Consumer preferences and willingness to pay for Aflatoxin-Free Milk in Pakistan

A. Abedullah[1]; S. Kouser[2]; M. Ibrahim[3]

1: Pakistan Institute of Development Economics, Environmental Economics, Pakistan, 2: COMSATS Institute of Information Technology, Islamabad, Economics, Pakistan, 3: International Livestock Research Institute, , Pakistan

Corresponding author email: abedullah@pide.org.pk

Abstract:

Aflatoxins are highly toxic compounds in milk and pose serious risks to human health. Past studies have observed high concentration of aflatoxin in raw milk of Pakistan. Nonetheless, this study contributes by investigating consumers' demand for aflatoxin-free raw milk. For this purpose, we conducted a discrete choice experiment with a random sample of 360 households drawn from three mega cities of Punjab province. Random parameter logit and latent class models are used to incorporate preference heterogeneity in the stated choice analysis. Empirical findings suggest that consumers want to pay a highest premium for milk having low concentration of aflatoxin. Based on these findings, we suggest that there is considerable scope for the rapid development of aflatoxin-free raw milk, even though it is marketed at prices that are significantly higher than current milk prices.

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Key words: *Aflatoxin, Choice Experiment, Pakistan*

1. Introduction

Milk is a vital constituent of human diet. Nevertheless, its contamination with aflatoxin has been recognized as a significant milk safety challenge. Contaminated animal feeds are a major source of entering aflatoxins in human food chain (Aslam et al., 2015). The US Center for Disease Control and Prevention has reported that 4.5 billion people in Asia and Africa have chronic exposure to aflatoxins (CDC, 2013), which cause liver cancer, heart diseases, abortion, immune suppression and impaired growth (Khlangwiset et al., 2011; Liu and Wu, 2010; Wu et al., 2011). Hence, reduction of aflatoxin intake is imperative to minimize human health hazards. The European Union (EU) has set the maximum safe limit of aflatoxin in milk at 0.05 parts per billion (ppb). Nonetheless, Pakistan Standard and Quality Control Authority has fixed the permissible limit at 10 ppb (Ashiq, 2014), which raises serious concerns about the government policies to provide safe milk to consumers.

Many studies have detected aflatoxin concentration above the safe limits in raw milk of Pakistan (Asi et al., 2012; Aslam et al., 2015; Iqbal and Asi, 2013; Iqbal et al., 2014). Aflatoxin reduction is beneficial not only from economic but also from health and productivity perspectives of both human and livestock. For this purpose, several strategies have been suggested to prevent aflatoxin contamination of animal feeds during storage stages (Kabak et al., 2006). Farmers' adoption of these strategies demand producer price increment to compensate for additional production and handling costs. In addition, dairy companies are also planning to devise various production schemes to deliberate this issue of contamination. But the value of safe milk based on consumer's willingness to pay a premium is unknown to farmers and dairy companies. Price premium for aflatoxin-free milk could lead to market based solution to make safe milk available to consumers in the country.

This article aims to assess consumers' preferences and willingness to pay for aflatoxin-free milk in Pakistan. More specifically, we wish to address the issue of complex tradeoffs between four different attributes of milk such as fat content, bad smell, aflatoxin concentration and price. To elicit preferences for these attributes, we conducted a stated preference discrete choice experiment with 360 randomly selected raw milk consumers of Punjab province in 2016. Choice experiment enables to estimate premium for each attribute despite the fact that some attributes/levels like low aflatoxin concentration may not actually exist in real market. We use random parameter logit and latent class models to analyze heterogeneity in consumers' preferences at individual and group level, respectively. Additionally, we estimate consumers' willingness to pay for different milk attributes.

Previous studies in agricultural and food economics have used discrete choice experiments to evaluate consumers' preferences for bio-fortified crops (Banerji et al., 2013; Meenakshi et al., 2012), genetically modified (GM) food (Kikulwe et al., 2011; Rigby and Burton, 2005), beef safety labels (Owusu-Sekyere et al., 2014), recycling of food packaging (Klaiman et al., 2017), and the use of GM feed or growth hormones in animal husbandry (Lusk et al., 2003). However, we have found only one choice experiment conducted in Kenya to examine consumers' preferences for aflatoxin-free milk (Walke et al., 2014). In their experimental design, they categorized color and smell as quality attribute and aflatoxin-free certification as safety attribute of raw milk. According to the best of our knowledge, no discrete experiment on aflatoxin-free milk has been so far implemented with Pakistani consumers and safety attribute defining unique levels of aflatoxin concentration. Hence, this study builds on existing works by quantifying consumers' valuation for different levels of aflatoxin in milk.

This study contributes to the prevailing literature by adding several innovations. First, the study introduces safety attribute, concentration of aflatoxin, by uniquely specifying its three hypothetical levels: high, medium and low. These levels would help consumers to make realistic choices keeping in view their own health safety. Second, this article analyzes consumers' demand of aflatoxin-free milk by using representative data compiled from across Punjab's higher educational/research institutions. This permits exploration of heterogeneity in consumers' preferences using random parameter logit and latent class models. Consumers with high education and income levels may be more willing to pay than their counterparts, since they may better understand the associated health benefits of aflatoxin-free milk. However, uncertainties regarding future availability of aflatoxin-free milk may curb their willingness to pay a premium. Third, it provides valuations of quality attributes such as fat content and bad smell which are germane to Pakistan's milk sector. Consequently, the study findings have far-reaching impacts on research, development and marketing of aflatoxin-free milk, besides formulation of policies and regulations articulated for consumers' milk safety in Pakistan (Ashiq, 2014).

The rest of this article is structured as follows: the next section describes aflatoxin contamination of milk supply in Pakistan. Section 3 deliberates choice modeling approach and experimental design used to analyze consumers' preferences. Description of data collection procedure and data are presented in section 4. Section 5 discusses the econometric results. The last section concludes and suggests policy recommendations.

2. Aflatoxin Contamination of Milk Supply in Pakistan

Pakistan is the fourth largest milk producer in the world, with annual production of nearly 52.6 million tonnes. Milk contribution to its agro-based economy is approximately Rs. 2.1 trillion which is substantially higher than the cumulative share of all major crops (GoP, 2016). About 50 million small farmers contribute 95% to the total milk produced in the country and millions of milkmen involved along the milk supply chain (GoP, 2006). Major share (97%) of the marketable surplus of milk is marketed in raw form by the informal sector (Jawaid et al., 2015). The per capita consumption of milk and dairy products is ranging between 150 to 200 liters per annum, indicating their highest share in the food expenditures (Malik et al., 2014).

Aflatoxin in milk poses serious public health hazards to humans. Previous studies have shown that contaminated animal feed and fodder contain the most common isoform B1 of aflatoxin (Battacone et al., 2003; Caloni et al., 2006). Figure 1 shows that when lactating animals consume contaminated feed with aflatoxin B1 (AB1), then alflatoxin M1 (AM1) is produced in their milk by hepatic microsomal mixed function oxidase system (Ismail et al., 2017). Battacone et al. (2003) have concluded that concentration of AM1 in milk is highly correlated with the level of AB1 in feed. The presence of AM1 in raw milk has been reported above the safe limits of EU for Lahore, Faisalabad and other cities of Punjab province (Iqbal et al., 2014). They have investigated that milk samples from urban farmhouses of Punjab have higher AM1 than those in rural areas. Asi et al. (2012) have documented that concentrations of AM1 were relatively high in winter milk than that in summer due to improper storage conditions in winter and better availability of fresh feed in summer. Hussain et al. (2010) have investigated milk of five species and concluded that the concentrations of AM1 were beyond permissible limits in milk of buffalo and cow. This brief review provides empirical evidences on the existence of aflatoxicosis in raw milk of Pakistan demanding immediate attention for stable solution.

Figure 1 is here

3. Choice Experiment Method

3.1. Theoretical Framework

This article uses a discrete choice experiment (DCE) method to elicit consumers' stated preferences for aflatoxin-free milk in Pakistan. The DCE allows evaluating consumers' demand for hypothetical good with non-market attributes, similar to real market options. The DCE is preferred over other stated preference elicitation methods like contingent valuation and conjoint analysis by eliminating various biases (Louviere et al., 2010). It is based on the theory of consumer choice (Lancaster, 1966), where consumers derive utility from the attributes of a good, rather than from the good itself. The DCE method has econometric grounding in random utility theory (McFadden, 1974), which allows integrating behavior with economic valuations. This article models urban consumer's choice of raw milk embodying aflatoxin-free trait and other attributes. Suppose consumer i chooses among J raw milk alternatives enclosed in a choice set C during choice situation t. Consumer's utility of this choice is denoted by a latent variable U^*_{ikt}. Given the budget constraint, consumer i will opt for a specific raw milk $k \in J$ if and only if $U^*_{ikt} > U^*_{imt}$ $\forall k \neq m$ and $k, m \in J$. The latent utility U^*_{ikt} can be observed indirectly if a particular alternative is chosen or not within a choice set C and utility maximizing decision is illustrated in Eq. 1:

$$U_{ikt} = \begin{cases} 1 \text{ if } U^*_{ikt} = \max\left(U^*_{i1t}, U^*_{i2t}, \ldots, U^*_{iJt}\right) \\ 0 \quad \text{Otherwise} \end{cases} \tag{1}$$

Following the existing stated preference literature, U^*_{ikt} presumes a linear functional form (Eq. 2). Therefore, marginal utility being monotonic in choice attributes provides corner solution, inferring that only one raw milk is selected in a defined choice set.

$$U^*_{ikt} = X'_{ikt}\beta + \varepsilon_{ikt} \tag{2}$$

The utility function U^*_{ikt} comprises two components: deterministic component ($X'_{ikt}\beta$) embodies vectors of attributes and their associated parameters for k^{th} alternative in a choice situation t, while stochastic component/error term (ε_{ikt}) represents the unobservable random variable, implying that predictions cannot be made with certainty. Following McFadden (1974), error term is assumed to have IID type-I extreme value distribution with constant variance. This assumption allows the probability (P_{ikt}) of choosing k among j choice alternatives to follow a logistic distribution (Hensher et al., 2005) as shown in Eq. 3:

$$P_{ikt} = \frac{e^{\beta X'_{ikt}}}{\sum_{j=1}^{J} e^{\beta X'_{ijt}}} \quad k \epsilon J \tag{3}$$

This indicates a simplest multinomial logit (MNL) model, which assumes homogeneity in tastes and preferences but in reality consumers are heterogeneous in their preferences. Green (2008) proposed accounting for heterogeneity in preferences for unbiased and reliable estimates of demand and welfare. The random parameter logit (RPL) model is less restrictive than MNL model as it relaxes IID assumption by allowing parameter values to vary across the population according to some pre-specified distribution (Greene and Hensher, 2003; McFadden and Train, 2000). P_{ikt} is computed by solving the following integral (Train, 2003):

$$P_{ikt} = \int \frac{e^{\beta_i X'_{ikt}}}{\sum_{j=1}^{J} e^{\beta_i X'_{ijt}}} f(\beta|\Omega) d\beta \tag{4}$$

where β_i is a vector of consumer specific parameters and Ω denotes symbolizes the distribution of random parameters. We assume normal distribution for coefficients of all attributes. The RPL model was first proposed by Boyd and Mellman (1980). Now it has been commonly employed in the studies of applied economics such as agriculture (Kouser and Qaim, 2013; Ward et al., 2015), livestock (Lusk et al., 2003), dairy (Walke et al., 2014), food safety (Hasselbach and Roosen, 2015) and health (Personn, 2002).

The latent class multinomial logit (LCMNL) model has also been applied to identify the sources of heterogeneity at the latent preference classes identified in the population (Louviere et al., 2000). Examination of preference heterogeneity for different classes is important for policy purposes, especially when estimating welfare impacts of introducing a new product (aflatoxin-free milk). The probability ($P_{ikt|s}$) of consumer i belonging to a particular class s choosing alternative k among j choice alternatives in choice situation t is expressed as:

$$P_{ikt|s} = \frac{e^{\beta_s X'_{ikt}}}{\sum_{j=1}^{J} e^{\beta_s X'_{ijt}}}, s = 1, \ldots, S \tag{5}$$

where β_s is a vector of class specific preference parameters. Class membership is conditioned by observable consumers' characteristics. The probability (P_{is}) of consumer i belonging to class s is given by:

$$P_{is} = \frac{e^{\alpha_s Z_i'}}{\sum_{s=1}^{S} e^{\alpha_s Z_i'}} \quad (6)$$

where Z_i' represents consumers' social, economic and demographic characteristics and α_s is the class specific parameter capturing the relative importance of each of these characteristics with respect to class membership. Alternatively, we can assume that P_{is} is random, which is a special case of (6) in which Z_i' is simply a null vector. In any case, P_{is} sums to 1 across S latent classes. The joint probability (P_{iks}) can be computed by assuming independence between probabilities of Eqs. 5 and 6 as:

$$P_{iks} = \left[\frac{e^{\alpha_s Z_i'}}{\sum_{s=1}^{S} e^{\alpha_s Z_i'}}\right]\left[\frac{e^{\beta_s X_{ikt}'}}{\sum_{j=1}^{J} e^{\beta_s X_{ijt}'}}\right] \quad (7)$$

where the first term in brackets denotes the probability of observing consumers in class s and the second term symbolizes probability of choosing k alternative conditional on belonging to class s. This composite LCMNL model permits homogenous preferences within heterogeneous classes of consumers.

Application of the LCMNL was initiated by Kamakura and Russell (1989) in the marketing field which was later on extended to recreation (Boxall and Adamowicz, 2002), transportation (Shen et al., 2006), environment (Milon and Scrogin, 2006), agriculture (Dalton et al., 2011) and livestock (Ruto et al., 2008). Its application in food economics remains, however, relatively limited. Only Kikulwe et al. (2011) have estimated heterogeneity in consumer demand for GM banana using this model.

3.2. Choice Experiment Design

The DCE design defines the good (milk) in terms of its attributes and associated levels. Based on the previous literature, informal discussions with consumers and intensive consultations with experts on livestock and microbiology, we identified four important attributes and their respective levels. The selected attributes and their levels are presented with suitable illustrations in Table 1.

Table 1 approximately here

From consumers' health safety perspective, the most undesirable attribute in milk choice is aflatoxin (AM1) concentration, which is measured in microgram per liter (ug/L)[1]. Based on prior work on aflatoxin concentration in raw milk of Pakistan (Ashiq, 2015), we generate three hypothetical levels: high (1.5 ug/L), medium (1.0 ug/L) and low (0.5 ug/L)[2]. This may help to investigate consumers' preferences for these levels.

The second attribute included in the DCE is fat content, represents the proportion of butterfat in raw milk and varies from whole fat milk (fat ≥ 3.5%), reduced fat milk (fat ≤ 2%), low fat milk (fat ≤ 1%) to non-fat milk (fat ≤ 0.2%). Consumers, who extract butterfat from raw milk, may prefer whole fat milk, though health-conscious consumers may prefer low/non-fat milk. Hence, this invisible attribute enables us to value consumers' utility or disutility for milk quality.

The third attribute, bad smell, also represents the physical quality of purchased milk but contrary to fat content, it is immediately observable. We generate two hypothetical levels: yes (presence of bad smell) and no (absence of bad smell).

The fourth and last attribute is price of milk as a payment vehicle, which portrays the amount of money (Pak Rs.) required to buy one liter of milk. It has four levels ranging between Rs.80/liter to Rs.140/liter, with an increment of Rs.20/liter. This monetary attribute allows computing welfare estimates of consumers' willingness to pay (WTP) a premium or willingness to accept (WTA) a discount based on other three attributes.

An experimental design method is employed to randomly combine the levels of these four attributes into choice sets. Following Kuhfeld (2010), an information efficient (D-optimal) design is adopted to construct a fractional factorial design, from a full factorial design, having minimum D-error. Our efficient design was comprised of 48 choice sets and to minimize respondents' cognitive burden, these choice sets were randomly grouped into six blocks. Each block encompasses eight choice sets, while each set contains two hypothetical milk profiles and one status quo option to opt out if neither of the alternative milk presented is acceptable to the respondent (Figure 2). Theses blocks were randomly assigned among respondents. To facilitate visual differentiations of different levels of milk attributes, suitable and colored illustrations were

[1] 1 ug/L corresponds to 1 ppb.
[2] 0.5 ug/L indicates permissible limit of the US Food Safety Regulations.

used. Moreover, choice cards were prepared in national language (Urdu). The remaining survey instrument was kept short and simple to minimize respondents' fatigue.

Figure 2 is here

4. Data

The DCE survey was conducted by two trained enumerators and a supervisor in February and March 2016. The primary unit of analysis was raw milk urban consumers of the Punjab province, which was mainly selected because previous literature had reported milk contamination with aflatoxin for this province only (Ashiq, 2015). The sample was obtained using a four-stage sampling procedure. First, we purposively selected three largest populous cities of Punjab: Lahore, Faisalabad, and twin cities of Rawalpindi and Islamabad because aflatoxin contamination has been reported for these cities (Iqbal et al., 2014). Second, four public universities/research institutes were randomly selected in each city. Third, we stratified employees into three strata: teaching/research faculty, administrative staff and lower-grade staff, belonging to different socio-economic groups. Lastly, we randomly selected 10 employees from each stratum, generating 30 observations for each university/institute. This leads to a total sample of 360 raw milk consumers. The overall response rate was very high due to face-to-face nature of the survey instrument.

A pre-tested and well-structured questionnaire was used to obtain primary data on respondents' socioeconomic characteristics, milk consumption habits and purchasing behavior, perceptions regarding aflatoxin and DCE. Prior to survey, awareness about aflatoxin in raw milk and its negative health impacts were carefully discussed through cheap talk. Further, respondents were informed about the hypothetical situation and to ensure uniform understanding among respondents, the attributes and their levels were elucidated carefully by using Table 1.

Table 1 approximately here

Descriptive statistics of sampled consumers' socio-economic characteristics are reported in Table 2. The respondents' average age was 49 years, with mean formal qualification of 12 years. Female respondents were 11% in our sample. The average family size was 6 members including children. The average monthly income was about Rs. 41102. In terms of income categories, there were 55% respondents falling in low income categories (≤ Rs. 30,000), 31% in medium income categories (Rs. 30,000 - Rs. 90,000) and 14% in high income category (≥ Rs. 90,000), indicating that largest proportion of our sample belongs to low income category which is in line with the national statistics. The average raw milk consumption was around 2 liters per day per family and 0.39 liter per day per capita. Only 10% respondents in our sample had heard about aflatoxin contamination. However, compared to country statistics (GoP, 2016), sampled consumers on an average were older, better educated, having large household size and higher monthly income. These difference can be explained by the fact that we have sampled from higher educational/research institutes of mega cities, where education and income levels are high compared to that in small towns and villages.

Table 2 approximately here

5. Results and Discussions

From 360 interviews, we have 2880 valid choice observations to estimate RPL model. Its coefficient and standard deviations represent mean values of random utility parameters and distributional parameters of marginal utilities and are reported in upper and lower panel of Table 3, respectively. All coefficients for RPL are significant with expected signs for all attributes except fat content.

Table 3 approximately here

Significant marginal utilities of safety attribute represent that consumers prefer raw milk with low concentration of aflatoxin over medium and medium over high concentration of aflatoxin. Further, it is observed that consumers prefer milk with high concentration of aflatoxin (1.5 ug/liter) over their currently available raw milk. These findings are generally consistent with those reported by Walke et al. (2014) that consumers have higher preferences for aflatoxin-free certified raw milk.

Insignificant coefficient of fat content indicates that consumers are indifferent for this quality attribute, implying that our sample is comprised of mixed individuals having likeness and dis-likeness about this attribute. Jabbar and Islam (2010) have reported that Bangladeshi consumers consider fat content to be the least important factor in determining milk quality. However, negative and significant coefficient of bad smell reveals that consumer's marginal disutility increases with bad smell which is in line with Walke et al. (2014). Finally, the marginal utility of milk price is negative, revealing that consumers prefer lower prices over higher prices, which is consistent with conventional demand theory.

Standard deviations of all random utility parameters are statistically significant (Table 3), implying that consumers have heterogeneous preferences for these attributes (Hensher et al., 2005). The largest standard deviation is observed for high aflatoxin, indicating huge variation in consumers' preferences for this attribute.

Consumers' valuation of milk attributes for RPL model is reported in Table 4, with standard errors estimated with parametric bootstrapped procedure proposed by Krinsky and Robb (1986) based on 1,000 random draws. The sampled consumers are generally willing to pay for all hypothetical attributes except fat content. However, they consider high aflatoxin to be the least valued attribute of raw milk safety; rather they give the highest consideration to low aflatoxin followed by medium aflatoxin. Estimates of WTP suggests that consumers are willing to pay a highest premium of Rs. 125/liter for milk having low concentration of aflatoxin. However, consumers are willing to accept a discount of Rs. 44/litter for milk having bad smell. These estimates seem relatively higher than the average milk price used in our DCE design, which could be due to hypothetical bias in the choice experiment. In brief, these estimates merely represent consumers' highest extent to pay for aflatoxin-free milk.

Table 4 approximately here

To incorporate additional dimensions of consumers' heterogeneous preferences, we estimate LCMNL model. The LCMNL models can be broadly categorized as either random latent class models or conditional latent class models. These models are estimated for up to five classes. Model diagnostics aiding in ultimate model selection are reported in Table 5. Since there are no absolute statistical criteria for selecting the optimal number of classes, we use balancing approach suggested in the literature (Andrews and Currim, 2003; Dalton et al., 2011; Louviere et al., 2000). With an increase in the number of classes, the log-likelihood function value and McFadden's pseudo-R^2 increase monotonically, but the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) decrease. Comparing these various statistics and estimated results across models, we observe that a four-class model appears better than the five-class model. Andrews and Currim (2003) have also suggested that AIC and BIC sometime may over fit the number of classes and lead to large parametric bias. The results of four class model are reported in Table 6.

Table 5 approximately here

Table 6 approximately here

The first four columns of Table 6 report results from the random latent class multinomial logit model. Almost all utility coefficients for all attributes are significant within all classes, implying that consumers in these classes value these hypothetical attributes of raw milk. Consumers in class 1 have marginal disutility for quality attributes like fat content and bad smell, though their marginal utility increases with safety attribute such as reduced concentration of aflatoxin in milk. Consumers in class 2 have marginal disutility for bad smell but have marginal utility for reducing fat content and aflatoxin concentration. Nevertheless, class 2 is pronounced as more smell conscious than any other class. Consumers in class 3 have no preference for fat contents but have marginal disutility for bad smell. However, these consumers have highest marginal utility for aflatoxin-free milk compared to those in any other class. Consumers in class 4 prefer raw milk free from bad smell and aflatoxin and are least price conscious.

The next four columns of Table 6 report results from the conditional latent class multinomial logit model. The upper panel shows utility coefficients of hypothetical raw milk attributes, while the lower panel reports the coefficients for conditioning participants' membership in various classes. Membership coefficients for fourth class are normalized to zero, facilitating identification of the sources of variation among classes (Boxall and Adamowics, 2002). The utility coefficients for class 1 are significant and positive for falling concentration of aflatoxin. Membership coefficients for this class reveal that these consumers are less educated male belonging to low income class and residing in Faisalabad and Lahore. Most of the studies have reported aflatoxin contamination of milk for these cities, as discussed in section 2. Members of class 2 exhibit highest marginal utility for falling concentration of aflatoxin, and based on the class conditioning variables, they are evidently less educated and more likely to live in Rawalpindi and Islamabad[3]. We note, however, that 20% of the consumers in the sample are members of this group. Members of class 3 have marginal utility for safety attribute and milk price and are less educated and residing in Rawalpindi and Islamabad. The utility coefficients for class 4 are significant for all attributes except high aflatoxin level, and have marginal utility for falling fat content and aflatoxin. Members of this class have exceptionally strong preference for bad smell-free milk. Membership coefficients of this class can be indirectly interpreted from the significant coefficients for other two classes unless they have same signs. Accordingly, consumers in class 4 are more likely to be highly educated female belonging to higher income group and residing in three selected cities of Punjab.

Consumers' WTP for conditional latent class model are estimated with parametric bootstrapped procedure and reported in Table 7. Members in class 1 are willing to accept a discount for quality attributes and willing to pay premium for safety attribute. Members in class 2 are relatively willing to pay higher premium for various concentrations of aflatoxin. Though highest premium is placed for low aflatoxin in raw milk. Class 3 members are not willing to pay for the hypothesized attributes but they represent small proportion of the sample. Members in class 4 are more willing to pay for falling fat content and more willing to accept discount for bad smell than any other class. However, these WTP are relatively large and should be interpreted cautiously. These findings are in line with the earlier studies (Jabbar and Islam, 2010; Walke et al., 2014).

Table 7 approximately here

6. Conclusions

Milk contamination with aflatoxin is posing serious risks to human health. Many studies have reported the concentration of aflatoxin above the safe limits in raw milk of Pakistan. The

[3] Highly educated and income group in Rawalpindi and Islamabad consume less proportion of raw milk.

provision of aflatoxin-free milk may contribute to achieve the Millennium Development Goals by improving human health and eradicating poverty and food insecurity.

This article contributes to the existing literature by investigating consumers' heterogeneous preferences for aflatoxin-free milk in Pakistan. A discrete choice experiment survey was conducted with a random sample of 360 raw milk consumers from mega cities of Punjab province. This experiment entails four attributes including fat content, bad smell, aflatoxin concentration and milk price. The random parameter logit model was estimated to account for heterogeneity in consumers' preferences. Additionally, the latent class model was employed to identify the sources of heterogeneity at group level. Our study confirms the presence of substantial heterogeneity in consumers' preferences for aflatoxin-free milk, which is at large preferred over currently available option. Furthermore, we observe that consumers differentiate between quality and safety attributes of raw milk and are willing to pay a significant premium for safe milk with low concentration of aflatoxin, indicating there is nascent demand for safety attributes of raw milk supply. Consumers' premium for safety attribute may compensate farmers for the extra cost involved in aflatoxin-free milk supply. Although consumers are willing to accept a discount for bad smell in milk. We have identified four classes in conditional latent class model. In short, consumers' higher price premium merely reveals a willingness to purchase aflatoxin-free milk if it would be available in future market. In addition, these estimates should be cautiously interpreted as they may entail hypothetical bias.

Milk quality and safety standards in Pakistan are not only poorly defined but also ineffectively enforced. Under such circumstances, our empirical findings may be used as a starting point to formulate effective policies for milk safety in particular. This article also provides financial incentives to farmers and dairy firms to introduce self-regulated standards to provide aflatoxin-free milk in the country. Besides, more valuation studies aided with rigorous laboratory based parameters may be conducted to expedite aflatoxin-free milk supply. Nonetheless, awareness campaigns regarding prevention and detoxification strategies may help farmers and suppliers to effectively control aflatoxin in milk. For brevity, consumers' demand led mechanism adopted in this article may improve milk quality and safety along its entire supply chain. Proper monitoring and enforced regulation may lead to improve export of milk and milk products and thus foreign exchange earnings.

References

Andrews, R. S., & Currim, I. S. (2003). A comparison of segment retention criteria for finite mixture logit model. *Journal of Market Research*, 40, 235–243.

Ashiq, S. (2014). Natural occurrence of mycotoxins in food and feed: Pakistan perspective. *Comprehensive Reviews in Food Science and Food Safety*, 14, 159–175.

Asi, M. R., Iqbal, S. Z, Ariño, A., & Hussain, A. (2012). Effect of seasonal variations and lactation times on aflatoxin M1 contamination in milk of different species from Punjab, Pakistan. *Food Control*, 25, 34–38.

Aslam, N., Rodrigues, I., McGill, D., Warriach, H., Cowling, A., & Haque, A. (2015). Transfer of aflatoxins from naturally contaminated feed to milk of Nili-Ravi buffaloes fed a mycotoxin binder. *Animal Production Science*, 56, 1637–1642.

Banerji, A., Chowdhury, S., De Groote, H., Meenakshi, J. V., Haleegoah, J., & Ewoo, M. (2013). Using elicitation mechanisms to estimate the demand for nutritious maize: Evidence from experiments in rural Ghana. Working Paper No. 10. HarvestPlus, Washington, DC.

Battacone, G., Nudda, A., Cannas, A., Borlino, A. C., Bomboi, G., & Pulina, G. (2003). Excretion of aflatoxin M1 in milk of dairy ewes treated with different doses of aflatoxin B1. *Journal of Dairy Science*, 86, 2667–75.

Boxall, P. C., & Adamowicz, W. (2002). Understanding heterogeneous preferences in random utility models: A latent class approach. *Environmental and Resource Economics*, 23, 421–446.

Boyd, J., & Mellman, J. (1980). The effect of fuel economy standards on the US. Automotive market: A hedonic demand analysis. *Transportation Research Part A: General*, 14, 367−378.

Caloni, F., Stammati, A., Frigg`e, G., & De Angelis, I. (2006). Aflatoxin M1 absorption and cytotoxicity on human intestinal in vitro model. *Toxicon*, 47, 409–415.

CDC, (2013). Aflatoxin. Atlanta, GA: U.S. Centers for Disease Control and Prevention (updated 13 January 2013). http://www.cdc.gov/nceh/hsb/chemicals/aflatoxin.htm

Dalton, T. J., Yesuf, M., & Muhammad, L. (2011). Selection of Drought Tolerance Maize Seed using Framed Field Experiments. Paper presented at Agricultural and Applied Economic Association annual meeting, Pittsburgh, PA, 24–26 July.

GoP, (2006). Pakistan Livestock Census 2006. Statistics Division, Agricultural Census Organization, Government of Pakistan, Lahore.

GoP, (2016). Pakistan Economic Survey 2014–15. Ministry of Finance, Government of Pakistan, Islamabad.

Greene, W. H., & Hensher, D. (2003). A latent class model for discrete choice analysis; Contrasts with mixed logit. *Transportation Research: Part B*, 37, 681–698.

Hasselbach, J. L., & Roosen, J. (2015). Consumer Heterogeneity in the Willingness to Pay for Local and Organic Food. *Journal of Food Products Market*, 21, 608−625.

Hensher, D. A., Rose, J. M., & Greene, W. H. (2005). Applied Choice Analysis: A Primer. Cambridge University Press, Cambridge.

Hussain, I., Anwar, J., Asi, M. R., Munawar, M. A., & Kashif, M. (2010). Aflatoxin M1 contamination in milk from five dairy species in Pakistan. *Food Control*, 2, 122–4.

Ismail, A., Levin, R. E., Riaz, M., Akhtar, S., Gong, Y. Y. & de Oliveira, C. A. (2017). Effect of different microbial concentrations on binding of aflatoxin M1 and stability testing. *Food Control*, *73*, 492–496.

Iqbal, S. Z., & Asi, M. R. (2013). Assessment of aflatoxin M1 in milk and milk products from Punjab, Pakistan. *Food Control*, 30, 235–239.

Iqbal, S. Z., Asi, M. R., & Selamat, J. (2014). Aflatoxin M_1 in milk from urban and rural farmhouses of Punjab, Pakistan. *Food Additive Contaminants: Part B*, 7, 17–20.

Jabbar, M. A., & Islam, S. M. F. (2010). Urban consumer preferences for quality and safety attributes of meat and milk in Bangladesh. In M. A. Jabar, D. Baker, & M. L. Fadiga (Eds.), Demand for Livestock Products in Developing Countries with a Focus on Quality and Safety Attributes: Evidence from Asia and Africa. Research Report 24. International Livestock Research Institute (ILRI), Nairobi, Kenya.

Jawaid, S., Talpur, F. N., Nizamani, S. M., & Afridi, H. I. (2015). Contamination profile of aflatoxin M_1 residues in milk supply chain of Sindh, Pakistan. *Toxicology Reports*, 2, 1418–1422.

Kabak, B., Dobson, A. D. W., & Var, I. (2006). Strategies to prevent mycotoxin contamination of food and animal feed: a review. *Critical Reviews in Food Science and Nutrition*, 46, 593–619.

Kamakura, W., & Russell, G. (1989). A probabilistic choice model for market segmentation and elasticity structure. *Journal of Marketing Research*, 26, 379–390.

Khlangwiset, P., Shephard, G. S., & Wu, F. (2011). Aflatoxins and growth impairment: a review. *Critical Review Toxicology*, 41, 740–755.

Kikulwe, E. M., Birol, E., Wessler, J., & Flack-Zepeda, J. (2011). A latent class approach to investigating demand for genetically modified banana in Uganda. *Agricultural Economics*, 42, 547–560.

Klaiman, K., Ortega, D. L., & Garnache, C. (2017). Perceived barriers to food packaging recycling: Evidence from a choice experiment of US consumers. *Food Control*, 73, 291–299.

Kouser, S., & Qaim, M. (2013). Valuing financial, health and environmental benefits of Bt cotton in Pakistan. *Agricultural Economics*, 44, 323−335.

Krinsky, I., & Robb, A. (1986). On Approximating the Statistical Properties of Elasticities. *The Review of Economics and Statistics*, 68, 715–719.

Kuhfeld, W. F. (2010). Marketing research methods in SAS: Experimental design, choice, conjoint, and graphical techniques. SAS Document MR 2010. http://support.sas.com/techsup/technote/mr2010title.pdf

Lancaster, K. (1966). A new approach to consumer theory. *Journal of Political Economy*, 74, 132–157.

Liu, Y., & Wu, F. (2010). Global burden of aflatoxin-induced hepatocellular carcinoma: a risk assessment. *Environmental Health Perspectives*, 118, 818–824.

Louviere, J. J., Flynn, T. N., & Carson, R. T. (2010). Discrete choice experiments are not conjoint analysis. *Journal of Choice Modelling*, 3, 57–72.

Louviere, J. J., Hensher, D. A., Swait, J. D., & Adamowicz, W. L. (2000). Stated choice methods: analysis and applications. Cambridge University Press, Cambridge, UK.

Lusk, J. L., Roosen, J., & Fox, J. A. (2003). Demand for beef from cattle administered growth hormones or fed genetically modified corn: A comparison of consumers in France, Germany, the United Kingdom, and the United States. *American Journal of Agricultural Economics*, 85, 16–29.

Malik, S. J., Nazli, H., & Whitney, E. (2014). Food Consumption Patterns and Implications for Poverty Reduction in Pakistan. 30th GM & Conference of Pakistan Society of Development Economists, Islamabad, Pakistan.

McFadden, D. (1974). Conditional logit analysis of qualitative choice behaviour. In P. Zarembka (Ed.), Frontiers in Econometrics (pp. 105–142). New York: Academic Press.

McFadden, D., & Train, K. (2000). Mixed MNL models for discrete response. *Journal of Applied Econometrics*, 15, 447–470.

Meenakshi, J. V., Banerji, A., Manyong, V., Tomlins, K., Mittal, N., & Hamukwala, P. (2012). Using a discrete choice experiment to elicit the demand for a nutritious food: Willingness-to-pay for orange maize in rural Zambia. *Journal of Health Economics*, 31, 62–71.

Milon, J., & Scrogin, D. (2006). Latent preferences and valuation of wetland ecosystem restoration. *Ecological Economics*, 56, 162–175.

Owusu-Sekyere, E., Owusu, V., & Jordaan, H. (2014). Consumer preferences and willingness to pay for beef food safety assurance labels in the Kumasi Metropolis and Sunyani Municipality of Ghana. *Food Control*, *46*, 152–159.

Personn, T. H. (2002). Welfare calculations in models of the demand for sanitation. *Applied Economics*, 34, 1509−1518.

Rigby, D., & Burton, M. (2005). Preference heterogeneity and GM food in the UK. *European Review of Agricultural Economics*, 32, 269–88.

Ruto, E., Garrod, G., & Scarpa, R. (2008). Valuing animal genetic resources: A choice modelling application to indigenous cattle in Kenya. *Agricultural Economics*, 38, 89–98.

Shen, J., Sakata, Y., & Hashimoto, Y. (2006). A comparison between latent class model and mixed logit model for transport mode choice: Evidences from two datasets of Japan. Discussion paper 06-05, Graduate School of Economics, Osaka University, Japan.

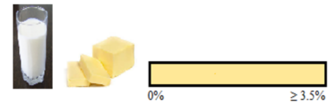
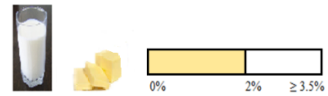
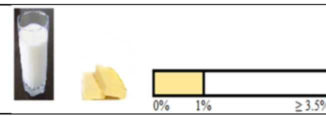
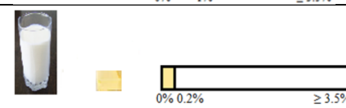
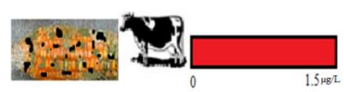
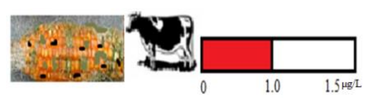
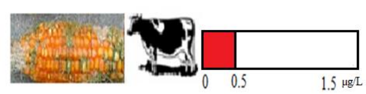
Train, K. E. (2003). Discrete Choice Methods with Simulation. University of California, Berkeley and National Economic Research Associates, Inc, Cambridge University Press.

Walke, M., Mtimet, N., Baker, D., Lindahl, J., Hartmann, M., & Grace, D. (2014). Kenyan perceptions of aflatoxin: an analysis of raw milk consumption. EAAE 2014 Congress Agri-Food and Rural Innovations for Healthier Societies, Ljubljana, Slovenia.

Ward, P. S., Ortega, D. L., Spielman, D. J., & Singh, V. (2015). Heterogeneous demand for drought tolerant rice: Evidence from Bihar, India. *World Development*, 64, 125–139.

Wu, F., Narrod, C., Tiongco, M., & Liu, Y. (2011). The health economics of aflatoxin: Global burden of disease. Working Paper 4, IFPRI, Washington, DC.

Table 1: Milk attributes and their levels used in the choice experiment

Attributes	Attribute levels	Illustrations
1. Fat content	1. Whole milk (≥ 3.5% fat)	
	2. Reduced fat milk (≤ 2% fat)	
	3. Low fat milk (≤ 1% fat)	
	4. Non-fat milk (≤ 0.2% fat)	
2. Bad smell	1. Yes	
	2. No	
3. Aflatoxin concentration	1. High (1.5 ug/liter)	
	2. Medium (1 ug/liter)	
	3. Low (0.5 ug/liter) *	
4. Milk price	1. Rs 80/liter	
	2. Rs 100/liter	
	3. Rs 120/liter	
	4. Rs 140/liter	

* The permissible limit set by the US Food Safety Regulations for aflatoxin safe milk is 0.5 µg/liter.

Table 2: Descriptive statistics of sampled consumers

Variables	Total (N=360)
Age (years)	48.975 (13.7536)
Education (years)	11.199 (5.801)
Gender (%)	0.106 (0.307)
Family size (number)	5.861 (2.607)
Monthly income (Rs)	41101.700 (44328.800)
Low income class (Rs ≤ 30,000)	0.550 (0.498)
Middle income class (Rs > 30,000 to < Rs 90,000)	0.306 (0.461)
High income class (≥ Rs 90,000)	0.144 (0.352)
Raw milk consumption (liter/day)	2.290 (1.217)
Awareness about aflatoxin (%)	0.106 (0.307)

Note: Standard deviations are given in parentheses.

Table 3: Results of random parameters logit model

Attribute	Coefficient
Random utility parameters	
Fat content	0.073 (0.046)
Bad smell	-2.149*** (0.161)
High aflatoxin	1.174*** (0.408)
Medium aflatoxin	5.400*** (0.315)
Low aflatoxin	6.124*** (0.336)
Milk price	-0.049*** (0.003)
Distribution parameters	
Std. deviation of absence of fat content	0.139* (0.082)
Std. deviation of bad smell	1.678*** (0.189)
Std. deviation of high aflatoxin	2.254*** (0.320)
Std. deviation of medium aflatoxin	0.483** (0.237)
Std. deviation of low aflatoxin	0.959*** (0.184)
Std. deviation of milk price	0.019*** (0.001)
Model statistics	
McFadden's pseudo R^2	0.401
LR χ^2 (12)	2539.664***
No. of observations	2880

Note: *, ***Significant at 10% and 1% levels, respectively.
Standard errors are in parentheses.

Table 4: Willingness to pay (WTP) for milk attributes based on random parameters logit model

WTP (Rs/liter)	Coefficient
Fat content	1.489 (0.943)
Bad smell	-43.909*** (3.474)
High aflatoxin	23.999*** (7.739)
Medium aflatoxin	110.348*** (3.785)
Low aflatoxin	125.151*** (4.062)

Note: ***Significant at 1% level.
Standard errors are in parentheses.

Table 5: Latent Class Diagnostics

Types	Classes	K	Log-likelihood	Pseudo-R^2	AIC	BIC
Random class membership	1	6	-2237.826	0.260	1.558	1.571
	2	13	-2011.970	0.364	1.406	1.433
	3	20	-1923.205	0.392	1.350	1.391
	4	27	-1852.939	0.414	1.306	1.361
	5	34	**-1814.944**	**0.426**	**1.284**	**1.354**
Conditional class membership	1	6	-2237.826	0.260	1.558	1.571
	2	20	-1951.868	0.383	1.369	1.411
	3	34	-1873.531	0.408	1.325	1.395
	4	48	-1764.964	0.442	1.259	**1.358**
	5	62	**-1728.841**	**0.454**	**1.244**	1.372

Note: These statistics are calculated for a sample of 2880 choices from 360 raw milk consumers. McFadden's Pseudo R^2 is calculated as *1-LL/LL(0)*, where *LL(0)* represents the log-likelihood for a restricted model having only intercept. The Akaike Information Criterion (AIC) is calculated as *-2(LL-K)*, where *K* represents the number of estimated parameters. The Bayesian Information Criterion (BIC) is calculated as *–LL+(K/2)*ln(N)* where *N* represents the sample size.

Table 6: Results of latent class model

Variables	Random latent class model				Conditional latent class model			
	Class 1	Class 2	Class 3	Class 4	Class 1	Class 2	Class 3	Class 4
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Utility parameters								
Fat content	-0.137* (0.073)	0.381*** (0.092)	0.082 (0.135)	-0.0003 (0.046)	-0.145* (0.078)	0.046 (0.111)	-0.025 (0.046)	0.395*** (0.087)
Bad smell	-1.677*** (0.199)	-4.340*** (0.259)	-1.149*** (0.263)	-0.756*** (0.082)	-1.936*** (0.228)	-0.987*** (0.216)	-0.733*** (0.085)	-3.920*** (0.221)
High aflatoxin	2.635*** (0.545)	-30.459 (806982)	11.001*** (1.178)	0.534** (0.236)	3.236*** (0.577)	9.291*** (0.857)	0.359 (0.244)	-23.135 (13855.082)
Medium aflatoxin	4.911*** (0.565)	2.786*** (0.549)	18.511*** (1.508)	2.067*** (0.241)	5.598*** (0.607)	15.750*** (1.070)	1.835*** (0.249)	1.875*** (0.509)
Low aflatoxin	5.137*** (0.557)	4.263*** (0.609)	19.127*** (1.525)	2.840*** (0.247)	5.860*** (0.618)	16.531*** (1.104)	2.500*** (0.252)	3.291*** (0.567)
Milk price	-0.053*** (0.005)	-0.024*** (0.004)	-0.158*** (0.012)	-0.005*** (0.002)	-0.060*** (0.005)	-0.135*** (0.009)	0.003* (0.002)	-0.017*** (0.004)
Parameters conditioning class membership								
Constant					0.508 (1.134)	1.489 (1.232)	1.835* (1.021)	
Education					-0.135*** (0.050)	-0.167*** (0.054)	-0.083* (0.050)	
Gender					-2.328*** (0.912)	-70.755 (0.582+15)	0.510 (0.469)	
Low income class					1.757** (0.731)	1.205 (0.928)	-0.108 (0.631)	
Middle income class					0.183 (0.660)	0.644 (0.852)	-0.453 (0.497)	
Awareness about aflatoxin					-0.412 (0.673)	1.138 (0.799)	0.480 (0.592)	
Faisalabad					1.734*** (0.541)	-1.923** (0.911)	-0.992** (0.484)	
Lahore					1.031* (0.611)	0.591 (0.581)	-0.513 (0.548)	
Probability of class membership	0.398	0.182	0.183	0.236	0.381	0.203	0.231	0.184
Sample size	2880				2880			

Note: *, **, *** Significant at 10%, 5% and 1% levels, respectively.
Standard errors are given in parentheses.

Table 7: Willingness to pay (WTP) for milk attributes based on conditional latent class model

WTP (Rs/liter)	Class 1	Class 2	Class 3	Class 4
Fat content	-2.411* (1.260)	0.343 (0.824)	-7.958 (106.420)	22.864** (9.744)
Bad smell	-32.118*** (4.329)	-7.331*** (1.548)	-233.961 (4603.437)	-226.919*** (67.868)
High aflatoxin	53.687*** (5.964)	68.999*** (3.076)	114.735 (788.869)	-1339.336 (895089.726)
Medium aflatoxin	92.858*** (4.220)	116.968*** (2.760)	585.738 (9965.186)	108.555*** (16.104)
Low aflatoxin	97.216*** (4.181)	122.766*** (2.023)	798.166 (13821.524)	190.547*** (25.999)

Note: *, **, *** Significant at 10%, 5% and 1% levels, respectively.
Standard errors are given in parentheses.

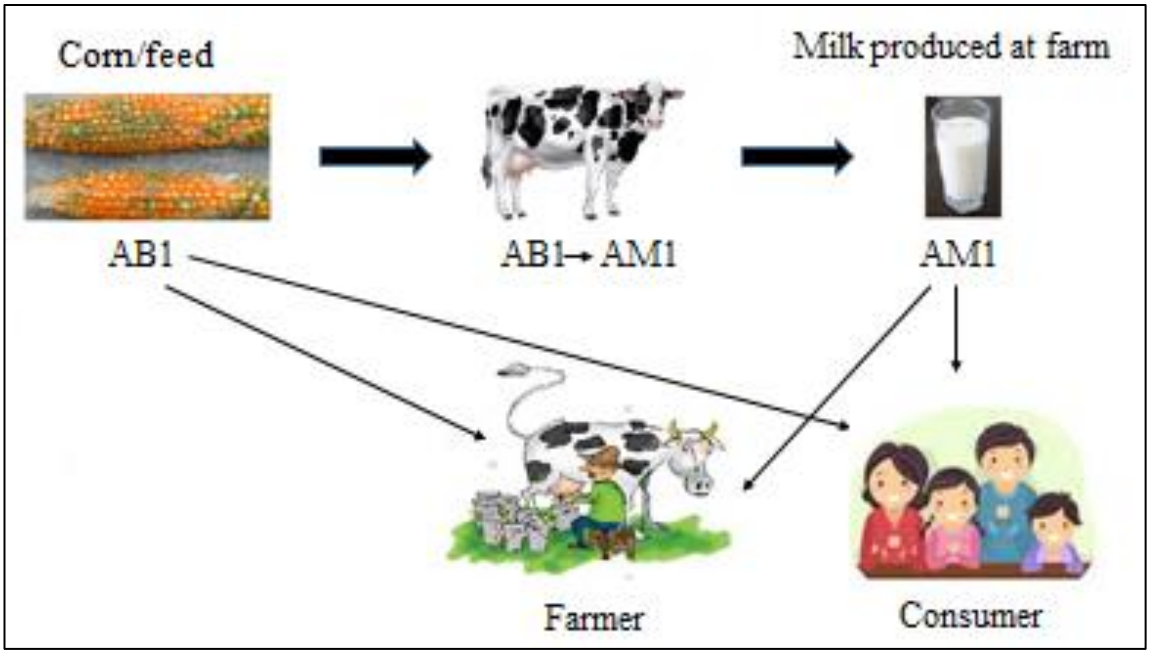


Figure 1: Aflatoxin contamination pathways

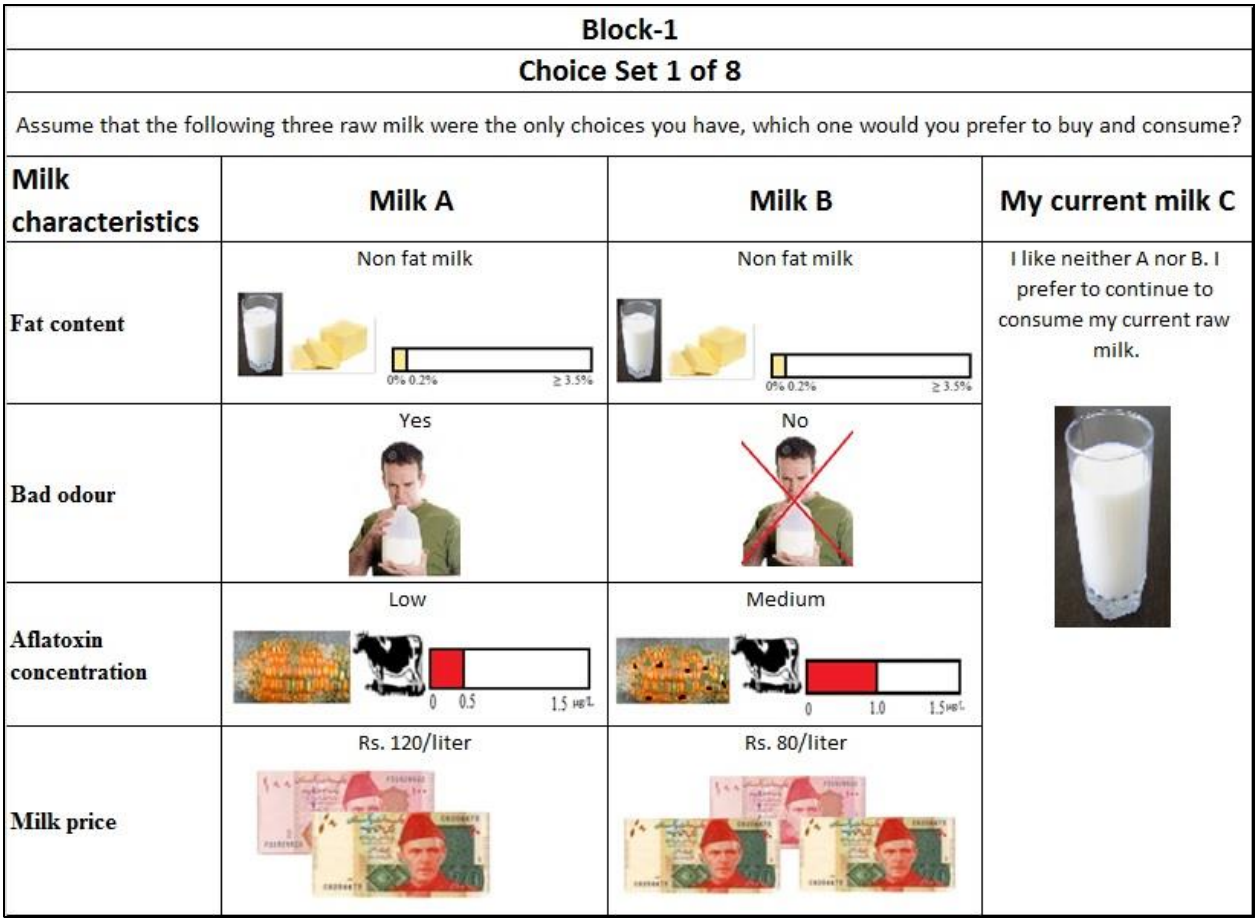


Figure 2: Example of choice set