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Is Food and Drug Administration policy governing artisan cheese consistent with consumers' preferences?

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ABSTRACT

United States government policy prohibits the sale of cheese made from unpasteurized milk aged less than 60 days despite contested science behind the policy. We use experimental auctions for artisan cheese to estimate the value of pasteurization and age as food safety attributes, which is the rationale for the policy. We also look at consumers' perception of the tradeoff between safety and quality. A survey was conducted with participants at farmers markets including experimental auctions and sensory analysis of pasteurized and unpasteurized cheese and questions concerning attitudes about food safety. There is no evidence of positive demand for pasteurization and there is no evidence of a tradeoff between safety and quality. On average artisan cheese consumers make purchasing decisions based on taste, not their attitude toward food safety. The results of this study raise questions about the possible extension of a minimum aging period for cheese made from unpasteurized milk.

Introduction

There is little consensus on the safety or risk of various food products and production processes and how to achieve a safer food system through government action or inaction. One reason for the lack of consensus is that scientists often disagree about the safety and risk involved (Millstone, 2009). This is illustrated by recent studies illuminating the differences of opinion on the safety of conventional versus organic foods (Brandt et al., 2011; Smith-Spangler et al., 2012). Another reason is that factors such as the underreporting of illness, difficulty in tracing outbreaks, and the changing nature of pathogens complicate the measurement of foodborne illness (Mead et al., 1999). It is also increasingly understood that decisions about the acceptability of risk in the food system involve perceptions, opinions and values as well as science (Nestle, 2010; Paxson, 2008). The lack of scientific consensus about food safety and risk, the lack of documentation on food safety outbreaks, and the range of opinions and values toward food safety make designing food safety policy particularly challenging.

The debate in the United States over whether or not the milk used in cheese making should be pasteurized is contentious. Federal regulation currently requires that cheesemakers using unpasteurized milk (also called raw milk) age the cheese for a minimum of 60 days before sale (Cheese from Unpasteurized Milk, 2011). The aging aspect of the regulation is based on scientific research that has found that beneficial bacteria can outcompete harmful or pathogenic bacteria as cheese ages (see discussion in D'Amico, 2008). In contrast, in Europe there is no aging requirement for unpasteurized cheese and some of the most expensive cheeses are made from unpasteurized milk without aging. Numerous cheese varieties such as Camembert de Normandie, Brie de Meaux, and Brie de Melun are required by law to be made only with unpasteurized milk and aged less than 60 days.

The US Food and Drug Administration (FDA) is considering tightening restrictions on raw milk cheese by lengthening the required aging period to 90 or 120 days, or banning unpasteurized milk cheese altogether (Neuman, 2011; Layton, 2011; Huffstutter, 2011). This regulation would further limit artisan cheesemakers' ability to produce certain types of cheeses without pasteurizing the milk first, and it would further limit the import of cheese made from unpasteurized milk that does not meet the standard. Pasteurization requires expensive equipment and eradicates the beneficial bacterial cultures that many artisan cheesemakers rely on for the flavor development that allows them to garner a premium in the marketplace (Paxson, 2008). In the United States, on average unpasteurized cheese sells for more money than pasteurized cheese (see Table 1). This difference is particularly pronounced for cheeses aged at least 60 days, for which direct price comparisons can be made for otherwise equivalent pasteurized and unpasteurized cheeses.

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Table 1
Average retail prices of pasteurized and unpasteurized cheese[*].

	All observations			Aged > 60 days only		
	Mean	St. dev	*N*	Mean	St. dev	*N*
Unpasteurized	$25.54	6.43	82	$25.54	6.43	82
Pasteurized	$23.59	10.95	145	$19.45	7.43	86
All Cheese[a]	**$24.29**	**9.60**	**227**	**$22.42**	**7.58**	**168**
Mann–Whitney[†]	Prob > |z| = 0.0141			Prob > |z| = 0.0000		

[*] Price data collected form the two largest online artisan cheese retailers in the U.S., March, 2013.
[a] Total refers to the average of all cheeses in the sample, both pasteurized and unpasteurized.
[†] Note: *P*-value for a two-sample Wilcoxon rank-sum (Mann–Whitney) test of equivalency between the price of pasteurized and unpasteurized cheese.

The debate over the use of unpasteurized milk in cheese production has recently revived. Artisan cheese consumption is on the rise and the number of artisan cheesemakers in the US has doubled since 2000 to more than 400, with seventy-five percent of them using unpasteurized milk for at least some of their products (Roberts, 2007). The debate is part of a growing fissure between the burgeoning artisan food movement and the more traditional industrial food system that became apparent during the passing of the Food Safety Modernization Act of 2010 (H.R. 2751).

Central to the discussion about the safety of products or processes is the role of risk assessment and the assumptions or 'framing' required in assessing risk (Millstone, 2009). Assumptions made in risk assessments can reflect societal or personal values and preferences as much as empirical evidence (Vaughan and Seifert, 1992). The artisan cheese trade group, the American Cheese Society (ACS) criticized the recent FDA risk assessment of soft ripened cheese (FDA, 2012) for relying heavily on personal values as well as parameters derived from controversial sources (ACS, 2013). The debate over the degree of regulation of production practices and specifically the pasteurization requirements of artisan cheese is ultimately a debate about the tradeoff between consumer sovereignty and consumer protection.

Given that values and preferences are so critical in defining risk and safety it is unfortunate that a rigorous treatment of consumer preferences is often excluded from the policymaking process. This paper addresses two research questions regarding the debate over the safety of cheese made from unpasteurized milk: (1) To what extent do artisan cheese consumers perceive pasteurization and aging to be food safety attributes? (2) How do they perceive tradeoffs between safety and quality? We explore these questions using experimental data, which allows us to create context and isolate causality. We can elicit values for real goods in an experimental setting to understand not only how much consumers will pay, but also what characterizes those consumers and what motivates their decisions. By combining an experimental auction with sensory experiments and a survey measuring consumer attitudes about food safety and demographics, we gain a lot more insight into why the transactions occurred than we do from simply analyzing retail prices.

Hedonic price analysis is commonly used to analyze the housing market and estimate the value of attributes such as the number of rooms, proximity to public transportation, or the quality of the school system (e.g. Sheppard, 1999). Under hedonic price theory, a good is defined by a set of attributes and the good's market price is the sum of the marginal implicit prices of each of those attributes, as estimated when the good's price is regressed on its attributes (Lancaster, 1966). We use hedonic price analysis of experimental data to estimate and explain the willingness to pay attributes that are related to the safety of artisan cheese (aging and pasteurization). We follow the example of Melton et al. (1996) in analyzing experimental auction bids in a hedonic framework in order to isolate the value of the cheese attributes (pasteurization and age) as well as the underlying characteristics of the participants in the auctions. We also explicitly look at consumers' choices of pasteurized and aged cheese and examine the relationship of these choices to their sensory ratings for each cheese and their attitudes about risk to gain a deeper understanding of the tradeoff consumers perceive between safety and quality.

Melton's work is situated within a broader literature that uses experimental auctions to estimate demand for food product attributes. Many of these studies use multiple methodological approaches for comparison of the value of an attribute estimated from experimental auction data. For example, there are studies that investigate the link between sensory evaluations and auction bids by comparing objective measurements of a given product attribute with subjects' bids or evaluations (e.g. Lusk et al., 2001; Feuz et al., 2004; and Platter et al., 2005). Other studies compare auction bids with hedonic ratings for an attribute and find that subjects bid more for products they think have that attribute (e.g. Umberger and Feuz, 2004; Melton et al., 1996; Platter et al., 2005). Still other studies compare experimental auction bids with hedonic ratings for an attribute through post-auction surveys (Lusk et al., 2001) or with risk tolerance by constructing an index based on answers to questions about risk (Brown et al., 2005).

Previous studies using experimental auctions to estimate demand for food safety have focused on consumer acceptance of a controversial product and the value of communicating product information to consumers. One approach to valuing food safety using experimental auctions is to endow participants with a product and ask the subject's WTP to upgrade an endowed product to a safer one (e.g. Hayes et al., 1995). Other experimental auction studies frame food safety in terms of willingness to accept a potentially riskier product (e.g. Lusk et al., 2001). Still other studies look specifically at the impact of knowledge and information about risk on food safety valuation (Fox et al., 2002; Nayga et al., 2006). We build on this literature by using a product where the safety is intrinsically *and perhaps inversely related* to the sensory quality of the product.

Methods

Sample

The hedonic price analysis of experimental auctions relies on auctions bids, sensory evaluations, and a short demographic survey with consumers at farmers' markets in multiple locations in Michigan, New York and Vermont. The experiments took place in June and July, 2013. Our target population for the experimental auctions included consumers likely to purchase artisan cheese since we are interested in consumers most affected by regulation of artisan cheese. The sampling approach does not include non-consumers of artisan cheese since they would not contribute information relevant to the research question and would present problems with interpretation. We would not be able to determine if a bid is censored at zero because the participant is not a

consumer of artisan cheese or because they are not willing to pay for pasteurized or unpasteurized cheese.

We conducted the experiments "in the field" to reduce sample selection bias since participants are intercepted rather than self-selected (Harrison and List, 2004). We chose three states that represent different cultures of cheese making in a nascent, intermediate and more developed context (Michigan, New York and Vermont respectively). This is the authors' classification based on qualitative interviews with key informants in the artisan cheese industry prior to the experimental auctions. Within each state we conducted experiments at farmers' markets in multiple cities that ranged in size and median income. We chose to sample at farmers' markets to capture the widest demographic of artisan cheese consumers and to have a consistent sample across and within states.

We identified three locations in each state where there was at least one farmers' market. We then contacted the market managers, discussed the research and scheduled a day to conduct research at the market if the market manager was amenable. In Michigan we conducted auctions in Ann Arbor (two day markets and two evening markets), Lansing (two day markets), Grand Rapids (one day), and Bath (one day). In New York we conducted auctions in Ithaca (one day and one evening market), Troy (one day and one evening), Albany (one day), and Schenectady (one day). In Vermont we conducted auctions at Burlington (two day markets), Brattleboro (two day markets), and Manchester (one day). The auctions varied in hours of operation from 3 to 6 h in length and in the number of people visiting the market. The total number of participants in the research across all locations was 347.

Auction procedure

A table was set up at each location during market hours with two monitors conducting experiments simultaneously using computer tablets. At the beginning of the day or after a participant completed an auction a new participant was recruited. We randomized participation by inviting every passerby to participate if someone was not already participating at that station. The protocol for the auction consisted of the exact same ten steps with every participant and is illustrated in Fig. 1.

In step 1, participants learned about the nature of the research and the benefits and risks to them and they were asked if they consented to participate. They were informed that they would be engaged in the research for approximately 15–20 min and would be compensated $5 and a half pound of cheese (approximately a $7 value) for participating in the auction.

In step 2, participants answered a series of questions concerning their basic demographic data, cheese consumption habits, and the frequency of purchasing cheese made from unpasteurized milk.

Step 3 was a non-binding practice round to introduce participants to the Becker–DeGroot–Marschak (BDM) auction mechanism (Becker et al., 1964). In the BDM auction, a "market" price is randomly generated from a pre-specified distribution chosen by the experimenter and compared to the sealed bid the participant submits. If the individual's bid is greater than the market price, the individual wins the good being auctioned and pays the market price. If the individual's bid is lower than the market price no transaction occurs. Lusk et al. (2004) demonstrated that BDM auctions and English auctions generate statistically equivalent bids regardless of whether participants receive an endowment, offer bids to upgrade, or offer full bids. A BDM mechanism is advantageous in this context because it allows us to conduct the auction in the field with a single participant, thus incorporating the participant's heuristics and the effect of the market experience (Lusk and Shogren, 2007).

In the practice round participants tasted two different samples of cheese (approximately 3/4″ cube) acquired from two different vendors at each market and labeled with random 3-digit numbers (eg. 324). It was not disclosed whether or not these cheeses were pasteurized. The use of sensory evaluation in this context was designed to look at how consumers make tradeoffs between cheese safety and quality attributes, not specifically to look at the differences in the sensory attributes between the cheeses.[1] We chose a cheddar cheese in this experiment for broad consumer appeal. The drawback with this selection is that the flavor differences would be expected to be a little less dramatic with a variety like cheddar, which is typically sold as an aged cheese.

Instructions on the tablet informed the participants that they were randomly endowed with one half pound of one cheese but they could offer a bid to switch to the other cheese if they preferred. This is referred to as an "endow and upgrade approach" following Shogren et al. (1994) and Lusk et al. (2005). If a participant accepted the endowed cheese, we refer to them as having chosen that cheese, and if they bid on the alternative cheese then that is the one they chose. Participants' bids were then compared with a random number between $0 and $5 generated by the computer tablet (participants were not informed of the distribution). The tablet then displayed a message informing participants that they won the auction if their bid to switch was higher than the random market price, or that they lost if their bid was lower. Participants were informed that they would receive the cheese they bid on and be expected to pay the randomly generated price if they won or keep the endowed cheese and pay nothing if they lost. The researcher then reiterated that the practice round was non-binding but there would be multiple rounds of bidding and a single randomly selected binding round at the end.

The endow-and-upgrade approach is advantageous in this context for multiple reasons despite an ongoing debate about the presence of an endowment effect, i.e. that people become attached to a good if they perceive that they own it (Hanemann, 1991; Shogren et al., 1999; Corrigan and Rousu, 2006; Plott and Zeiler, 2011). Upgrading directs participant attention away from field substitutes (in this case a field substitute would be a similar cheese available by a vendor at the market) and focuses attention on the marginal difference between the attributes of interest. Endowing participants also minimizes uncertainty and information effects such as the option value problem, where people expect to gather more information in the future about the value of the goods (Corrigan, 2005). We split the participation fee into cash and a cheese endowment. The cheese endowment generates interest in the auction since the subject will leave with the good either way (Lusk and Shogren, 2007). The relatively small amount of cash allows us to avoid a house money effect, i.e. that people bid more because they are not using their own money (List and Rondeau, 2003).

In step 4, each participant was given a small piece of the three cheeses used in the auction (60-day unpasteurized, 60-day pasteurized, and 90-day unpasteurized) and told that they would be taking home a half-pound of one of these cheeses. From here on we refer to the three cheeses as 60R, 60P, and 90R, respectively. These cheeses were all organic Vermont cheddar cheese made by the same artisan cheesemaker and differed only in the date they were processed (60 or 90 days old) and whether or not they were pasteurized. Participants were asked to blindly evaluate the sensory attributes of the three cheeses using a marked scale. They were instructed to rate the visual, olfactory, and taste attributes of each cheese on a 0–10 scale.

[1] If the objective were to isolate the sensory attributes, a more appropriate experimental design would involve multiple varieties of cheese as per Colonna et al. (2011).

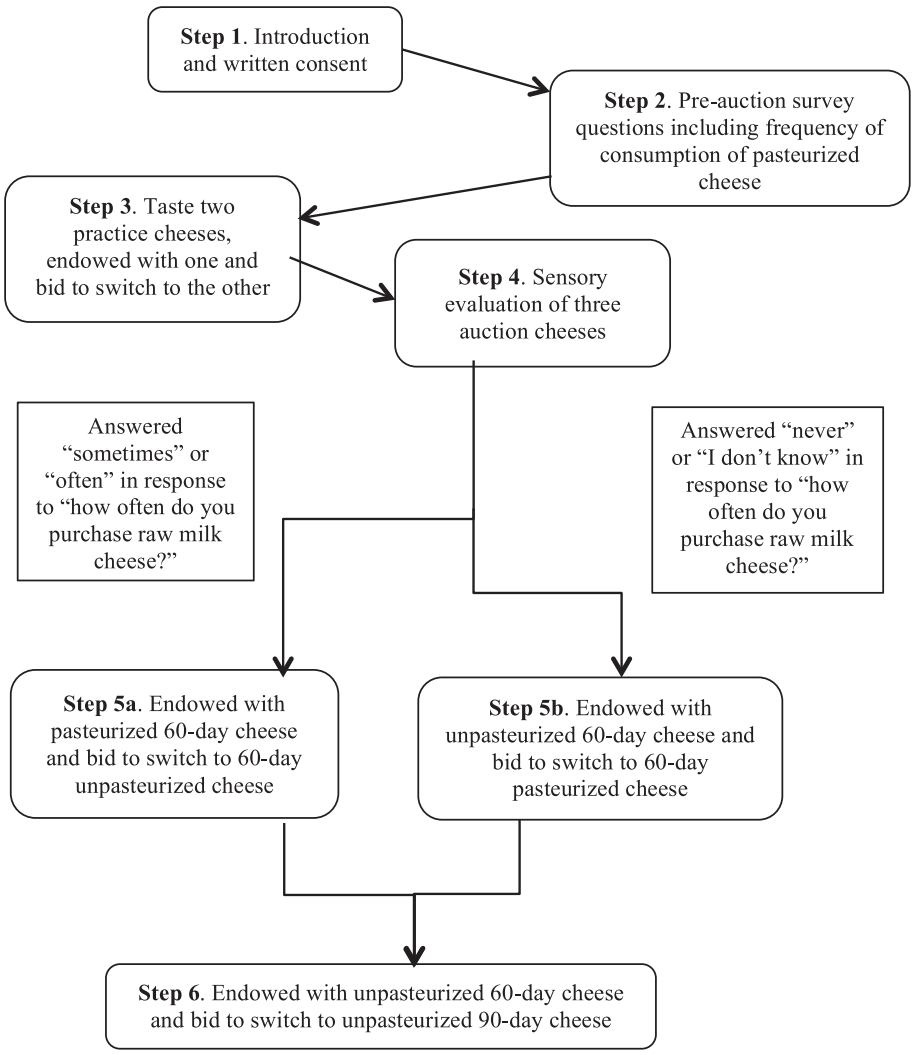

Fig. 1. Schematic of auction procedure.

In total, subjects tasted five different types of cheese including the two practice round cheeses. Numerous studies have required participants to physically consume a product that was considered riskier because the study was designed to quantify food safety in terms of the amount consumers were willing to accept to consume the riskier product (e.g. Lusk et al., 2005). That type of approach focuses the participants' attention only on the food safety of the product. In contrast, our design was intended not to bias participants in terms of the safety but rather to let them generate homegrown values for a product that has both positive and negative attributes for some consumers, one of which is food safety.

In step 5, participants were presented with two cheese samples aged approximately 60 days and identical except that one was pasteurized and one was not. The cheeses were identified as aged for 60 days and pasteurized or unpasteurized and the participant was "endowed" with the cheese that did not fit their stated preference during the pre-auction survey. Participants who answered "never" or "I don't know" in response to whether they purchase cheese made from unpasteurized milk were endowed with unpasteurized cheese (step 5a), and participants who answered "sometimes" or "often" were endowed with pasteurized cheese (step 5b). Participants were then given the opportunity to upgrade to the cheese they were not endowed with. The purpose of step five is to isolate the positive or negative value of pasteurization.

In step 6, all participants were endowed with a 60-day unpasteurized cheese and given the opportunity to bid to switch to the unpasteurized version aged for 90 days. The purpose of step 6 is to isolate the value of aging cheese between 60 and 90 days.

Estimation strategy

Applications of hedonic price analysis can be relatively straightforward with durable goods characterized by highly differentiated and easily defined attributes such as homes or cars (Court, 1939; Griliches, 1961). Application of hedonic theory to non-durable food goods such as wine or coffee is increasingly common although measures of quality are more subjective in food products (Combris et al., 2000, 2003; Benfratello et al., 2009). Hedonic analysis has also been extended to explore less orthodox attributes of food products such as the value of origin denomination (Teuber and Herrmann, 2012) and the value of the physical characteristics of vineyards (Cross et al., 2011).

Carlucci et al. (2013) estimate a hedonic model of yogurt based on the container size and various other attributes commonly found with commercially produced yogurt. Santos and Ribeiro (2005) use a series of products (including cheese) to determine if place of origin has a positive price premium only controlling for the milk type and whether the cheese was "cured." Hassan and Monier-Dilhan

(2006) also examine a number of products (one of which is Camembert cheese) and find that when two quality signals coexist on the same product their value declines. We did not find any studies that take a hedonic approach to studying the intrinsic characteristics of cheese as has been undertaken with wine. Hedonic price analysis has been used fairly extensively with wine (Castriota et al., 2012; Oczkowski, 2001), so we construct a hedonic price model of artisan cheese by looking at how wine, a product with similar intrinsic characteristics, has been modeled in the literature.

Benfratello et al. (2009) identify three categories of attributes that generally appear in the specification of hedonic functions of wine price. The first category includes *objective characteristics* such as the wine vintage, denomination, region, or grape variety, which usually appear on the label and are therefore easy for consumers to identify. The other two categories involve quality, which is not easy to evaluate objectively with wine. *Sensorial quality* is measured through sensory evaluation such as the wine's aroma, finish and harmony of components, which experts say determine the wine's price. Wine buying guides sometimes publish sensory ratings but they do not represent a random sample of wines, and they are written and evaluated by a limited number of evaluators who may be biased in personal preferences (Castriota et al., 2012). Combris et al. (2003) compare predictions of quality ratings from a jury of evaluators and prices of wines from both sensory and objective characteristics; they find that quality is mainly defined by the sensory characteristics of a wine whereas price is better predicted with objective characteristics. The other quality-related category identified by Benfratello et al. (2009) is a wine's *reputation*, which conveys quality information to the consumer. Landon and Smith (1997) differentiate a wine's individual reputation (specific maker and vintage) from its collective reputation (membership in an appellation); they find that ignoring reputation can overstate the impact of quality on market price.

According to standard hedonic price theory a basic model for artisan cheese prices would have the price of cheese P_c determined by the three categories of characteristics described by Benfratello et al. (2009):

$$P_c = f(O_c, S_c, R_c) \tag{1}$$

where cheese attributes are classified as objective (O_c), sensory (S_c), or reputation (R_c). Objective characteristics are relatively straightforward to identify for artisan cheese since these attributes become a selling point for producers and are often readily available on labels. Basic objective characteristics of artisan cheese include the production region or location, milk type, style of cheese (including bacterial cultures and rind type), size of the cheese wheel, age of the cheese, and whether or not the cheese was pasteurized.

Sensory characteristics are more difficult to capture with cheese in the absence of a buying guide or a unique panel of expert jurist ratings as per Combris et al. (2003). The lack of this information on quality suggests that quality is not as well defined for cheese as it appears to be for wine. Defining cheese quality thus becomes a significant estimation challenge. Using experimental auctions, however, sensory characteristics can be measured directly by asking participants to rate features of the cheese such as taste, odor and texture.

Public awards received at exhibitions or contests enhance reputation among artisan cheese producers. The most prominent awards for American cheese producers come from the American Cheese Society (ACS) in the US and the World Cheese Awards covering Europe and US.

Given the nature of the market for cheese and the information available, two distinct approaches emerge to estimate the value consumers place on age and pasteurization, each with different data requirements. One approach would be to estimate a hedonic model based on observed retail prices to predict the price of cheese as a function of a wide variety of objective attributes (including pasteurization and aging time) across a wide variety of cheeses. This approach would not capture any measure of sensory quality but would have high validity in that it uses objective characteristics from a large volume of actual market transactions. Alternatively, in the experimental setting we can have participants bid on and submit sensory ratings for a small number of cheeses that differ only in a limited set of objective attributes but we can measure their perceptions of quality, attitudes about food safety and other demographic characteristics. An experimental approach better enables us to address our research questions about the extent to which consumers perceive pasteurization and aging as food safety attributes, and how they perceive tradeoffs between safety and quality.

A hedonic price model of experimental auction bids is set up as per Melton et al. (1996). In this analysis our objective is to evaluate the tradeoff between WTP for sensory quality and WTP for safety attributes. We use a combination of sensory ratings, objective characteristics (including the safety attributes), and consumer attitudes about food safety to see what drives WTP for artisan cheese. The objective characteristics used in the experimental auction model are derived from specific comparisons of two characteristics isolated in the experiment: whether the milk was pasteurized and how long it was aged. Due to the small number of cheeses used we cannot determine the marginal value of other objective attributes of the cheese as we would in a hedonic model of retail prices, nor do we incorporate reputation variables because all the cheeses in the experiment are made by the same cheesemaker.

Sensory data used in the model come from consumers who participated in auctions and not from expert panels as in Combris et al. (2003). Thus, the sensory data reflect personal preferences. Sensory rating is measured on a Likert scale ranging from 0 to 10. The demographic characteristics of the consumers are gathered through a series of questions posed to participants prior to the experimental auctions. Participants' attitudes about food safety are gathered following the auctions through a series of questions relating to food safety regulation and attitudes toward bacteria.

We model participants' WTP for each cheese as a function of the objective characteristics (safety attributes), sensory ratings and food safety attitudes. We use a Tobit specification since the dependent variable in this case is the participant's experimental auction bid, which could be censored at zero if they prefer the cheese they were not endowed with. Eq. (2) is a hedonic price equation that explains the auction bids as follows:

$$\mathrm{WTP}_{ij} = \alpha v_{ij} + \beta z_{ij} + \gamma w_{ij} + \partial x_{ij} + (u_i + \varepsilon_{ij}) \tag{2}$$

where WTP_{ij} is the willingness to pay for cheese i by person j; v_i is a vector of objective attributes (including pasteurization and age); z_{ij} is a vector of sensory attributes (taste, visual, texture); and w_{ij} is a vector of socio-demographic characteristics; x is a vector of attitudinal characteristics (about risk and food safety); and α, β, γ and ∂ are parameter vectors to be estimated; u_i is the participant specific random effect and ε_{ij} is the individual bid specific error term. The random effect is used to capture the relationship between multiple bids coming from the same participant.

Results and discussion

Descriptive statistics of participants in the experimental auction

Table 2 summarizes the descriptive statistics for selected demographic variables. One hundred fifty-three, 98, and 96 consumers from farmers' markets in Michigan, New York, and Vermont,

Table 2
Descriptive statistics and definitions of demographic variables. *Source*: experimental auctions at farmers markets in Michigan (MI), New York (NY) and Vermont (VT).

Variable	Definition	All	MI	NY	VT
Gender	1 if individual is male	0.36	0.37	0.37	0.34
		(0.48)	(0.48)	(0.48)	(0.48)
Age	Age in years	42.94	43.77	43.56	41.01
		(16.55)	(17.89)	(15.1)	(15.78)
Education	High school	10%	11%	9%	10%
	College	52%	53%	54%	47%
	Post graduate	38%	35%	37%	43%
Income	<$30,000	26%	27%	14%	33%
	$30,000–80,000	34%	33%	43%	23%
	>$80,000	29%	25%	31%	28%
	Prefer not to answer	11%	15%	7%	9%
Children	1 if children under 16 are living at home	0.25	0.26	0.26	0.23
		(0.43)	(0.44)	(0.44)	(0.42)
Primary shopper	1 if individual is primary shopper in household	0.8	0.83	0.75	0.8
		(0.4)	(0.4)	(0.44)	(0.41)
Pounds	Cheese consumption in pounds in the last 2 weeks	1.96	1.92	2.12	1.85
		(1.72)	(1.47)	(2.45)	(1.02)
Artisan	1 if individual consumes artisan cheese	0.86	0.84	0.97	0.78
		(0.35)	(0.37)	(0.17)	(0.42)
% Artisan	% of cheese consumption that is artisan	26.86	26.22	28.78	25.92
		(25.63)	(26.63)	(22.37)	(27.28)
Unpasteurized cheese	Never purchase	9%	9%	9%	10%
	Sometimes purchase	43%	39%	43%	50%
	Often purchase	14%	13%	13%	17%
	Do not know	34%	40%	35%	23%
Food poisoning	1 if individual has had food poisoning	0.57	0.63	0.52	0.54
		(0.50)	(0.49)	(0.50)	(0.50)
Observations		347	153	98	96

Notes: Mean value is reported except when a percentage is indicated for categorical variables. Standard deviations are in parentheses.

respectively participated in experimental auctions for a total of $n = 347$ participants. The sample was approximately 36% male with an average age of 43. The highest level of education attained by 10% of the sample was high school, the highest level of education attained by 52% of the sample was a college degree, and 38% attained postgraduate education. This sample was more educated than the average American, where high school was the highest level of education for 47.07% of the population and 30.9% attained a college degree or higher (United States Census Bureau, 2012). The distribution of reported household income in our sample was relatively similar to the overall US population albeit with fewer participants from the highest income households. Across the US approximately 32% of households have income less than $30,000, 40% have income between $30,000 and $80,000 and 28% have income more than $80,000 (United States Census Bureau, 2012). There were two slight differences between New York and Vermont which balanced each other out overall: in New York fewer participants than average were in the $30,000 to $80,000/year category and in Vermont slightly more than average fell into the less than $30,000/year category. Approximately 25% of the sample had children and 80% of participants considered themselves the primary shopper in the household.

Participants reported consuming an average of about two pounds of cheese in their household in the last two weeks and 86% reported consuming artisan cheese in the last two weeks overall. Approximately 27% of all the cheese reportedly consumed by participants in the last week was artisan cheese. The majority of participants consume cheese made from unpasteurized milk: 43% "sometimes" purchase it and 14% "often" purchase it. Thirty-four percent of participants answered "I don't know" and 9% never purchase it.

We also calculated the percentage of participants in each state who were local residents based on the zip codes provided. In Michigan, 97% of participants were Michigan residents, in New York 82% were New York residents, and in Vermont only 65% were Vermont residents. The demographics in Vermont appear to be influenced by a transient tourist or student population while the participants at farmers' markets in Michigan were almost all local residents. The average participant in Vermont was younger, more educated, had lower income, consumed less cheese and less artisan cheese in particular but was more likely to consume cheese made from unpasteurized milk. In the analysis that follows we control for any differences in demographics but in general we find that they have little influence on WTP.

Sensory evaluations

Participants were instructed to rate the sensory characteristics: visual, olfactory, and taste, on a scale from 0 (labeled dislike) to 10 (labeled like). The default on each scale was set to 5, which was labeled as neutral to participants.

First, in Table 3 we look at means comparisons between the three states (Michigan, New York, and Vermont) and then within the three cheeses (60R, 60P, 90R). One-way ANOVA comparison of multiple means determined that there was no statistical difference in the visual or olfactory ratings across the states. With respect to taste there was a difference in ratings between consumers in Michigan and the other two states. Between Michigan and New York there was a difference of −0.39 at the 3% confidence level and between Michigan and Vermont there was a difference of −0.50 at less than 1% confidence. There was no statistical difference between New York and Vermont.

The difference in the visual ratings between the three cheeses for participants in all states was not significant at a conventional level. There was no significant difference between the olfactory ratings of the unpasteurized 60-day cheese and the pasteurized 60-day cheese but there was between each of those two cheeses and the unpasteurized 90-day aged cheese (indicated by the

Table 3
Summary of sensory ratings. *Source*: experimental auctions at farmers markets in Michigan, New York and Vermont.

All States	Visual	Olfactory	Taste
Unpasteurized 60-day	6.96	6.09[a]	6.18[a]
	(1.95)	(1.99)	(2.23)
Pasteurized 60-day	6.72	6.10[a]	6.41[a]
	(1.84)	(1.75)	(2.06)
Unpasteurized 90-day	6.94	6.54[b]	7.08[b]
	(1.93)	(1.85)	(1.94)
Michigan	Visual	Olfactory	Taste
Unpasteurized 60-day	7.01	6.09	6.58[a]
	(1.96)	(2.08)	(2.26)
Pasteurized 60-day	6.75	6.14	6.59[a]
	(1.85)	(1.82)	(2.21)
Unpasteurized 90-day	6.94	6.53	7.25[b]
	(1.96)	(1.89)	(2.05)
New York	Visual	Olfactory	Taste
Unpasteurized 60-day	6.89	6.06	5.95[a]
	(1.96)	(2.08)	(2.19)
Pasteurized 60-day	6.76	6.12	6.28[a]
	(1.85)	(1.71)	(2.01)
Unpasteurized 90-day	6.78	6.54	7.02[b]
	(1.99)	(1.88)	(1.98)
Vermont	Visual	Olfactory	Taste
Unpasteurized 60-day	6.95	6.10	5.80[a]
	(1.95)	(1.74)	(2.13)
Pasteurized 60-day	6.65	6.03	6.26[a]
	(1.82)	(1.71)	(1.84)
Unpasteurized 90-day	7.09	6.57	6.85[b]
	(1.82)	(1.80)	(1.70)

Note: Ratings are based on a scale of one to ten with ten being the highest and five neutral. Mean values of the taste ratings are presented and standard deviations are in parentheses. If two mean ratings within a state for a given cheese have the same letter they are not statistically different from each other. If cheese types have different letters then the Bonferroni-adjusted significance of the difference between the three cheese varieties is 5% or better for that sensory category in that state. If there are no letters, there is no statistical difference across the three cheeses.

superscripted letters in Table 3). The higher ratings on the olfactory and taste characteristics of the aged cheese make sense since these qualities tend to improve as a cheese ages. In Michigan there were differences in the taste ratings between the two younger cheeses and the 90-day aged cheese as in the aggregated data. In New York and Vermont the only statistical difference was that the taste of the unpasteurized 60-day cheese had a lower rating than the unpasteurized 90-day cheese.

From these ratings we conclude that on average an artisan cheese consumer does not have a taste preference between pasteurized and unpasteurized cheese but does have a taste preference for aged cheese. These findings differ from Colonna et al. (2011), who conducted sensory tests with pasteurized and unpasteurized versions of numerous cheeses and found that more people preferred cheese made from unpasteurized milk cheese on average (in blind taste tests and particularly when they were labeled).

Attitudes about food safety

We asked a series of questions to gauge consumers' perceptions of safety and risk as it relates to food and the responses are reported in Table 4. Other authors have found that attitudes toward technology, nature and food affect individuals' perceptions of the benefits and risks of production technologies like genetic modification (Bredahl, 1999, 2001).

On average the artisan cheese consumers who participated in the study worry about food safety. They don't particularly trust that government food safety regulations protect them but they would like to see stronger food safety regulations imposed. This suggests there may be some debate about exactly what stronger regulations would entail and what food safety means to participants. Subjects say they would pay more for a product with higher food safety. Participants appear to be very concerned about expiration dates despite the inconsistency and lack of regulation governing the use of expiry dates. Overall, subjects were neutral about food that falls on the floor while being prepared but notably there was wide variation in these responses, suggesting that some participants discard food that falls on the floor and some do not. On average, participants think it is safe to drink unpasteurized milk if they know the source and presumably those who chose the unpasteurized cheese were more likely to agree with this statement. On average, participants in the study indicated that they aim to eat natural foods. Presumably the differences in the attitudes of participants about food safety can help explain their choice between pasteurized and unpasteurized cheese. We explore the responses to these attitudinal questions and other determinants of choosing a pasteurized or aged cheese in the next section.

WTP for pasteurization and age

Summary statistics of WTP for the unpasteurized, pasteurized, and aged cheese in the experimental auctions are reported in

Table 4
Summary statistics and definitions of attitudinal variables. *Source*: experimental auctions at farmers markets in Michigan, New York and Vermont.

Variable	Description (1 = disagree; 10 = agree)	Mean (SD)
Worry	I worry about the safety of the food I buy	6.79 (2.99)
Trust government	I trust that government food safety regulations protect me adequately.	4.35 (2.82)
Stronger standards	I would like to see stronger food safety standards imposed in the US.	6.22 (2.75)
Pay more	I would pay more for a product with a higher than average level of food safety.	6.60 (2.75)
Expiration date	I check the expiry or "best before" date on food before purchasing it.	8.12 (2.48)
Floor	I throw out any food that falls on the floor while being prepared.	4.91 (4.73)
Raw milk	I think it is safe to drink unpasteurized milk if I know the source.	6.71 (2.80)
Natural	I usually aim to eat natural foods.	7.87 (2.07)

Table 5
Summary statistics of WTP by cheese type.

Round	*N*	Mean WTP	Std. dev	Min WTP	Max WTP	Non-zero obs
Unpasteurized	198	$1.20	$1.55	0	5	99
Pasteurized	149	$0.94	$1.44	0	5	62
Aged	347	$1.54	$1.66	0	6	208

Notes: Participants either bid to switch to an unpasteurized cheese (198) or a pasteurized cheese (149) and then all participants bid to switch from an unaged to an aged version (347). All cheese samples were approximately 0.5 pounds.

Table 6
Test of equivalence of WTP across cheese by pasteurization and age.

Test	P60	U60	
Bonferroni	0.39*	N/A	
Two-sided *t*	(0.08)**		U60
Two-sample Wilcoxon	[0.05]†		
Bonferroni	0.00	0.04	
Two-sided *t*	(0.00)	(0.00)	U90
Two-sample Wilcoxon	[0.00]	[0.00]	

Notes: U60 = unpasteurized 60-day aged, U90 = Unpasteurized 90-day, and P60 = Pasteurized 60-day. *P*-values for a Bonferroni multiple comparison test*, two sided *t*-test** and two-sample Wilcoxon rank-sum (Mann–Whitney) test of equivalence† of WTP across cheese by pasteurization and age (60-versus 90-day aged, $N = 347$).

Table 5. The mean price difference that participants were willing to pay to give up one half pound of the endowed cheese to switch to one half pound of the unpasteurized, pasteurized, and aged cheese was $1.20, $0.94, and $1.54 respectively.

Table 6 reports the results of a Bonferroni multiple-comparison test, a parametric two-sample *t*-test and a non-parametric Mann–Whitney *U* test of the difference in WTP for the three cheeses. More emphasis should be placed on the non-parametric test given the non-normality of the censored data, which find significant difference in the WTP between all pairs of cheeses.

Hedonic analysis of auction bids

Table 7 reports the results of hedonic price analysis of experimental auction bids using a Tobit-type model to accommodate the large number of censored bids from consumers who bid zero because they preferred the cheese they were endowed with. A random effects specification is used since each participant bid in each of the rounds and their bids are thus related across rounds. We used an *F*-test to determine which demographic variables did not contribute to the model and dropped the ones that did not.

Results demonstrate that artisan cheese consumers who participated in the study are not willing to pay more for pasteurization status or age after controlling for socio demographics, sensory preference, and attitudes toward food safety. The most important determinant of how much a consumer is willing to pay for artisan cheese is their income level, followed by their taste preferences. As we would expect, consumers in higher income brackets were willing to pay more than those in lower income groups to get the cheese they wanted. Taste matters very much to consumers; the higher they rated a given cheese the more they were willing to pay for it. The highest ratings were for the aged cheese, indicating that consumers prefer the taste of the aged cheese, than the unpasteurized 60-day cheese, and then the pasteurized 60-day cheese.

Table 7
Hedonic analysis of experimental auction bids (Random effects tobit model). *Source*: experimental auctions at farmers markets in Michigan, New York and Vermont.

WTP	d*y*/d*x*	Std.	*z*
Safety attributes			
Pasteurized	0.21	0.65	0.33
Aged	−0.06	0.45	−0.13
Socioeconomic variables			
Age (years)	−0.01	0.00	−1.32
Income (>80,000)	0.59***	0.22	2.70
Income (30–80,000)	0.20	0.18	1.06
Income (not reported)	0.53**	0.29	1.82
College graduate	0.02	0.22	0.08
Post graduate	0.15	0.24	0.62
Pounds consumed	0.05	0.04	1.27
Sensory attributes			
Taste 60R (0–10)	0.24***	0.06	4.33
Taste 60P (0–10)	0.19***	0.07	2.59
Taste 90R (0–10)	0.28***	0.05	6.24
Attitudinal variables			
Worry	0.02	0.03	0.83
Trust_government	−0.01	0.03	−0.42
Stronger_standards	−0.04	0.03	−1.14
Pay_more	−0.03	0.04	−0.97
Expiry_date	−0.02	0.03	−0.55
Floor	−0.01	0.02	−0.48
Raw_milk	0.01	0.03	0.34
Natural	0.04	0.04	1.17
Other variables			
Endowment (dummy)	0.21	0.17	1.20
Constant	−1.54***	−0.9	−1.71
Sigma u	0.11	−1.88	0.06
Sigma e	2.53	−0.14	18.12
Rho	0	−0.07	0
Observations	690		
Censored	337		

Notes: All coefficients reported are marginal effects.
** Significance at the 5% level.
*** Significance at the 1% level.

None of the questions about attitudes toward food safety played a role in determining consumer WTP for artisan cheese. This suggests that attitudes toward food safety and risk do not determine how much consumers will pay for a cheese. This is also further evidence that improved safety does not influence why consumers prefer aged cheese. The endowment variable, which refers to whether they were bidding on the cheese they were endowed with, is not a significant determinant of WTP.

Conclusions

U.S. federal government policy prohibits the sale of pasteurized cheese aged less than 60 days and there is consideration to lengthen the minimum aging period to 120 days even though the science behind this policy is contested. There is burgeoning demand in the U.S. for artisan cheeses including unpasteurized cheeses, and unpasteurized cheeses garner a price premium in the market. Assumptions underlying food safety policies depend not only on science but also on values and preferences, but often do not reflect consumer values and preferences. It is in this context that this paper addresses two research questions: To what extent do artisan cheese consumers perceive pasteurization and aging to be food safety attributes? How do they perceive tradeoffs between safety and quality?

The answer to the first question is relatively straightforward. Hedonic price analysis of experimental auction bids demonstrates that consumers of artisan cheese are not willing to pay more for pasteurization as a food safety attribute. All else equal, artisan cheese consumers are willing to pay more for an aged cheese. However, in the experimental data we see that their WTP for aged cheese is not significant when we control for sensory preferences, suggesting that this preference is related to an improvement in the quality of taste rather than safety.

Our second question concerns how artisan cheese consumers perceive tradeoffs between safety and quality. Answering this question is more challenging. In blind sensory analysis there was no significant difference in the ratings between pasteurized and unpasteurized cheese, but there were differences in the taste ratings between the 60 and 90-day aged cheeses. There is a small segment of consumers with unambiguous preferences for either pasteurized or unpasteurized cheese (when labeled and unlabeled), particularly in favor of unpasteurized cheese. However, on average artisan cheese consumers are making purchasing decisions based on taste, not their attitudes toward safety. The science is ambivalent on the safety of cheese made from unpasteurized milk (D'Amico et al., 2008), and this research demonstrates that affected consumers are on average not concerned about the safety of unpasteurized cheese. The heterogeneity in preferences and the importance of taste as opposed to safety attitudes in determining WTP provides justification for policy that allows two distinct markets to exist for pasteurized and unpasteurized cheese.

As consumer preferences for artisan food products continue to grow, crafting one-size-fits-all food safety policy will continue to become problematic. A recent risk assessment suggests more stringent regulation is planned in the future (FDA, 2012). Additional regulation governing the production of cheese made from unpasteurized milk potentially increases equipment costs for artisan producers who prefer to produce cheese made from unpasteurized milk and threatens their market niche. Further limiting the sale of unpasteurized cheese would decrease consumer welfare more than a policy that allows both pasteurized and unpasteurized cheese to be sold and distinguished by labels. Regulation of artisan cheese in the United States also has international trade implications, specifically for unpasteurized cheese imported from Europe, which would be subject to the same restrictions. The results of this study offer no justification for extending a minimum aging requirement on cheese made from unpasteurized milk.

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