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Consumption of Milk and Other Dairy Products as Influenced by Dietary Habits of Vegetarians and Non-vegetarians in Kamrup District of Assam, India: A Study

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Authors' contributions

This work was carried out in collaboration among all authors. Author SB collected the data for the study and performed the statistical analysis. Author BS assisted to frame the questionnaire as well as for statistical analysis. Author UC guided for data feeding and graphs. Authors SM and SG helped to manage the literature searches and the author AV wrote the draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Consumption of dairy products plays a critical role in enhancing nutritional security of the humans. Current study was planned to estimate the expenditure on milk consumption pattern and preferences by different dietary groups in Kamrup district of Assam. Monthly Per Capita Expenditure (MPCE) of various food commodities also revealed significant differences in household spending patterns. Cereals had the highest mean expenditure pointed out their importance as a staple food item across households. Consumption of Pulses showed more consistent spending suggesting a steady role in household diets. Fruits and vegetables, demonstrated substantial variations in spending on food items. Expenditure on Meat consumption indicated substantial variability as per household preferences followed by Fish which highlighted the diverse consumption preferences in the study area. The multivariate test statistics indicated significant differences in the consumption patterns. This supported that there was a significant difference in the consumption of food products between vegetarians and non-vegetarians. Further, approximately forty percent of the variance in food consumption was explained by dietary pattern differences as expressed by Wilks' lambda, and remaining 58% was due to other factors. Moreover, Pillai's trace and Lawley-Hotelling trace had confirmed significant differences, suggesting that dietary preferences substantially impact food expenditure. Vegetarian families tend to spend more on liquid milk, implying that milk plays a central role in the vegetarian diet, possibly as a primary source of protein. The most significant difference was seen in powder milk expenditure, where vegetarians spend more than non-vegetarians. Non-vegetarian households, spend more on curd, and also showed higher expenditure on paneer, ghee, and butter, though the differences in these items were less pronounced. Overall, the vegetarian households allocated more of their budget to powdered milk, sweets, and ice cream, while non-vegetarian households spent more on curd, paneer, and other dairy products.

Keywords: KRLS; MPCE; Pillai's; lawley-hotelling trace; wilks' lambda.

1. INTRODUCTION

In India, where malnutrition remains a significant public health issue, dairy products play a critical role in enhancing nutritional security as according to the National Dairy Development Board (NDDB), the consumption of milk and milk products significantly contributes to meeting the recommended dietary allowances (RDA) for these nutrients (Chaudhari et al., 2024). Research indicates that regular consumption of dairy is associated with lower risk of several chronic conditions like osteoporosis, cardiovascular diseases, and type 2 diabetes (Mandal et al, 2020). The overall domestic consumption of milk was over 207 million metric tons in 2023 Statista. (2024). Some common milk products include: Ghee, Curd, Butter, Ice Cream, Powder milk and Condensed milk etc. The demand for milk and milk products is rising sharply, driven by population growth, increasing incomes, and urbanization. There is strong evidence that consuming dairy products (total dairy, milk, cheese and dietary calcium) decreases risk of colorectal cancer. This inverse association is largely attributed to high calcium content in milk and its products. In addition to calcium, lactic acid-producing bacteria may also protect against colorectal cancer, while the casein and lactose may increase calcium bioavailability. This increased demand is expected to be met by domestic production. However, the quantity and types of milk consumed vary significantly across regions due to disparities in purchasing power across socioeconomic groups, differences in taste and dietary habits shaped by agro-climatic conditions, regional resource availability, and temporal variations in milk supply within different areas (Sharma and Omena 2024). Though India is self-sufficient in milk production, there exist significant regional variation in milk production and in this regard, the North Eastern Region is deficient in milk production (Mili and Dutta 2024). Assam was purposively selected for the study as the organized milk marketing is still quite small despite previous attempts to create and advance collective market mechanisms in northeast region of India (Nicolini et al., 2022). According to the 20th Livestock Census, total livestock population of Assam was recorded as 180.92 lakhs where the cattle population constitutes the largest group with 60% followed by goat population 24% and pig 12%. During 2022-23, the total milk production was recorded to be 1006.42 MT and per capita availability of milk

was only 78 gm/day in Assam which is below all national average. Assamese consumers favor raw milk over processed liquid or powdered milk due to the way milk is used in the state - either as a tea whitener or in milk sweets

2. METHODOOGY

The study was planned to estimate the expenditure on milk consumption pattern and preferences by different dietary groups in Kamrup district of Assam. The study was carried out in the Kamrup district of Assam using a multistage random sampling technique considered the both Metropolitan and rural areas. Within the Kamrup Metropolitan area, the localities of Bhangagarh and Kahilipara were selected, while Palashbari and Boko were chosen from the Kamrup Rural region. A total of 50 households were sampled from each locality, resulting in 200 respondents for the study. Primary data were collected from each household using a pre-structured schedule through a personal interview method conducted between February to May in the last year 2024.

2.1 Multiple Variable Regression Analysis

As an Individual household's food consumption behavior was discrete and independent however, consumption expenditure on food depended on a number of explanatory variables (Ferwerda et al., 2017). To model individual household's consumption behavior, monthly per capita consumption expenditure (MPCE) was estimated. Further, to model consumption behavior, multiple variable regression analysis was adopted following the below mentioned econometric framework.

$$MPCE_{veg} = \alpha_i + \sum_{i=1}^{n} \theta_i X_i + \varphi_i D_i + \varepsilon_i$$

$$MPCE_{veg} = \alpha_i + \sum_{i=1}^{n} \theta_i X_i + \varphi_i D_i + \varepsilon_i$$

where, MPCE denoted per capita monthly consumption expenditure, X represented set of explanatory variables and D accounted for set of dummy variables.

2.2 Kernel Based Regularized Least Square

The consumer preferences towards milk and milk products were assessed by non-parametric Kernel-based Regularized Least Squares (KRLS) framework in the study. Researchers, however, can never be sure that all possible non-linear relationships are taken care of in their chosen specifications, because the number of polynomials and interaction effects grows exponentially when the number of characteristics included in the models increases. One way out is the use of KRLS estimator that it allows the researcher to estimate regression-type models without making any assumption regarding the functional form (or doing specification search to find the best-fitting functional form). As detailed in Hainmueller and Hazlett the method constructs a flexible hypothesis space using kernels as radial basis functions and then finds the best-fitting surface in this space by minimizing a complexity-penalized least squares problem (G´orecki and Smaga 2017). (Hainmueller and Hazlett 2014) point out that the KRLS method can be thought of in the "similarity-based view" in two stages. In the first stage, it fits functions using kernels, based on the assumption that there is useful information embedded in how similar a given observation is to other observations in the dataset. In the second stage, it utilizes regularization, which gives preference to simpler functions. The KRLS thus uses a machine learning approach to learn the functional form from the data. In doing so, it protects against misspecification that leads to biased estimates.

KRLS is an advanced non-parametric regression technique that allows for flexible modeling of complex relationships between predictors and outcomes. It is particularly suited for this analysis, as it captures the non-linear effects of various factors on household preferences for milk and its products.This method assumes that the target function (i.e., the relationship between the outcome and explanatory variables) can be expressed as:

$$\boldsymbol{y = f(x)}$$

Here, *y* was the outcome of interest i.e., milk or any milk product, and *x* represented the explanatory variables. The KRLS method then approximated the function *f(x)* as a weighted sum of kernel functions, as shown below:

$$\boldsymbol{f(x) = \sum_{i=1}^{N} c_i k(x, x_i)}$$

In this equation, $k(x,x_i)$ represented the kernel function, which captured the similarity between the point of interest x and the covariate vector x_i, where *i* ranged from 1 to N. The weight c_i was assigned to each kernel function based on its

Fig. 1. Study area

contribution to the overall approximation (Cameron and Trivedi 2005). Essentially, this approach helped to estimate how similar inputs x_i affected the target variable y, allowing the KRLS framework to flexibly model non-linear relationships.

3. RESULTS AND DISCUSSION

3.1 Monthly Per Capita Expenditure & Family Expenditure of Food Items

The Monthly Per Capita Expenditure (MPCE) of various food commodities also revealed differences in household spending patterns as observe in Table 1. Cereals had the highest mean expenditure at ₹492.93, with a standard deviation of ₹303.54, reflects their importance as a staple food item across households. Pulses, with a mean expenditure of ₹261.47 and a relatively low standard deviation of ₹119.11, showes more consistent spending, suggesting a steady role in household diets. Fruits and vegetables, with a mean expenditure of ₹782.57 and a high standard deviation of ₹631.91, demonstrate substantial variation in spending. This could be due to factors like household size, preferences, and seasonal availability (Ray and Singh 2023). Meat has a mean expenditure of ₹456.08 and a standard deviation of ₹313.01, indicates variability in household preferences for meat consumption, which might be influenced by dietary patterns or income levels. Fish, with a mean expenditure of ₹360.91 and a standard deviation of ₹268.12, also showed variability, reflective of the diverse consumption preferences in the study area. Eggs had the lowest mean expenditure at ₹38.91, with minimal variability (standard deviation ₹28.85) which suggests low but consistent consumption of eggs across households. These results highlight the diversity in food consumption patterns in the surveyed population.

Further, the family monthly expenditures on various food products, indicates Cereals had a mean expenditure of ₹1,855.94, show the moderate variability with a standard deviation of ₹969.25 implying the consistent consumption across households. Pulses had a lower mean expenditure of ₹914.01 with a standard deviation of ₹524.92, reflecting relatively uniform spending. Fruits and vegetables had the highest mean expenditure at ₹2,691.60, with a large standard deviation of ₹1,463.16, pointed out significant variation, which might be due to factors such as household size, dietary preferences, and the availability of seasonal produce. Meat also

showed substantial variability, with a mean expenditure of ₹1,996.17 and a standard deviation of ₹1,258.98, suggesting that different households had differing preferences for meat consumption (Ahmadi Kaliji et al., 2019). Moreover, Fish, with a mean expenditure of ₹1,687.28 and a standard deviation of ₹932.57, reflecting similar variability. Eggs exhibit the lowest mean expenditure at ₹159.93, with a standard deviation of ₹109.03, indicates consistent spending patterns across households. Overall, the data highlights the diverse consumption behaviours for essential and non-essential food items in the sample households.

3.2 Monthly Per Capita Expenditure & Family expenditure on Milk and Milk Products

As evident from the Table 2 presents the Monthly Per Capita Expenditure (MPCE) on milk and milk products among households. Liquid milk, with a mean expenditure of ₹563.52 and a standard deviation of ₹303.91, represents the largest share of dairy consumption. The relatively high standard deviation suggesting the moderate amount of variability in household spending on liquid milk, likely influenced by factors such as family size, dietary habits, and income. Powdered milk, on the other hand, expresses a mean expenditure of ₹62.50, but a remarkably high standard deviation of ₹423.80, and indicates significant variation in its consumption. This reflects that only a few households rely on it as a substitute for liquid milk (Lapar et al., 2010). Moreover, the Curd with an average expenditure of ₹86.65 and a lower standard deviation of ₹97.37, suggest more consistent consumption across households. Ghee, with a mean of ₹33.08 and a standard deviation of ₹66.96, shows less expenditure but greater variability, likely due to its occasional use in cooking or special meals. Butter and paneer also show lower mean expenditures, ₹27.05 and ₹60.58, respectively, with standard deviations of ₹75.08 and ₹69.02, reflect variability in household preferences.

The family expenditure for milk and milk products also revealed the diverse spending patterns. Liquid milk, a staple in most households, showing the highest mean expenditure at ₹2,085.23, with a substantial standard deviation of ₹1,069.09, indicates a wide variation in household spending on this essential product. Powder milk, though less commonly consumed, had a mean expenditure of ₹206.25, but a very high standard deviation of ₹1,365.73, suggesting that only a few households spend significantly on it, skewing the average. The mean expenditure on Curd was ₹301.71 and a standard deviation of ₹274.71, show moderate variation, reflecting its regular consumption more over the differences in quantity and frequency varies among the households. Ghee and butter, with mean expenditures of ₹95.86 and ₹130.20, respectively, show moderate variability, indicating that they are consumed selectively, likely based on household preferences or income levels. Paneer (₹216.31) and sweets (₹557.31) had higher variability in their expenditure, reflecting their more occasional consumption. Less values of mean expenditure for Ice cream ₹87.89 expressed wide variation (SD ₹296.70), which might be to seasonal or sporadic consumption patterns. These findings had pointed out the varied priorities and preferences of households for dairy products in the study area.

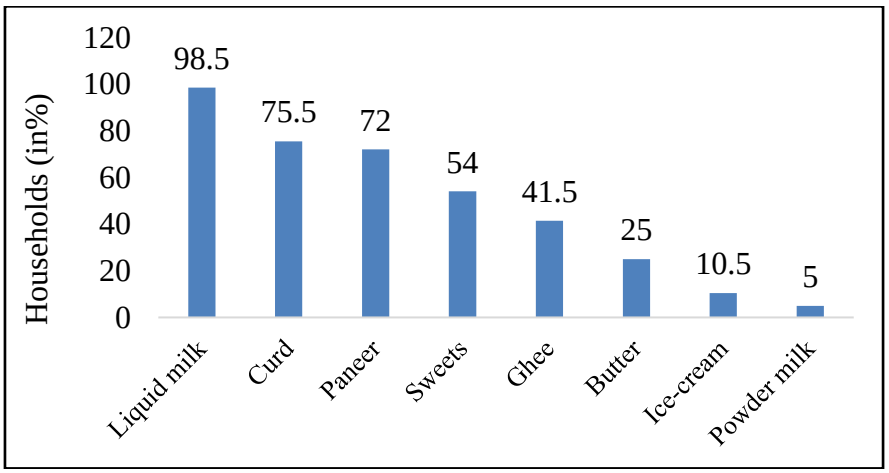

Fig. 2. Consumption preferences of milk and milk products

Table 1. Monthly per capita expenditure & Family expenditure of food products of households

Food items	Mean ± SD	Mean± SD
Cereals (₹)	492.93±303.54	1855.94±969.25
Pulses (₹)	261.47±119.11	914.01±524.92
Fruit & Vegetables (₹)	782.57±631.91	2691.60±1463.16
Meat (₹)	456.08±313.01	1996.17±1258.98
Fish (₹)	360.91±268.12	1687.28±932.57
Egg (₹)	38.91±28.85	159.93±109.03

Table 2. Monthly per capita expenditure & Family expenditure on Milk and milk products

	Mean± SD	Mean± SD
Liquid Milk (₹)	563.52±303.91	2085.23±1069.09
Powder Milk (₹)	62.50±423.80	206.25±1365.73
Curd (₹)	86.65±97.37	301.71±274.71
Ghee (₹)	33.08±66.96	95.86±224.87
Butter (₹)	27.05±75.08	130.20±246.92
Paneer (₹)	60.58±69.02	216.31±192.96
Ice-cream (₹)	23.55±87.75	87.89±296.70
Sweets (₹)	149.46±209.43	557.31±702.56

Table 3. Multivariate tests for consumption pattern of Milk and Milk Products vis-à-vis food products

Measures	F (9, 190)	F	Prob>F	Significance	F (6, 193)	F	Prob>F	Significance
Wilks' lambda	0.8212	4.6	0.001	e	0.4213	44.18	0.001	e
Pillai's trace	0.1788	4.6	0.001	e	0.5787	44.18	0.001	e
Lawley-Hotelling trace	0.2177	4.6	0.001	e	1.3734	44.18	0.001	e
Roy's largest root	0.2177	4.6	0.001	e	1.3734	44.18	0.001	e

Table 4. Monthly per capita expenditure (MPCE) on food products

	Non-Vegetarian (n= 165)	Vegetarian (n= 35)		Non-Vegetarian (n= 165)	Vegetarian (n= 35)
Food items	**Mean ± SD**	**Mean± SD**		**Mean ± SD**	**Mean± SD**
Cereals (₹)	459.99±211.74	648.19±541.24	**Meat (₹)**	552.82±255.10	**Nil**
Pulses (₹)	254.18±113.89	295.82±137.82	**Fish (₹)**	437.46±231.38	**Nil**
Fruit & Vegetables (₹)	724.92±509.90	1054.34±995.43	**Egg (₹)**	47.17±24.87	**Nil**

Table 5. Monthly per capita expenditure & Family expenditure on milk and milk products across different dietary pattern groups

Diet	Non-Vegetarian (n= 165)	Vegetarian (n= 35)	Non-Vegetarian (n= 165)	Vegetarian (n= 35)
	Mean ± SD	**Mean± SD**	**Mean± SD**	**Mean± SD**
Liquid Milk (₹)	535.67±262.52	694.78±432.06	2066.55±1080.88	2173.29±1022.11
Powder Milk (₹)	35.15±113.44	285.71±962.81	68.18±502.56	857.14±3028.23
Curd (₹)	88.16±97.16	79.54±99.48	318.07±283.52	224.60±215.72
Ghee (₹)	21.44±56.84	53.50±128.60	82.35±209.84	159.56±280.22
Butter (₹)	30.14±61.08	46.94±89.49	117.09±229.99	192.00±311.36
Paneer (₹)	55.45±53.51	84.76±115.49	210.77±193.65	242.40±190.25
Ice-cream (₹)	16.12±61.54	58.58±158.97	60.93±226.05	215.00±498.61
Sweets (₹)	129.64±163.07	242.88±342.85	513.88±655.92	762.00±872.59

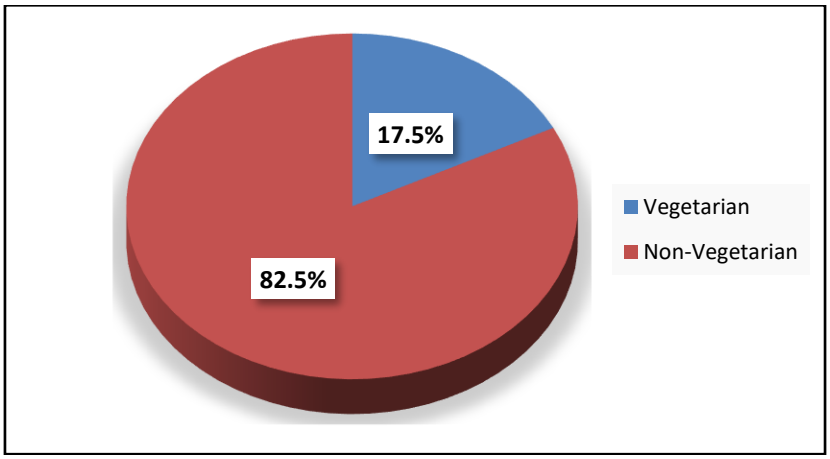

Fig. 3. Distribution of sample households based on dietary pattern

3.3 Classification of Sample Households based on Dietary Pattern

The classification of sample households into different dietary pattern groups was presented in Fig. 3 as about 35 (17.5%) of the households belonged to vegetarian group while 165 (82.5%) of the households belonged to non-vegetarian group. This distribution highlighted the predominance of non-vegetarian dietary habits among the respondents.

3.4 Multivariate Tests for Consumption Pattern of Food Products Across Different Dietary Pattern Groups

The results of four multivariate test statistics Wilks' lambda, Pillai's trace, Lawley-Hotelling trace, and Roy's largest root—observed the significant differences in the consumption patterns of the respondents of the present study, with a p-value of 0.001 across all tests. This meant the null hypothesis had been rejected and the hypothesis of significant difference in the consumption of food products between vegetarians and non-vegetarians had accepted . H_0: There was no difference in consumption pattern for food products (MPCE) in the study area across different dietary pattern groups.

H_1: There was a significant difference in consumption pattern for food products (MPCE) in the study area across different dietary pattern groups.

Wilks' lambda showed that approximately 42% of the variance in food consumption is explained by dietary pattern differences, while the remaining 58% is due to other factors. Pillai's trace and Lawley-Hotelling trace both confirm significant differences, suggesting that dietary preferences substantially impact food expenditure. Roy's largest root reinforces this conclusion, with an F-value of 44.18. These results suggested that vegetarian and non-vegetarian households in the study area exhibit distinct consumption patterns for food products, highlighting the influence of dietary choices on household expenditure (Devi et al., 2022).

3.5 Multivariate Tests for Consumption Pattern of Milk and Milk Products across Different Dietary Pattern Groups

Similarly four multivariate test statistics had expressed highly significant results (p-value = 0.001), which further confirmed that the null hypothesis can be rejected (Table 3). H_0: There is no difference in consumption pattern for milk and milk products (MPCE) in the study area across different dietary pattern groups. H_1: There is a significant difference in consumption pattern for milk and milk products (MPCE) in the study area across different dietary pattern groups.

Specifically, Wilks' lambda shows that around 82% of the variance in consumption patterns is explained by factors other than dietary groups, while 18% is attributable to dietary differences. Meanwhile, Pillai's trace, Lawley-Hotelling trace and Roy's largest root further confirm these findings, supporting the presence of a statistically significant difference between the two groups. The F-statistic (4.6) and corresponding degrees of freedom (9, 190) reinforce that the consumption patterns of milk and milk products differed significantly between vegetarians and

non-vegetarians. These results suggested that dietary preferences play a key role in determining the expenditure on milk and milk products in the study area.

3.6 Consumption Pattern Across Different Dietary Pattern Groups

3.6.1 Monthly per capita expenditure (MPCE) on food products

Table 4 presents the monthly per capita expenditure (MPCE) on various food products across non-vegetarian and vegetarian households, highlighting the differences in their dietary preferences and spending patterns. Vegetarian households show higher expenditure on cereals, pulses, and fruits & vegetables compared to non-vegetarian households. Specifically, the average expenditure on cereals was ₹648.19 for vegetarians, much higher than ₹459.99 for non-vegetarians. Similarly, vegetarians spend more on pulses (₹295.82) and fruits & vegetables (₹1054.34). These higher values reflected the greater reliance of vegetarians on plant-based food products as their primary sources of nutrition. In contrast, non-vegetarians allocated a significant portion of their budget to animal-based products, with average expenditures of ₹552.82 on meat, ₹437.46 on fish, and ₹47.17 on eggs. These categories had no expenditure for vegetarians, as they do not consume these items due to their dietary restrictions. Overall, the Table 4 revealed that vegetarians tend to spend more on plant-based staples like cereals, pulses, and fruits & vegetables, while non-vegetarians distributed their food expenditure across both plant-based and animal-based products, with substantial spent on meat and fish (Bahety et al., 2022). These patterns highlighted the key differences in the dietary structure of vegetarian and non-vegetarian households.

3.6.2 Monthly per capita expenditure and Family expenditure

Table 5 presents the monthly per capita expenditure (MPCE) on milk and milk products for non-vegetarian and vegetarian households. The data reveals notable differences in consumption patterns between the two groups. Vegetarians had higher average expenditure on liquid milk (₹694.78) compared to non-vegetarians (₹535.67), likely reflects their reliance on milk as a protein source. Similarly, vegetarians spend significantly more on powdered milk (₹285.71) and ghee (₹53.50), perhaps due to dietary preferences for dairy-based fats. The expenditure on sweets was also notably higher among vegetarians (₹242.88). Non-vegetarians, on the other hand, had a slightly higher mean expenditure on curd (₹88.16) and butter (₹30.14), though these differences were relatively small. Expenditure on paneer and ice cream was also lower in non-vegetarian households. Overall, vegetarians allocated more of their budget to dairy products, particularly milk, ghee, and sweets, while non-vegetarians showed more moderate spending across a wider range of dairy products. This difference in MPCE could reflect dietary habits, availability, and preferences for specific dairy items.

The family expenditure on milk and milk products between dietary groups had expressed, the variation for non-vegetarian and vegetarian households (Goyal et al., 2024). Vegetarian families tend to spend more on liquid milk, with an average expenditure of ₹2173.29, compared to ₹2066.55 for non-vegetarian families. This suggests that milk plays a central role in the vegetarian diet, possibly as a primary source of protein. The most significant difference was in powdered milk expenditure, where vegetarians spend an average of ₹857.14, far exceeding the ₹68.18 spend more than non-vegetarians. This indicates a preference for milk alternatives or convenience products. Non-vegetarian households, however, spend more on curd, averaging ₹318.07 compared to ₹224.60 for vegetarians, and also showed higher expenditure on paneer, ghee, and butter, though the differences in these items were less pronounced. For ice cream and sweets, vegetarians spend significantly more. Overall, the vegetarian households allocated more of their budget to powdered milk, sweets, and ice cream, while non-vegetarian households spend more on curd, paneer, and other dairy products.

4. CONCLUSIONS AND RECOMMENDATIONS

The multivariate test statistics Walks' lambda, Pillai's trace, Lawley-Hotelling trace, and Roy's largest root—indicates significant differences in the consumption patterns. This supports that there was a significant difference in the consumption of food products between vegetarians and non-vegetarians. Further, approximately forty percent of the variance in food consumption was explained by dietary

pattern differences as expressed by Wilks' lambda, and remaining 58% was due to other factors. Moreover, Pillai's trace and Lawley-Hotelling trace had confirmed significant differences between dietary preferences substantially impact food expenditure. Vegetarian families tend to spend more on liquid milk, implying that milk plays a central role in the vegetarian diet, possibly as a primary source of protein. The most significant difference was seen powder milk expenditure, where vegetarians spend more as by non-vegetarians. Non-vegetarian households, spend more on curd, and also show higher expenditure on paneer, ghee, and butter, though the differences in these items were less pronounced. Overall, the vegetarian households allocated more of their budget to powdered milk, sweets, and ice cream, while non-vegetarian households spend more on curd, paneer, and other dairy products.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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