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Influence of raw milk quality attributes on its pricing in Pakistan

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In developing countries, milk quality characteristics are not maintained by the milk producers and the middlemen. This study initially estimates the influence of various milk quality attributes on its price and then estimate the effect of socio-demographic characteristics on the marginal price of the milk components. Data collected from milk consumers through personal interview method, and milk sample took from the same consumers are used to estimate a two-stage hedonic model. In the first stage, prices were estimated for milk components and in the second stage, implicit price of each component was used as the dependent variable. The first stage results show that fat, solids-not-fat, total plate counts, color, and pleasant aroma have a significant impact on the milk price. The second stage results indicate that fat and solids-not-fat values are a function of the socio-demographic characteristics of consumers. To maintain milk quality attributes, we recommend the establishment of chilling centers for maintenance of quality, checkpoints and mobile laboratories for testing quality, provision of basic testing equipment at subsidized rates, hygiene awareness program for stakeholders in value chain, health risk awareness for consumers consuming raw milk and its products, and introduction and popularization of enzyme-based lactoperoxidase preservation technology.
Keywords: Hedonic analysis, two-stage method, milk components, sensory characteristics.

INTRODUCTION

Milk is a balanced nutritive diet and ensures proper growth and development of the human body. It is a perfect food that is easily digested and absorbed. Dairy food products ensure the public health and contribute significantly to nutrient intake in many countries. Milk production converts human inedible resources to nutritious food. World milk production is expected to increase by 22 percent by 2027 and the major share of this increase will be from developing countries especially Pakistan and India (OECD/FAO, 2018). By 2050 the consumption of dairy products (fresh milk equivalent) is forecasted to increase from 52 kg/person/year in 2005/2007 to 76 kg/person/year (Alexandratos and Bruinsma, 2012). The increase will primarily be in developing countries where dairy supply chain will go through a structural change to meet the rising demand. The increase is expected because of increase in population and income growth as well as urbanization. Consumers in developing countries prefer to consume raw milk marketed informally as they believe that the raw milk is pure, natural and healthy compared to processed packed milk. The raw milk has a share of 83 percent in India, 85 percent in Kenya and 90 percent in Tanzania, Uganda, and Pakistan (Farooq, 2016).

There are many challenges in maintaining the quality of milk informally marketed from producer to the end consumer. These include poor infrastructure (roads, transport, lack of chilling facilities), quality assurance and management of seasonality (Farooq, 2016). Due to these challenges, milk quality deteriorates in the value chain from producers to consumers due to milking of soiled animals (soiled with manure, mud, feeds or bedding), milking by hand, poor cleaning and sanitation of milk containers, using of contaminated water for washing utensils and udder before milking, maintaining an uncleaned housing environment, exposing milk to dust and flies, adding water to milk and inability to cool the milk rapidly (Grace *et al.,* 2009; Kumar *et al.,* 2017). The microbial quality of milk from the healthy animal at the time of milking is generally good. The natural inhibitory systems in milk do not allow significant growth of undesirable microbial counts for the first three or four hours at ambient temperatures (Jay *et al.,* 2005). Milk being a balanced nutritive food serves as an ideal medium for the growth of various organisms (Bonfoh *et al.,* 2003). The informal market, which handles the major share of raw milk in developing counties like India and Pakistan (number one and three in world milk production, respectively) is characterized by sale of milk in simple channels that have

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inadequate transport, storage, and chilling facilities; and normally involves more than four hours duration between the extraction of milk from animal teats and boiling of milk by the consumers. Many undesirable changes occur in the quality of milk when it is not properly handled due to contamination by a variety of spoiling organisms. The form of spoilage is apparent in the form of taste, color, aroma, and freshness especially due to the absence of refrigeration facilities (Ness *et al.,* 2010). These changes consequently influence the price of raw milk and its intake by the consumers (Stroebele and Castro, 2004).

Quality perception is generally assumed to be multidimensional and is perceived by combining many dimensions or characteristics. Economic theory on product quality makes the distinction between search, experience and credence characteristics (Nelson, 1974). Quality of milk can be discovered by the consumers at different stages. Search characteristics i.e., color, aroma, smell, etc. can be identified before the purchase. In contrast, experience characteristics like taste can be established only after consumption (Nelson, 1974). Unlike the above characteristics, credence characteristics cannot be established at any stage of purchase even after consumption (Grunert *et al.,* 2004). These characteristics are not visible and need certification by the government or other agency (Caswell and Mojduszka, 1996) but nowadays these characteristics are becoming more important for consumers (Brunso *et al.,* 2002). Search, experience and credence characteristics of raw milk may change which consequently influence the buying and willingness to pay by consumers. Besides the attributes of the milk, consumer buying behavior and price sensitivity are also affected by demographic variables like education, profession, the number of children, etc. (Moser *et al.,* 2011; Tiryaki and Akbay, 2010).

Although several studies valued milk components by using its embodied characteristics i.e., fat, solids-not-fat, etc., but ignored attributes especially relating to sensory variables. It might be because milk in advanced countries is sold in a standardized form and meet certain standards. However, in developing countries like Pakistan, India, Nepal, and Bangladesh, milk is collected either by "Dudhiya" (i.e., first stage milk collector) or milk processing firms from millions of small landholders and landless households having milk animals. As far as the "Dudhiya" milk collections system is concerned, the pricing system has no link with butterfat percentage or other components of milk. Further, transportation of raw milk from producers to consumers by the "Dudhiya" is done mostly on motorcycles without cooling facilities and preservation techniques. This poor hygienic conditions encourage the growth of harmful organisms which influences the color, aroma, taste, and freshness of the milk. The color of food influences sweetness perception, food acceptability, and judgment about food (Ares and Deliza, 2010) while spoilage of milk reduces aroma, pleasantness, and taste which has a negative influence on its price. Perrin (1980) has suggested that for determining retail level milk component values, product characteristics framework is useful, and these characteristics are the primary utility generating entities, and not the product itself (Lenz *et al.,* 1994). So for developing countries, besides the components of milk, other quality factors like smell, color, aroma, and freshness are very important where milk is marketed in unprocessed form. These factors also influence milk intake and choice, and consequently, the price that consumer's pay. However, the influence of such factors on the pricing of milk components is not fully understood. This study makes a significant contribution to the existing literature by investigating (a) the impact of various components of milk and other quality attributes on its price especially in the context of developing countries and (b) the contribution of socio-demographic characteristics of respondents in the determination of the marginal price of the milk components.

MATRIALS AND METHODS

The contingent valuation and hedonic pricing system are two commonly used approaches to estimate price premiums for each attribute. Many studies have used contingent valuation approach to determine price premiums for food product attributes but it requires consumer survey data to estimate premium for each attribute. Further, there are two problems with this approach: (i) it shows consumer intentions but not his actual actions in terms of purchasing behavior (Satimanon and Weatherspoon, 2010) and (ii) consumers may over-estimate their willingness to pay during the survey which results in an overestimation of price premium (Diamond and Hausman, 1994; Blumenschein *et al.,* 1998; 2008).

Many studies used hedonic pricing analysis approach to determine the preference for attributes and the price premiums for various attributes of different commodities (Ahmad and Anders, 2012). This approach is based on the theory of consumer behavior and explains how a consumer allocates his limited income among the available goods and services to maximize his satisfaction. According to the hedonic price model, a consumer increases his utility not by consuming an economic good but by the attributes of that good (Lancaster, 1966). For example, the utility which is derived from the consumption of milk can be viewed as the aggregate satisfaction obtained from milk attributes i.e., fat, solids-not-fat, taste, aroma, color, etc. Two types of milk would provide different levels of utility if they differ in characteristics. Further, hedonic approach does not require the joint consumption of goods from a group as in the contingent valuation approach. According to the hedonic price analysis approach, the price per unit of a commodity that a consumer pays can be decomposed with reference to its quality attributes. As these attributes may be nutrients and non-

nutrients in nature so the price of food good can be reported as:

$$P = \sum_{i=1}^{n} V_i(C)Q_i + \varepsilon \qquad (1)$$

Where P is the price per unit of the commodity, $V_i(C)$ is the value per unit of commodity's ith characteristic as perceived by a household with demographic characteristics C, and Q_i is the quantity of ith attribute available from one unit of the commodity. If the data are available about the prices paid by the household and the contents of characteristics per unit of the commodity, then it is possible to estimate the implicit values of characteristics through regressions (Lenz *et al.*, 1991). The values and contents of various characteristics are likely to be perceived differently by various households because of differences in household characteristics. Therefore, to account for these differences, there is a need to add error term in the decomposed equation. For milk, the decomposed equation can be written as

$$P = V_{FAT}(C)[FAT] + V_{SNF}(C)[SNF] + V_{TPC}(C)[TPC] + V_{CLR}(C)[CLR] + V_{ARM}(C)[ARM] + V_{TAS}(C)[TAS] + V_{PFS}(C)[PFS] + \varepsilon \qquad \text{--- (2)}$$

where V is the implicit value per unit of characteristic as perceived by households having characteristics C (for definitions of various variables see Table 1). In developing countries, quality characteristics are neither established at the producer level nor maintained by an intermediary (i.e., the milk collector who collects and supplies the major share to the consumers) when the product moves from producer to consumer. This is particularly true for sensory variables which are badly affected by the poor infrastructure and non-use/unavailability of refrigeration facilities to a majority of milk collectors due to usage of motorcycle for the collection/transportation of milk. According to Stroebele and Castro (2004), consumer's expectation and behaviour depend partly on the color, taste, aroma, and freshness of the product; therefore, these variables should be included in the hedonic price model of milk for developing countries.

Most of the studies on hedonic price analysis estimated the first stage of the two-stage analysis proposed by Rosen (1974), and Brown and Rosen (1982). There are a few studies that estimated the second stage i.e., supply and demand functions for the characteristics. Since the daily supplies of characteristics of fresh milk are given each day and this supply cannot be changed, therefore, the supply of characteristics is perfectly inelastic and can be treated as exogenous. It implies that the prices of characteristics are solely determined by demand and the two-stage model can be used to estimate demand functions for characteristics (Kristofersson and Rickertsen, 2007). It may be noted that in the case of exogenous inelastic supply, second stage estimates are efficient if the first stage hedonic price function estimates are accurate (Teuber, 2010).

The hedonic literature does not definitely specify a functional form for the hedonic price models. However, Cropper et al. (1988) by taking the least errors as the choice criterion, have concluded that linear Box-Cox function appears to be the best functional form (Box and Cox, 1964) when estimating hedonic price functions out of six functional forms i.e., linear, semilog, double-log, Box-Cox linear, quadratic and quadratic Box-Cox. Therefore, in this study, we estimated hedonic price function using Box-Cox transformation in the first stage and implicit value functions for fat and solids-not-fat components of milk in the second stage following Brown and Rosen (1982), Lenz *et al.* (1991), Lenz *et al.* (1994), Edmeades (2007) and Teuber (2010). At the first stage, the following empirical model is estimated.

$$P_i^{\lambda_0} = V_{FAT}(C)FAT_i^{\lambda_1} + V_{SNF}(C)SNF_i^{\lambda_2} + V_{TPC}(C)TPC_i^{\lambda_3} + V_{CLR}(C)[CLR] + V_{ARM}(C)[ARM] + V_{TAS}(C)[TAS] + V_{PFS}(C)[PFS] + \varepsilon$$

Table 1. Descriptive Statistics of Variables.

Variable	Description	Mean	Std. Dev.
Price	Milk price per litre (US$)	0.71	0.073
FAT	Butter-fat (grams/litre)	38.08	8.41
SNF	Solids-not-fat (grams/litre)	72.20	10.37
TPC	Total plate count (cfu/ml)	5.34×10^7	1.41×10^8
CLR	1 if the color of milk is good, zero otherwise	0.66	0.48
TAS	1 if the taste of milk is good, zero otherwise	0.74	0.44
ARM	1 if the aroma of milk is pleasant, zero otherwise	0.78	0.41
PFS	1 if the consumer feels milk is fresh, zero otherwise	0.75	0.44
DUM	1 if education is less than high school level, zero otherwise	0.25	0.44
DMTG	1 if education is from high school to graduation level, zero otherwise	0.38	0.49
DOG	1 if education is above graduation level, zero otherwise	0.37	0.49
DW	1 if household head holds a white-collar job, zero otherwise	0.43	0.50
DB	1 if the household head is a businessman, zero otherwise	0.36	0.48
DL	1 if the household head is a labourer, zero otherwise	0.21	0.41
PR16	Percent family member with age 16 years and under	39.11	29.22
PRM16	Percent family member with age more than 16 years	60.09	29.88

$$P_i^{\lambda_0} = \begin{cases} \left(\frac{P_i^{(\lambda_0)} - 1}{\lambda_0}\right); & \lambda_0 \neq 0 \\ \log P_i; & \lambda_0 = 0 \end{cases};$$

Where

$$FAT_i^{\lambda_1} = \begin{cases} \left(\frac{FAT_i^{(\lambda_1)} - 1}{\lambda_1}\right); & \lambda_1 \neq 0 \\ \log FAT_i; & \lambda_1 = 0 \end{cases};$$

$$SNF_i^{\lambda_2} = \begin{cases} \left(\frac{SNF_i^{(\lambda_2)} - 1}{\lambda_2}\right); & \lambda_2 \neq 0 \\ \log SNF_i; & \lambda_2 = 0 \end{cases};$$

$$TPC_i^{\lambda_3} = \begin{cases} \left(\frac{TPC_i^{(\lambda_3)} - 1}{\lambda_3}\right); & \lambda_3 \neq 0 \\ \log TPC_i; & \lambda_3 = 0 \end{cases}$$

The variables are defined as in Table 1.

The function is estimated by regressing the observed milk prices on all characteristics of milk. The marginal values of fat and solids-not-fat attributes are obtained by using the estimates from the first stage hedonic price model as under for each consumer:

$$\hat{P}_{FAT_i} = V_{FAT} FAT_i^{(\lambda_1)-1}$$

$$\hat{P}_{SNF_i} = V_{SNF} SNF_i^{(\lambda_2)-1}$$

The second stage involves the estimation of the implicit value function for fat and solids-not-fat as a function of shifter variables i.e., socio-demographic characteristics. At the second stage, the following models are estimated.

$$\hat{P}_{FAT_i} = \beta_1 DUM_i + \beta_2 DMTG_i + \beta_3 DOG_i + \beta_4 DW_i + \beta_5 DB_i + \beta_6 DL_i + \beta_7 PR16_i + \beta_8 PRM16_i + \varepsilon_i$$

$$\hat{P}_{SNF_i} = \alpha_1 DUM_i + \alpha_2 DMTG_i + \alpha_3 DOG_i + \alpha_4 DW_i + \alpha_5 DB_i + \alpha_6 DL_i + \alpha_7 PR16_i + \alpha_8 PRM16_i + \mu_i$$

We have presented the implicit value functions for fat and solids-not-fat nutrients of milk, while these functions for non-nutrients have been ignored as they are not of primary interest.

***Study Area*:** The study is confined to a developing country, Pakistan which is situated in the South Asia region. This region has about 745 million of the dairy animal population that shares 21 percent of global dairy animals. It produces about 200 million tons of milk that accounts for 21 percent of global production. Among the South Asian countries, India and Pakistan account for 69.4 and 18.5 percent of total dairy animals in the region (Siddiky, 2017). According to OECD/FAO (2018), these two countries are expected to share 32 percent of global milk production and most of the additional production of milk will be consumed locally as fresh dairy products. Pakistan is the third largest milk producer in the world following India and USA (Farooq, 2016). Pakistan represents a very well case of countries like India, Bangladesh and many other developing countries where a major part of raw milk is marketed through traditional channels that do not involve any processing. In these countries, milk yield per animal is low and indicate the presence of potential in this sector. These countries are experiencing faster growth in population, rapid urbanization and increasing demand for livestock products due to rising per capita income. As milk marketing in these countries is facing challenges like poor infrastructure, quality assurance, adulteration, etc. so the finding of this study will have useful implications for many developing countries.

In Pakistan, livestock's contribution to the total value of agriculture was 60.56 percent in 2019-20, and the major products of livestock were milk and meat. During this period, 61.69 million tons of milk was produced and around 80 percent of produced milk is consumed by humans while in the remaining 20 percent, about 15 percent is wasted during transportation and 5 percent is used for feeding calves (GoP, 2020). About 26 percent of the food budget is spent on milk and milk products (GoP, 2015). In the case of milk, the usual concept of the market is not applicable because of non-existence of market for milk like food grain market, fruit market, etc. (Sharif *et al.*, 2003). About 90 percent of the total milk entered in marketing is contributed by subsistence farmers and the remaining is shared by commercial dairy farms. The milk marketing system consists of two channels i.e., traditional that market raw unprocessed milk, and non-traditional that procure, process and distribute processed milk. Nearly 40 percent of the total milk produced is marketed through these channels (Farooq, 2016) and the informal traditional channels share about 90 percent of the marketed milk (Riaz, 2008). The traditional milk marketing channel involves the collection of milk from small-sized milk producers by an intermediary called "Dudhiya" who then transport it to consumers in urban areas by using a motorbike. During this journey, most of the middlemen take their collected milk initially to the creamery for cream (i.e., fat) extraction from milk, and then distribute the cream extracted milk to consumers. During summer because of intense heat, middlemen further dilute milk through the addition of unclean and un-hygienically produced ice. They also add carbonate, bicarbonates, hydrogen peroxide, caustic soda, and sometime formalin to prevent the spoilage of milk (Riaz, 2008). A middleman trades 50 to 150 liters of raw milk and sells at consumer's doorstep (Sharif *et al.*, 2003).

For this study, the data has been collected from milk consumers at household level by using a pre-tested questionnaire and by taking milk sample from the same household from Faisalabad city, the third largest city in Pakistan. Raw milk is sold to the consumers by several retailers and most of them buy milk from the producers. The retailers move from house to house to sell their milk to the consumers every day. For a retailer, these consumers are scattered either in the same location or in different locations. Therefore, 96 consumers were selected from different locations having different levels of income. Data were obtained about the socioeconomic and demographic characteristics of respondents, and perceptions about quality attributes of the milk i.e., color (desirable or undesirable), taste (good or not good), aroma (pleasant or unpleasant) and

perceived freshness (yes or no). Milk sample taken from each respondent was used to determine the milk components and total plate count in a laboratory.

The definitions and descriptive statistics for variables considered in this study are reported in Table 1. The average price charged for milk is US$ 0.71 per litre (local price of milk in Pak. Rupees was converted into US$ using 1 US $ = Rs 110). There is wide variation in the price that is paid by the consumers. It is common practice that each "Dudhiya" supplies more than one kind of milk and he charges according to the quality of milk supplied to the consumer. Consumers are also aware of the quality of milk they are buying i.e., they pay a high price for pure milk, lower price for adulterated milk and still lower price for more adulterated milk.

The average quantity of fat and solids-not-fat are 38.08 grams and 72.20 grams per litre of milk, respectively in the sample. These quantities are lower than the standard quantities of fat and solids-not-fat found in cow and buffalo milk. For example, the standard cow milk contains 43.9 grams of fat and 91.10 grams of solids-not-fat, while the respective figures for buffalo's milk are 67.1 grams and 101.10 grams. Mean amount of water is 889.72 grams per litre in the sample compared to 865.00 grams and 831.80 grams in cow and buffalo milk, respectively (Buffalo milk versus cow milk, 2013). The average number of total plate counts in the sampled data set is 5.34 x 10^7cfu/ml that is higher than the International Microbial Criteria for cow/buffalo milk i.e., 10^5cfu/ml for cow milk and 1.5x10^6cfu/ml for buffalo milk (Institute of Medicine National Research Council of the National Academics, 2003). These results show that in the sampled milk, fat and solids-not-fat contents are lower, while water and total plate count are higher than the quantities of these contents in the standard milk. This is mainly due to adulteration of milk through the addition of water by the informal traders and the milk producers, and poor hygienic conditions. Milk producers and middlemen add water in the traditional marketing channels to increase the revenue from the sale of milk because they know that their milk will not be checked for quality by anyone at the time of selling.

RESULTS

To eliminate the effect of influential observation, the present study used the DFFITS criterion as suggested by Belsley *et al.* (1980). Application of this criterion resulted in the exclusion of four observations and reduced sample to 92 observations.

Five different Box-Cox models were estimated with the same or different levels of transformations on the dependent and independent variables. In all Box-Cox models, the signs of different coefficients were consistent with expectation. For the identification of the best model, we computed the following statistics for various models (Asteriou and Hall, 2007).

$$\left(\frac{1}{2}n\right)\ln\left(\frac{RSS_2}{RSS_1}\right)$$

Where n is sample size, RSS_2 is Residual Sum of Square (RSS) of the equation with higher RSS, RSS_1 is RSS of other equation

Based on the above test, the Box-Cox model having the same transformation for independent variables (λ= 0.675) and no transformation of the dependent variable provided the best results. To check the econometric problems associated with the estimation of the hedonic pricing model, Ramsey's Regression Specification Error Test (RESET) is used to test the specification error. The calculated value of this test is 1.14 and is insignificant and indicates that the model is correctly specified. Mean value of VIF was 1.33 and is less than 10 i.e., the rule of thumb maximum value (Gujarati *et al.*, 2009) for the existence of high multicollinearity and indicates that it is not a critical problem in the estimated model. To check the heteroscedasticity, Breusch-Pagan/Cook-Weisberg test was used. In this test, χ^2 statistic is 0.12 and was insignificant. Hence, we cannot reject the null hypothesis of constant variance and conclude that the assumption of homoscedasticity is not violated. The results for the estimated econometric model are reported in Table 2.

Table 2. OLS Estimates of Box-Cox Hedonic Model of Milk.

Variable	Coefficient	Slope	Elasticity
$FAT^{\lambda 1}$	0.79 ‡	0.243	0.118
	(0.375)		
$SNF^{\lambda 2}$	2.16 †	0.537	0.494
	(0.256)		
$TPC^{\lambda 3}$	-0.05	-0.013	-0.009
	(0.031)		
CLR	3.48 §		
	(1.838)		
TAS	1.19		
	(2.378)		
ARM	8.95 †		
	(2.528)		
PFS	2.64		
	(1.944)		
Mean VIF			1.33
Breusch-Pagan / Cook-Weisberg test for heteroscedasticity			0.12
RESET Specification Test			1.14
R Square			0.99
F Test			1301.47†

†, ‡ and § shows the coefficient is statistical significance at 5, 10 and 20 percent level of significance. The robust standard error is reported in the parenthesis

The F-statistics is 1301.47 and indicates that regressors are jointly significant in explaining variations in milk prices. In

Table 3. Implicit Value of Fat and Solids-not-fat Based on Box-Cox Model.

Variable	Ordinary Least Square Procedure		Weighted Least Square Procedure	
	Fat	Solids-Not-Fat	Fat	Solids-Not-Fat
Age (Reference PR16)				
PERM16	0.001 †	0.003 †	0.001 †	0.003 †
	(0.000)	(0.000)	(0.000)	(0.000)
Education (Reference DOG)				
DUM	0.116 †	0.272 †	0.113 †	0.266 †
	(0.016)	(0.034)	(0.016)	(0.034)
DMTG	0.067 †	0.140 †	0.067 †	0.138 †
	(0.014)	(0.029)	(0.014)	(0.028)
Profession (Reference DL)				
DB	0.135 †	0.293 †	0.135 †	0.294 †
	(0.013)	(0.026)	(0.014)	(0.026)
DW	0.118 †	0.266 †	0.118 †	0.266 †
	(0.016)	(0.032)	(0.016)	(0.032)
R Square	0.944	0.950	0.944	0.951
F Test	351.230 †	413.760 †	354.730 †	428.710 †

† shows that the coefficient is significant at 1 percent level of significance, The robust standard error is reported in the parenthesis

the estimated model, signs of all variables are according to expectations and most of them are significant. The elasticity estimate of fat indicates that an increase in fat by one percent increases the milk price by 0.118 percent. The elasticity estimated for solids-not-fat shows that an increase in it by one percent increases milk price by 0.494 percent. The effect of total plate count on milk price is negative but significant at 20 percent level of significance. The parameters estimated for color, taste, aroma and perceived freshness are positive but significant for color and taste only.

The second stage is estimated under ordinary and weighted least squares procedures. Weights are equal to the inverse standard error obtained at the first stage. It implies that more weight is assigned to more precise estimates than less precise ones (Teuber, 2010). It has been pointed out that for unequal variances of estimated regression coefficients at first stage, the estimates obtained in the second stage will be inefficient if estimated by ordinary least squares method (Kristofersson and Rickertsen, 2007). In such a case, weighted least squares can be used to obtain unbiased and efficient estimates at the second stage. Various functional forms were estimated in this stage, but linear model reported the best results. The implicit value functions estimated at the second stage for fat and solids-not-fat are reported in Table 3. The ordinary least squares and weighted least squares estimates obtained for various variables are consistent in terms of the direction of the impact for both fat and solids-not-fat. Further, the parameters are not very different and the magnitude of the impact of dummies is very similar to fat as well as solids-not-fat for both models. These results show implicit values for fat and solids-not-fat that differ depending on the type of household making the decision. Most of the signs of coefficients conform to a priori expectations.

DISCUSSION

The results about fat are quite in line with the research work of Lenz *et al.* (1991). Real life behaviour of consumers also indicates that they pay a lower price for cow milk than buffalo's milk because of a low-fat percentage while purchasing milk. Milk processing firms also pay price based on fat percentage. The negative effect of total plate count on milk price can partly be explained by the fact that an increase in total plate count in milk will result in more chances of spoilage of milk. The dummy variable for color had a significant positive impact on the price of milk in the estimated model and milk color influenced consumer's judgment and perception about it. The results are in line with the finding of Stroebele and Castro (2004) who reported that consumer's expectation and behaviour about the beverages and food depends partly on the color. Further, if the product is in favourite color then this product is rated high. The parameter estimate for taste was although positive but not statistically significant. This is probably because taste is an experience characteristic and can be established after consumption (Nelson, 1974). The parameter estimate for the aroma of milk is positive and significant. It indicates that it is a search characteristic and can be identified by consumers before purchase. Further, good aroma product is always preferred over the undesirable (Stroebele and Castro, 2004) and unpleasant aroma - a characteristic of the spoiled product (Hayes *et al.*, 2002). Dummy for perceived freshness was positive but insignificant and hence indicated that variables related to color and aroma have more importance in the determination of milk price.

From the results of second stage, it can be observed that all the households irrespective of educational level, profession,

and proportion of children to adults place more value on fat and solids-not-fat components of milk. The dummy variables for under high school education and high school to the graduate level of education had significant positive parameter estimates for fat indicating that the buyers with a low level of education attach more value to fat and are less health conscious about the undesirable effects of more consumption of fat on health than for buyers having above graduate level education. A possible explanation may be that relatively better-educated buyers rely more on other milk characteristics such as solids-not-fat. The marginal price paid for solids-not-fat is significantly higher for buyers having education up to graduate level compared to buyers having education above graduation level. A possible explanation of this is that an insufficient level of solids-not-fat is being consumed by a large majority of buyers having education up to graduation level and suggests that the consumption of the additional unit of solids-not-fat would be desirable for most buyer households. White collared households and business professionals have positive significant coefficients both for fat and solids-not-fat and indicates a higher marginal valuation for both components than households with laborer profession. The higher valuation may be due to the difference in taste, nutrient requirements, awareness, and level of income. The significant positive coefficients for households with a higher proportion of family members with age more than 16 years indicate higher marginal valuation for both fat and solids-not-fat than did with households with a lower proportion of family members with age up to 16 years. Thus, there is a strong statistical support that marginal valuation of both fat and solids-not-fat changes with age.

Conclusion: We used the revealed preference framework and hedonic price modeling to understand the influence of various quality attributes of milk on prices paid by household consumers. Determination of the sources of price variation is useful for producers to understand consumer preferences for specific quality attributes of milk. From the first-stage results it can be concluded that consumers are paying a premium price for milk which has higher quantities of fat, solids-not-fat, desirable color and aroma. The second-stage results showed that irrespective of education level, profession, and proportion of children/adults, households place more value on fat and solids-not-fat components of milk.

The results of the present study have several policy implications. Firstly, the results indicate that consumers are paying a premium price for both fat and solids-not-fat milk components but unfortunately, the milk supplied to the consumers has less fat and solids-not-fat percentage than their minimum quantities specified in Food Ordinance 1960. During summer, milkmen add ice for chilling purposes and add various non-recommended additives and preservatives. Further, they de-cream milk to increase their revenues and profits from the sale of milk. Lack of quality checks is an ignored area in the raw milk marketing system. As there is no test at any point in the informal marketing chain so there is a strong need for the establishment of checkpoints to maintain the quality of milk and stop adulteration. There is also a need for expanding the scope of existing food safety laws beyond the contents of fat and solids-not-fat to incorporate other serious problems such as adulteration, microbial counts, etc.

Secondly, in the present marketing system, chilling centres should be established in rural areas to increase the shelf life of milk. It will help in reducing adulteration through less use of ice. Further, road infrastructure is very poor and marketable quantities of milk are either not collected or partially collected from the interior villages due to high transportation cost. So, the government should develop proper infrastructure in order to enable consumers to get good quality milk at less price.

Thirdly, milk markets are not well developed like other agricultural commodities markets. Mainly this sector comprises of small-sized milk producers and middlemen who are involved in milk collection and distribution. These functionaries are well scattered and involvement of long-duration between producers and consumers require the development proper milk collection systems to ensure the provision of good quality milk.

Fourthly, the study indicates that an increase in total plate count has a negative effect on the price of milk. Poor hygienic conditions right from the point of production to consumption deteriorate the quality of milk. There is enough evidence that total bacterial count is positively correlated to the inadequate or poor cleaning of teats, unsanitary conditions of udder, poor health and hygiene of milking animal, inadequate cleaning and sanitation of milking utensils and equipment, poor quality of cleaning water, poor sanitation of housing, etc. (Pantoja *et al.*, 2009; Nada *et al.*, 2012). According to Park et al. (2019), 'hygiene' is an important variable across participants in the selection of milk in Korea. Thus, we suggest that the proper milk hygiene awareness programs may be launched for milk producers for their awareness about the importance of hygienic practices and housing environment in the production and handling of milk at household level. This awareness can significantly reduce undesirable initial level of microbial load which ultimately reduce microbial load at later stages. Similarly, awareness programs need to be initiated for all stakeholders involved in the milk value chain for milk handling and hygiene. Provision of basic milk testing equipment at subsidized rates can be used during milk collection for improvement of its quality. Further, establishment of mobile laboratories easily accessible to consumers and other stakeholders in the value chain for testing the quality of milk will also help in improvement of quality.

Fifthly, in order to prevent or delay the growth of harmful organisms, milk preservation techniques need to be adopted by middlemen and milk producers to enhance the shelf life of milk. Thermal pasteurization and cool storage are the

common technologies for safeguarding the quality of milk in developed countries. It may not be possible to use these methods in many developing countries due to technical/economic reasons. Food and Agricultural Organization (Muehlhoff *et al.,* 2013) and International Dairy Federation (2013) advocate the use of lactoperoxidase, a natural enzyme found in milk, as a catalyst for preserving milk. Adding a pre-packaged activator containing thiocyanate and sodium percarbonate activates the natural lactoperoxidase system in raw milk. It prevents bacteria multiplication and extends the acceptable quality of raw milk between 6 to 8 hours at 30C or for 24 hours at 15C (International Dairy Federation, 2013). Application of this technology will enhance the shelf life of milk and provides enough time to the middlemen and small milk producers to store and/or transport milk.

Finally, due to various harmful organisms, raw milk available at the retail level to consumers is of poor quality and hazardous for human consumption. Consumers believe that bacteria and other harmful substances present in the milk are killed once the milk is boiled. They are not aware of health risks associated with the ingestion of organisms from the consumption of raw and/or raw fermented milk. Therefore, necessary legislation needs to be done immediately for the sale and distribution of pasteurised milk.

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