 to 2032 (Shireen and Aneesh, 2021). However, studies on the consumer awareness and consumption habits towards functional dairy foods are extremely uncommon in India and virtually absent in Tamil Nadu. Therefore, the present study was undertaken to explore the level of awareness, current consumption patterns and key factors moderating the consumption of functional dairy foods in the northern part of Tamil Nadu state.

Data and Methodology

The study was conducted in the northern part of Tamil Nadu due to the region's concentration of dairy industries and its well-developed dairy supply chain infrastructure. For this study, both Chennai and Salem districts were purposively selected. As a metropolitan city, Chennai has a well-established awareness of health considerations among consumers, along with a strong supply network for functional dairy foods. The Salem district, leads in average daily milk sales (1.86 LLPD (lakh litres per day)) among district unions and ranked first in daily milk procurement (5.13 LLPD) by the district cooperative milk producers' union for the year 2021-2022 (Animal Husbandry, Dairying, Fisheries and Fishermen Welfare Department, 2022). The study is based on both primary and secondary data. The primary data were collected by direct personnel interview method using a well-developed and pre-tested structured interview schedule. A total of 160 respondents were selected randomly from different purchase locations equally in both the districts' urban/semi-urban and rural areas. The supply chain intermediaries (60 sale points equally in both districts' urban/semi-urban and rural areas) were also selected using random sampling method. The sale of functional dairy foods (agencies, quantities, prices) from sellers were also collected using semi-structured interview schedule. The secondary data on information about functional dairy foods, market players and different products details, etc., were collected from various published articles and websites.

The analytical tools used in the study were tabular and frequency analyses for consumption pattern as well as awareness and double-hurdle model for factors influencing consumption expenditure on various functional dairy foods. The entire sample of households was stratified into three distinct income groups using a cumulative square root frequency approach (Dalenius and Hodges, 1957).

Double-Hurdle Model

For this study, the double-hurdle model was preferred over the tobit model due to the latter's inherent assumptions about the nature of zero expenditures. The tobit model assumes that zero consumption arises solely from corner solutions — economic decisions in which certain exogenous factors lead to non-consumption. However, this framework does not account for situations where zero expenditures result from factors unrelated to economic constraints, such as infrequency of purchase, social or psychological preferences, or ethical considerations (Deaton and Irish, 1984; Jones, 1989). For instance, vegetarians abstain from meat for reasons other than price, and many non-smokers would refrain from smoking even if tobacco were free (Atkinson, Gomulka, and Stern, 1990; Garcia and Labeaga, 1996). Given this limitation, the double-hurdle model offers a more flexible approach by allowing for two distinct processes that can result in zero expenditures. First, it models the consumer's discrete decision to participate in the market, and second, it analyzes the continuous decision regarding the quantity to purchase.

The Hurdle models (Cragg,1971) are characterized by the relationship as per Equation (1)

$$y_i = s_i h_i^* \qquad \ldots (1)$$

where, y_i is the observed value of the dependent variable which is per capita consumption expenditure on functional dairy foods (₹/day).

The selection variable, s_i, is 1 if the dependent variable is not bounded and 0, otherwise. In the Cragg model, the lower limit that binds the dependent variable is 0 and the selection model is shown in Equation (2)

$$s_i = \begin{cases} 1 & if\, z_i\gamma + D_i\delta + \varepsilon_i > 0 \\ 0 & otherwise \end{cases} \qquad \ldots (2)$$

where z_i and D_i are vectors of explanatory variables and dummy explanatory variables, respectively as follows: z_1 = Family size (No.), z_2 = log of monthly family income (₹), D_1 = Occupation of household head (0= Business, 1= Salaried employment, 2= Self-employment), D_2 = Area of household location (0= Rural, 1= Urban/Semi-urban), D_3 = District of household location (0= Chennai, 1= Salem), D_4 = Food habit (0= non-vegetarian, 1= vegetarian), γ and δ are vectors of coefficients of z_i and D_i, respectively and ε_i is the standard normal error-term.

The continuous latent variable h_i^* is observed only if s_i = 1. The outcome model can be either the linear model or the exponential model, as proposed in Cragg model (1971) and is shown in Equation (3)

$$\begin{aligned} h_i^* &= x_i\beta + \vartheta_i && \text{(linear)} \\ h_i^* &= \exp\,(x_i\beta + \vartheta_i) && \text{(exponential)} \end{aligned} \qquad \ldots (3)$$

where x_i is the vector of explanatory variables as follows: x_1 = log of monthly family income (₹), x_2 = log of monthly food expenditure (₹), x_3 = log of monthly non-food expenditure (₹), x_4 = Price of functional dairy foods (₹), β is a vector of coefficients of x_i and ϑ_i is the error-

term and $\vartheta_i \sim N(0, \sigma^2)$. For the linear model, ϑ_i has the truncated normal distribution with lower truncation point $x_i\beta$. For the exponential model, ϑ_i has the normal distribution.

Results and Discussions

A. Distribution of consumers by income groups

The family income typically plays a crucial role in shaping the consumers' expenditure on functional dairy foods. The average monthly household income was ₹90,775. The classification of households into various income groups is presented in Table 1. These income groups are significantly different from one another at $p < 0.05$.

Table 1: Distribution of sample households by income class

Income Groups	Income (₹/month)	Average family income (₹/month)	No. of households
Group 1	Up to 74,000	49,846 [a]	78 *(48.75)*
Group 2	74,000 to 1,54,000	98,333 [b]	60 *(37.50)*
Group 3	1,54,000 to 4,00,000	2,15,273 [c]	22 *(13.75)*
Total			160 *(100)*

Figures within the parentheses indicate percentages of total respondents in the respective columns
(The values with different superscripts indicate the significant difference at P<0.05)
Source: Authors' calculations

B. Awareness status and sources of information for functional dairy foods

The Evaluation of consumers' awareness on functional dairy foods was crucial, as it plays a key role in positioning these products successfully in the Indian functional food market. The awareness status of consumers for functional dairy foods across income groups has been shown in Figure 1. It was found that 84 per cent respondents were aware about the functional dairy foods, and only 16 per cent were unaware. In that 84 per cent aware respondents, only 8 per cent respondents were aware about the functional dairy food (FDF) before explaining the term and 76 per cent became aware after explaining the term.

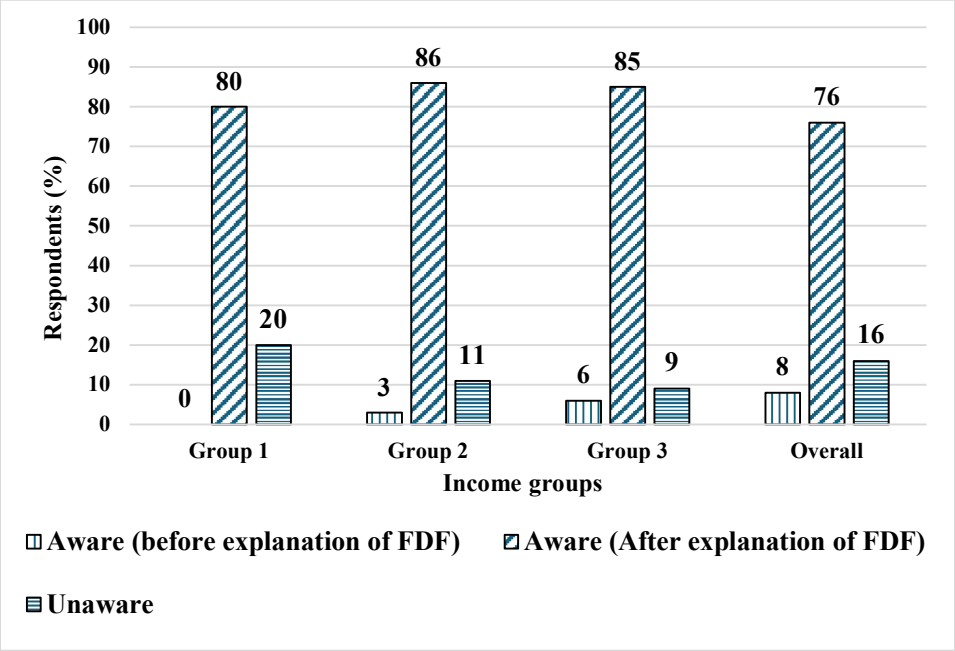


Figure 1: Awareness status of consumers for functional dairy foods

Source: Authors' calculations

The various sources of information about functional dairy foods have been shown in Figure 2. The analysis of the results indicates that the primary source of information for consumers about functional dairy foods was electronic television advertisements, accounting for nearly 38.75 per cent. After electronic television advertisement, social media was secondary source of information which made up to 21.88 per cent. Newspapers contributed the least, with just 10 per cent of consumers citing them as their source of information.

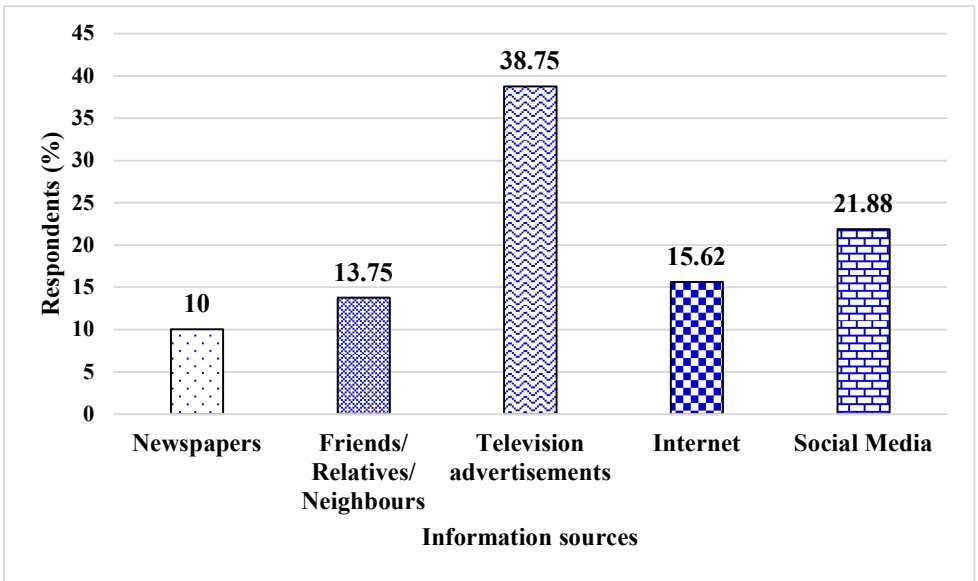


Figure 2: Sources of information about functional dairy foods

Source: Authors' calculations

C. Sources of purchase and usage frequency of functional dairy foods

The analysis of purchase sources for functional dairy foods was essential for identifying the locations where consumers showed a greater preference for buying these products. The various sources for purchase of different functional dairy foods have been shown in Figure 3.

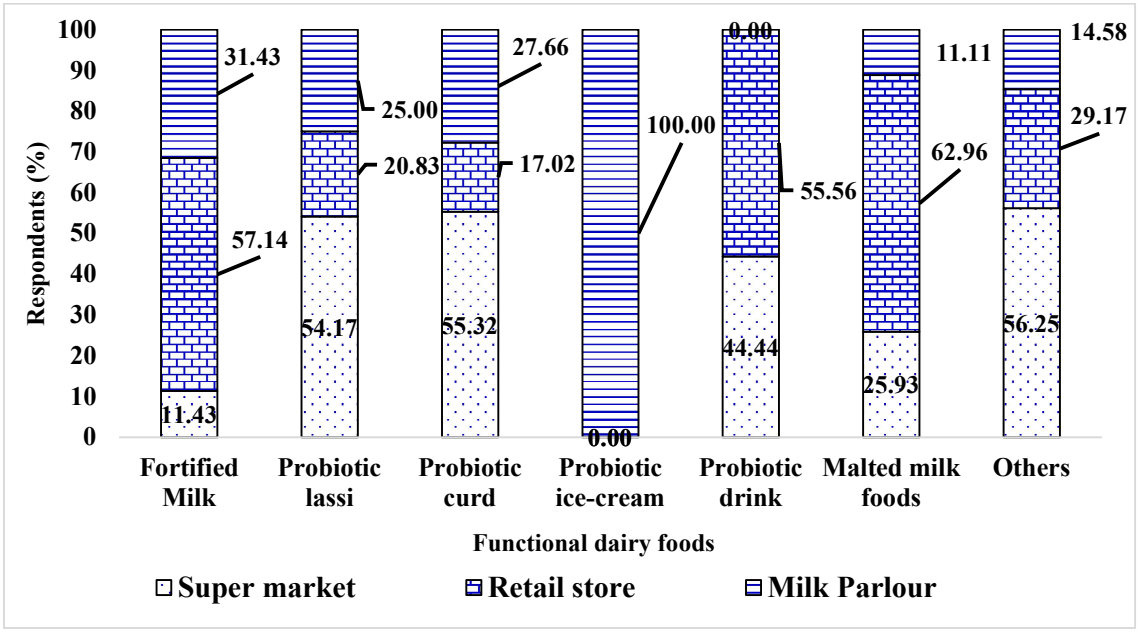


Figure 3: Sources for purchase of functional dairy foods

Source: Authors' calculations

Fortified milk: It was found that the majority of consumers purchased fortified milk from the retail shops (57.14%), followed by milk parlours (31.43%) and supermarkets (11.43%). Thus, consumers gave maximum importance to retail shops which were usually in close vicinity of households which made it convenient for consumers to purchase the product.

Probiotic food items: For the purchase of probiotic lassi of various brands, majority of consumers opted for supermarkets (54.17%), followed by milk parlours (25%) and retail stores (20.83%). The reason for purchase from supermarkets was better availability of probiotics there as compared to other locations. A similar pattern was observed for the purchase of probiotic curd of various brands. The milk parlours were exclusively chosen for purchasing probiotic ice-cream (100%) because local retail stores and supermarkets offer a wide variety of regular ice creams. The probiotic ice cream was available only in certain areas of Chennai and Salem, specifically at Mercelys ice cream parlour and in ice cream parlours having Mercelys probiotic ice-cream within large malls.

For probiotic drinks, such as Yakult, the retail stores had a slightly higher share (55.56%) compared to supermarkets (44.44%). This was because Yakult, a popular probiotic drink brand, was commonly found in medium-sized retail shops as well as supermarkets. For malted milk foods, retail stores had a higher share (62.96%) compared to supermarkets (25.93%). This was because malted milk foods were commonly found in retail shops as well as supermarkets in sachets, bottles and tetra packs. Other functional dairy foods such as fruit yoghurt, sugar-free desserts, low-calorie products, etc., were predominantly bought from the supermarkets

(56.25%) because these products are not commonly purchased by most people, leading local retail shops to not stock them.

The frequency for consumption of various functional dairy foods has been presented in Figure 4. The study has revealed that 22.86 per cent consumers rarely consumed the fortified milk, while 65.71 per cent consumers used fortified milk on daily basis. Most of the respondents reported that the additional vitamins indicated on the milk packet provide them confidence that it will help-improve their health. However, the probiotic lassi was rarely consumed by 100 per cent consumers, because most people do not drink lassi on regular basis.

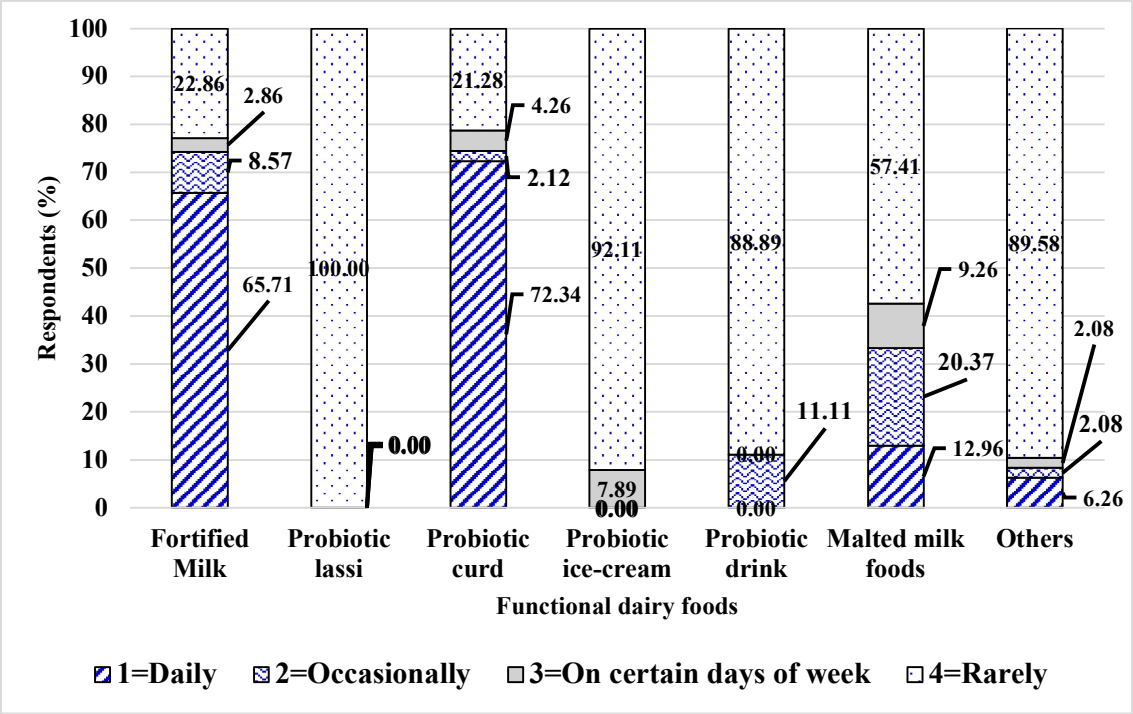


Figure 4: Frequency of consumption of functional dairy foods

Source: Authors' calculations

It was found that (i) 21.28 per cent consumers rarely consumed the probiotic curd, (ii) around 2.12 per cent consumers consumed probiotic curd occasionally, (iii) 72.34 per cent consumers used probiotic curd on daily basis, and (iv) 92.11 per cent consumers took probiotic ice-cream rarely. The analysis of frequency of consumption of probiotic drink showed that most of the consumers rarely used the probiotic drink (88.89%), followed by occasionally (11.11%). The consumption of malted milk foods and other functional dairy products was infrequent, with 57.41% and 89.48% of respondents consuming them rarely. Ultimately, the results reveal that functional dairy foods are consumed rarely or on occasional basis.

D. Consumption pattern of functional dairy foods

The study of consumption pattern of households for the functional dairy foods has a prime importance in order to expand the market in Tamil Nadu as well as in India. Table 2 represents the number of consumers consuming the different functional dairy foods in their income group category.

Table 2: Distribution of consumers across income groups based on consumption of functional dairy foods

Products	Income Group 1 (n=78)	Income Group 2 (n=60)	Income Group 3 (n=22)	Overall (n=160)
Fortified milk	10 *(12.82)*	14 *(23.33)*	11 *(50.00)*	35 *(21.88)*
Probiotic lassi	8 *(10.26)*	10 *(16.66)*	6 *(27.27)*	24 *(15.00)*
Probiotic curd	16 *(20.51)*	20 *(33.33)*	11 *(50.00)*	47 *(29.38)*
Probiotic ice-cream	11 *(14.10)*	20 *(33.33)*	7 *(31.82)*	38 *(23.75)*
Probiotic drink	8 *(10.26)*	3 *(5.00)*	4 *(18.18)*	15 *(9.38)*
Malted milk foods	22 *(28.20)*	23 *(38.33)*	9 *(40.91)*	54 *(33.75)*
Others	20 *(25.64)*	19 *(31.67)*	9 *(40.91)*	48 *(30.00)*

Figures within the parentheses indicate percentages of total respondents (n) in the respective columns

Source: Authors' calculations

It was found that the consumption of fortified milk, probiotic lassi, probiotic curd, malted milk foods and other functional dairy foods was highest in Income Group 3, and probiotic ice cream was in Income Group 2. The consumption of probiotic drink has been found consistently low across all groups.

The average monthly per-capita consumption of milk and functional dairy foods by sample households are shown in Table 3. It can be seen that the average monthly per-capita consumption of functional dairy foods was 4.23 kg, after converting all products to a common unit using specific gravity, and 3.6 litres in terms of milk equivalent quantity* (MEQ). When compared with the average monthly per-capita milk availability of 10.77 litres (BAHS, 2023) in Tamil Nadu, the functional dairy foods accounted for 33.43% of the total per-capita milk availability.

Table 3: Average monthly per-capita consumption of milk and functional dairy foods by sample households in Tamil Nadu

Products	Income Group 1 (n=78)	Income Group 2 (n=60)	Income Group 3 (n=22)	Overall (n=160)
Milk (l)	10.11	10.17	6.18	9.56
Functional dairy foods				
Fortified milk (l)	1.24	3.02	6.41	2.68
Probiotic lassi (l)	0.35	0.54	0.94	0.51
Probiotic curd (kg)	0.28	0.47	0.69	0.41

Probiotic ice-cream (l)	0.26	0.49	0.42	0.37
Probiotic drink (l)	0.03	0.02	0.04	0.03
Malted milk foods (kg)	0.08	0.14	0.14	0.11
Total (kg)	2.30	4.81	8.89	4.23
Total (MEQ*)	2.21	4.32	6.27	3.60

Source: Authors' calculations

The average monthly per-capita consumption expenditure on milk and functional dairy foods by sample households has been depicted in Table 4. It is seen that the average monthly per-capita expenditure on functional dairy foods was ₹363.83.

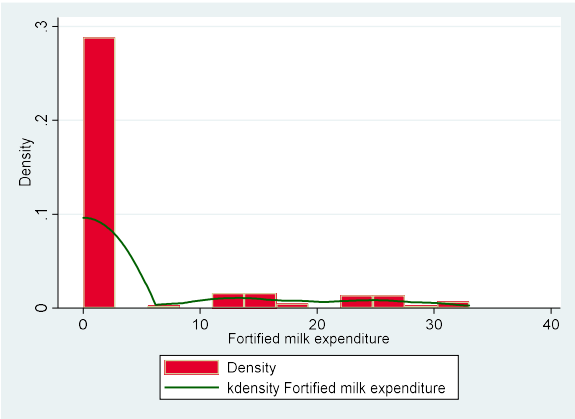
Table 4: Average monthly per-capita expenditure on milk and functional dairy foods by sample households (in ₹)

Products	Income Group 1 (n=78)	Income Group 2 (n=60)	Income Group 3 (n=22)	Overall (n=160)
Milk	505.25	575.61	323.79	505.26
Functional dairy foods				
Fortified milk	54.41	133.58	282.11	118.01
Probiotic lassi	6.40	71.73	124.60	67.57
Probiotic curd	34.69	58.27	86.01	51.20
Probiotic ice-cream	44.20	83.30	71.40	63.11
Probiotic drink	8.96	4.44	11.26	7.61
Malted milk foods	30.09	80.31	79.48	56.33
Total	178.75	431.63	654.86	363.83

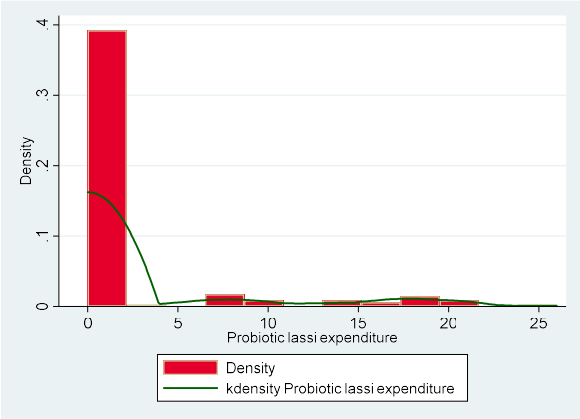
Source: Authors' calculations

E. Determinants of consumption expenditure

The present study aimed to identify the factors that influence per-capita consumption expenditure on functional dairy foods. Before applying the double hurdle model, a histogram with a kernel density (kdensity) overlay was employed to visually assess the distribution of the dependent variable (consumption expenditure). This initial step was crucial for detecting the shape of the data distribution, identifying any skewness or potential outliers.



(a)



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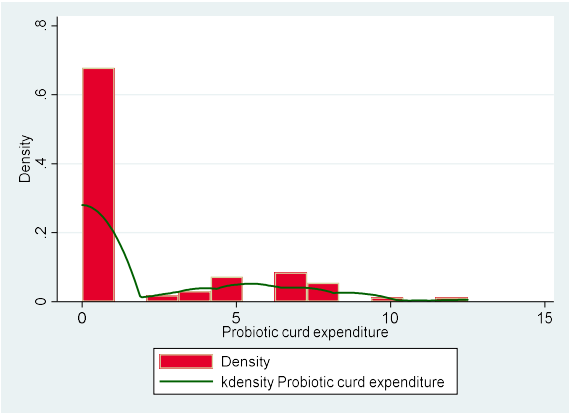

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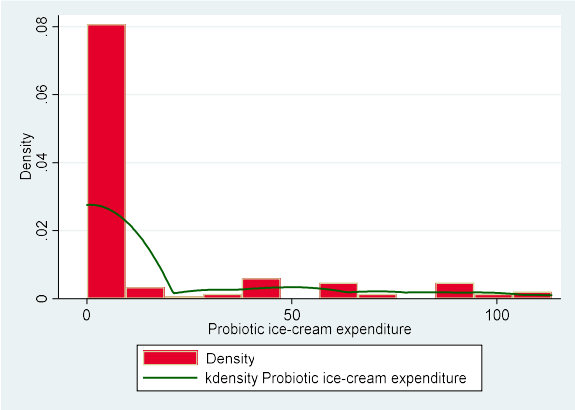

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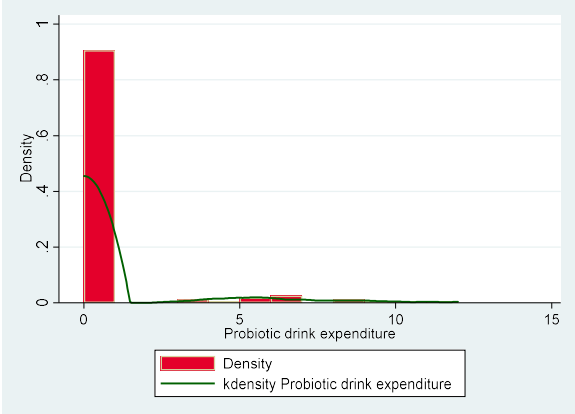

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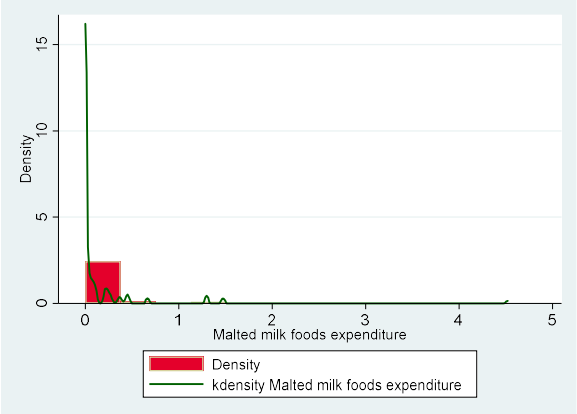

(f)

Figure 5: Histogram with kernel density estimate (Kdensity) overlay of various dependent variables used in the double-hurdle model

Source: Authors' calculations

The distribution of various dependent variables used in the double-hurdle model has been shown in Figures 5 (a-f). There is a spike near zero expenditure in all the histograms. This indicates that a significant proportion of the sample did not spend anything on the functional dairy foods. The presence of zero expenditures justified the use of a double-hurdle model, which is designed to handle situations where a proportion of the population has zero expenditure and the rest have positive expenditures. So, the factors determining per-capita consumption expenditure on functional dairy foods was analysed using Cragg double-hurdle model as well as tobit model for comparison and the results are presented in Tables 5 and 6.

Table 5: Factors influencing per-capita expenditure on functional dairy foods by double-hurdle model

Variables	(1) Per capita fortified milk expenditure (₹/day)		(2) Per capita probiotic lassi expenditure (₹/day)		(3) Per capita probiotic curd expenditure (₹/day)	
	Outcome equation	**Selection equation**	**Outcome equation**	**Selection equation**	**Outcome equation**	**Selection equation**
Family size		-0.252		0.244*		-0.113
		(0.154)		(0.142)		(0.144)
Occupation dummy (Base= Business)						
Salaried employment		-0.075		-0.617*		0.012
		(0.307)		(0.335)		(0.305)
Self-employment		-0.231		-0.784*		0.315
		(0.388)		(0.413)		(0.358)
Area dummy (Base = Rural)						
Urban/ Semi-urban		0.780***		-0.026		1.200***
		(0.299)		(0.284)		(0.289)
District fixed effect = Yes (Base= Chennai (d_0))						
Salem (d_1)		-0.438*		-0.487*		-0.333
		(0.258)		(0.282)		(0.241)
Food habit dummy (Base= non-vegetarian)						
Vegetarian		-0.161		0.671**		0.249
		(0.296)		(0.291)		(0.268)
Monthly family income	-0.727	0.681***	-0.475	0.126	-0.880	0.591**
	(1.951)	(0.249)	(2.172)	(0.274)	(0.736)	(0.236)
Monthly food expenditure	4.017		7.061		-0.515	
	(4.104)		(4.805)		(1.516)	
Monthly non-food expenditure	-0.618		5.418		2.076*	
	(2.857)		(3.951)		(1.083)	
Price	-0.712***		-0.716***		-0.219***	
	(0.087)		(0.210)		(0.065)	
Constant	32.547	-7.766***	-14.237	-2.996	25.786	-7.643***
	(43.757)	(2.858)	(68.155)	(3.148)	(16.018)	(2.720)
log sigma	1.417***		1.458***		0.684***	
	(0.123)		(0.154)		(0.108)	
Model adequacy check						
Observations (No.)	35	160	24	160	47	160
Pseudo R^2	0.1852		0.1288		0.1280	

Note: Standard errors within the parentheses

*** p<0.01, ** p<0.05, * p<0.1

Contd…

Variables	(4) Per capita probiotic ice-cream expenditure (₹/day)		(5) Per capita probiotic drink expenditure (₹/day)		(6) Per capita malted milk food expenditure (₹/day)	
	Outcome equation	**Selection equation**	**Outcome equation**	**Selection equation**	**Outcome equation**	**Selection equation**
Family size		-0.414**		-0.195		0.013
		(0.203)		(0.212)		(0.117)
Occupation dummy (Base= Business)						
Salaried employment		0.273		0.387		-0.290
		(0.378)		(0.447)		(0.295)
Self-employment		0.316		-0.055		-0.110
		(0.506)		(0.560)		(0.345)
Area dummy (Base = Rural)						
Urban/ Semi-urban		0.141		0.305		0.808***
		(0.315)		(0.344)		(0.237)
District fixed effect = Yes (Base= Chennai (d_0))						
Salem (d_1)		-5.800		-0.633*		0.646***
		(177.523)		(0.341)		(0.237)
Food habit dummy (Base= non-vegetarian)						
Vegetarian		0.255		0.713**		-0.037
		(0.328)		(0.315)		(0.256)
Monthly family income	-2.640	0.756**	1.002	0.079	0.374	0.410*
	(11.878)	(0.309)	(1.399)	(0.308)	(0.424)	(0.223)
Monthly food expenditure	-15.181		-0.441		0.366	
	(26.569)		(3.514)		(0.668)	
Monthly non-food expenditure	-7.332		-0.269		0.204	
	(17.364)		(2.288)		(0.457)	
Price	-0.677**		-0.066**		0.000	
	(0.289)		(0.030)		(0.001)	
Constant	531.699**	-7.423**	18.935	-1.876	-11.937*	-5.799**
	(265.325)	(3.498)	(37.017)	(3.563)	(6.868)	(2.581)
log sigma	3.340***		0.644***		0.281***	
	(0.140)		(0.188)		(0.090)	
Model adequacy check						
Observations (No.)	38	160	15	160	54	160
Pseudo R^2	0.1527		0.1358		0.3281	

Note: Standard errors within the parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' calculations

In double-hurdle model, the outcome equation was modelled linearly for all functional dairy foods, except malted milk foods, for which exponential model was used as it provided the best fit. The double-hurdle model has provided valuable insights into the factors influencing the selection and expenditure decisions for various functional dairy products. It has revealed that fortified milk, the selection-decision was significantly influenced by area, district and income, while per-capita expenditure was affected only by 'price'. These results suggest that people residing in urban or semi-urban areas and having higher incomes are more likely to consume in the fortified milk products compared to the rural residents. The district fixed effect has indicated lower participation in Salem than Chennai. Additionally, an increase in the price of fortified milk would lead to a reduction in per-capita expenditure.

In the case of probiotic lassi, the factors family size, occupation, district and food habits significantly influenced the selection-decision, while price was the sole determinant of per-capita expenditure. An increase in family size by one member positively influenced market participation, potentially due to the ease of availability of probiotic lassi at a small price difference from regular lassi, encouraging consumers to switch to a nutritionally superior product option. It was also found that salaried or self-employment people were less likely to participate compared to those in business. The district effect has shown a lower participation in Salem than Chennai, and vegetarians demonstrated a higher likelihood of consumption than non-vegetarians. As expected, an increase in price reduced the per-capita expenditure on probiotic lassi.

For probiotic curd, the selection-decision was significantly affected by the factors area and income, while monthly non-food expenditure and price factors influenced the per-capita expenditure. The respondents from urban or semi-urban areas and those with higher incomes were more inclined to participate in the probiotic curd market than rural residents. The price increase led to a decline in per-capita expenditure. Conversely, higher monthly non-food expenditure was associated with increased per-capita expenditure on probiotic curd. This pattern suggests that the households with higher non-food expenditure likely have greater disposable income, enabling them to allocate more resources to premium products like probiotic curd. This could indicate that probiotic curd is perceived as a higher-value or non-essential product that wealthier households are more likely to purchase, even as they spend more on non-food items.

For probiotic ice cream, the factors family size and income were significant determinants of the selection-decision, while price influenced the per-capita expenditure. The larger families were less likely to participate in the probiotic ice cream market, possibly due to budget constraints, while the higher-income households were more likely to participate. Any Price increase reduced the per-capita expenditure on probiotic ice cream. In the case of probiotic drinks, district and food habits significantly affected the selection-decision, with price influencing per-capita expenditure. The participants in Salem district were less likely to participate than those in Chennai district, and the vegetarian participants have revealed a higher likelihood of participation than non-vegetarians. As with other products, the price increase reduced the per-capita expenditure.

Finally, for malted milk foods, the factors area, district, and income significantly influenced the selection-decision. The urban and semi-urban residents, as well as higher-income households, were more likely to participate in the malted milk foods market than rural residents. Interestingly, the district fixed effect has revealed that respondents in the Salem district were more likely to participate than those in Chennai.

F. Comparative Analysis of results from tobit and Double-Hurdle Models

The results of tobit analysis have provided a contrasting perspective on the factors influencing the consumption of functional dairy foods. Notably, the tobit model has suggested that an increase in the price of various functional dairy foods would lead to an increase in the consumption expenditure—a counterintuitive finding that is inconsistent with the economic theory. This inconsistency is particularly evident when a comparison is made with the double-hurdle model results, which showed price increases leading to reduced consumption expenditures across all product categories.

Table 6: Factors influencing the per-capita expenditure on functional dairy foods by tobit model

Variables	(1) Per capita fortified milk expenditure (₹/day)	(2) Per capita probiotic lassi expenditure (₹/day)	(3) Per capita probiotic curd expenditure (₹/day)	(4) Per capita probiotic ice-cream expenditure (₹/day)	(5) Per capita probiotic drink expenditure (₹/day)	(6) Per capita malted milk food expenditure (₹/day)
Family size	4.388**	-1.443	-0.639*	-16.551*	-0.995	-0.020
	(1.922)	(1.505)	(0.374)	(9.950)	(0.650)	(0.119)
Occupation dummy (Base= Business)						
Salaried employment	4.907	-6.889**	1.915***	16.432	10.363***	-0.166
	(3.230)	(2.966)	(0.725)	(13.252)	(1.994)	(0.221)
Self-employment	2.054	-0.694	1.815*	3.746	5.686***	-0.277
	(4.942)	(4.046)	(0.926)	(16.916)	(2.151)	(0.279)
Area dummy (Base = Rural)						
Urban/ Semi-urban	1.873	2.628	-1.664*	24.126**	3.265***	-0.107
	(3.535)	(2.452)	(0.945)	(10.701)	(1.200)	(0.205)
District fixed effect = Yes (Base= Chennai (d_0))						
Salem (d_1)	-15.356***	1.398	-1.798***	-94.199	2.772*	0.346*
	(3.331)	(2.327)	(0.624)	(2,957.771)	(1.489)	(0.189)
Food habit dummy (Base= non-vegetarian)						
Vegetarian	8.055**	5.783**	1.203**	-6.550	-6.457***	0.356*
	(3.250)	(2.405)	(0.601)	(9.973)	(0.982)	(0.197)
Monthly family income	4.674	-2.661	-0.100	16.177	3.564***	-0.292
	(3.370)	(2.926)	(0.744)	(12.427)	(1.023)	(0.246)
Monthly food expenditure	-17.937**	21.622**	-2.374	-7.656	6.311**	0.742*
	(8.415)	(9.385)	(1.587)	(34.733)	(2.915)	(0.441)
Monthly non-food expenditure	4.141	-0.544	2.072*	-17.585	6.294***	0.054
	(4.774)	(4.454)	(1.080)	(16.982)	(2.303)	(0.296)
Price	0.703***	0.244***	0.110***	0.380***	0.090***	0.003***
	(0.085)	(0.047)	(0.014)	(0.059)	(0.013)	(0.000)
Constant	36.299	-186.872**	-1.807	41.638	-187.265***	-5.421
	(79.714)	(81.825)	(16.294)	(298.378)	(45.770)	(4.037)
Model adequacy check						
Observations (No.)	160	160	160	160	160	160
Pseudo R^2	0.3974	0.5261	0.5591	0.3451	0.7635	0.3563

Note: Standard errors within the parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations

The tobit model has also indicated contradictory findings regarding consumer characteristics. For instance, vegetarians were found less likely to participate in the probiotic drink market, contrary to the double-hurdle model findings, which revealed that vegetarians tend to participate more. However, some results from the tobit model aligned also with the double-hurdle model. For example, the respondents in the Salem district were less likely to participate in the fortified milk market and were more likely to participate in the malted milk food market. Additionally, family size negatively influenced participation in the probiotic ice cream market, and non-food expenditure positively impacted probiotic curd consumption expenditure, which are findings consistent with the double-hurdle model.

The contrasting results highlight the limitations of the tobit model in this context. The tobit specification assumes a single decision-making process, failing to account for situations where certain variables influence the selection decision (whether to participate) but not the outcome decision (how much to consume), or vice versa. For instance, variables such as occupation and food habits significantly influenced selection decisions but had minimal impact on outcome decisions. The double-hurdle model addresses this limitation by separately modelling the selection and outcome processes, thus providing more accurate and meaningful insights into the determinants of functional dairy food consumption.

Conclusions and Policy Implications

The study revealed the consumption patterns and key factors influencing the consumption of functional dairy foods in northern Tamil Nadu. Notably, it found a high level of awareness (84%) about functional dairy products among the participants. However, despite this high awareness, the information asymmetry limits the consumers' ability to fully increase their consumption. This highlights the need to educate the public on the specific health benefits of these products. Currently, the fortified milk has been found to be the most consumed functional dairy product in the region. The expanding consumer knowledge about the health advantages of other functional dairy products could promote a more diversified consumption pattern.

Also, improvements in the distribution networks are essential to enhance the accessibility of functional dairy products, ensuring their availability in both supermarkets and local retail shops. This would facilitate easier access for consumers and potentially increase purchase rates. Additionally, as consumer decisions are increasingly shaped by digital platforms such as social media and the Internet, there is a growing need to focus on digital marketing strategies to further boost awareness and sales.

It has observed that income, price, occupation, dietary habits, family size and location are the factors which influences consumption of functional dairy foods. The urban residents, individuals with higher incomes and vegetarians have been found to be more likely to spend on these products. Addressing these factors through targeted marketing and distribution efforts could help in promoting the wider adoption of functional dairy foods.

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Appendix

Table A1 Major functional dairy product categories available in Tamil Nadu

Product categories
Fortified milk (fortified with Vitamin A & D)
Probiotic lassi of various flavours
Probiotic curd
Probiotic ice-cream of various flavours
Probiotic drink
Malted milk foods
Others include Fruit/probiotic yoghurt of various flavours, Fruit lassi of various flavours, Fortified lassi, Sugar free desserts, Low-calorie products such as low-fat cream, etc.

Source: Based on data collected by authors and may not be a complete listing.