Educational interventions to address misconceptions about antibiotic residues in milk can alter consumer perceptions and may affect purchasing habits

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ABSTRACT

The industrialization of the agri-food industry and resultant decrease in the number of people employed on farms has contributed to a knowledge gap among consumers about food production processes. A commonly reported concern of dairy consumers is the use of antibiotics in dairy animals, even though these drugs are an important tool for promoting animal health and welfare and food safety. The extent to which consumers are aware of antibiotic residue avoidance practices in dairy production is unknown, and it is unclear whether acquisition of such knowledge could affect purchasing behavior and perceptions of dairy farming. The objectives of this study were to assess consumers' perceptions about the quality and production of dairy products in the United States and determine whether educational materials on processes that limit the occurrence of antibiotic residues in milk can change consumers' perceptions of dairy products and purchasing behaviors. We surveyed 804 consumers and assigned them to 1 of 3 interventions: (1) a control arm (reading the content of the Dairy page of the USDA's myplate.gov website); (2) an educational brochure on the processes that prevent antibiotic residues in milk; and (3) a video on the same processes. We found that a majority (86.1%) of participants believe that the quality of dairy products in the United States is high, although many had concerns about the treatment of dairy animals and chemicals (pesticides, antibiotics, hormones) in dairy products. Compared with the control intervention, the brochure was associated with a significant decrease in the level of concern consumers had about chemicals in their milk [−0.20 points on a Likert scale, 95% confidence interval (CI), −0.32 to −0.08] and a significantly increased comfort in purchasing conventional dairy products (odds ratio 2.43, 95% CI, 1.62 to 3.66). The video was

associated with even stronger effects: a 0.29-unit decrease in the level of concern about chemicals in milk (95% CI, −0.42 to −0.016) and 2.94 times greater odds of purchasing conventional dairy products (95%, CI 1.92 to 4.49). Although consumer food decision making is complex and driven by multiple factors, it appears that education about the processes that promote food safety can reassure consumers about their concerns and potentially affect purchasing habits.

Key words: consumer, dairy product, organic, education, antibiotic

INTRODUCTION

Trends in consumer food choice are complex, not entirely rational, and drive changes across the food industry (Chalfant and Alston, 1988; Ares et al., 2014). In supermarkets where there is abundant product choice and where multitudes of food attributes and labels compete for shoppers' attention, consumers operate in a state of information overload (Mick et al., 2004). Moreover, because of the industrialization of the agri-food industry and the resultant decline in on-farm employment, consumers are often unfamiliar with the processes behind food production (Princen, 1997; Weis and Weis, 2007; Asioli et al., 2017). An understanding of consumer food decision making is essential for food industries to appropriately respond to consumer demands and stay competitive in a dynamic food industry. This is particularly important in the dairy industry, where fluid milk consumption in the United States has been declining since the 1970s (Stewart et al., 2013).

One commonly reported concern of dairy consumers is the use of antibiotics in dairy animals (Kaiser et al., 1992; Harwood and Drake, 2018). Products with an “organic” or “antibiotic-free” label are frequently perceived to be indicative of a superior and safer product (Hughner et al., 2007; Van Loo et al., 2010; Van Loo et al., 2013). These consumers are often not familiar with animal production practices (Curtis, 1987; Wolf et al., 2016) and may not understand principles of withdrawal

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times or know about the rigorous systems in place to prevent antibiotic residues from entering the food chain. Namely, farmers are required to discard milk from cows treated with certain antibiotics, and substantial penalties are imposed in the event of a violation. Additionally, the Pasteurized Milk Ordinance requires that all raw and grade A milk be screened at the level of the bulk milk pickup tank for β -lactam antibiotic residues. Thus, all milk sold to consumers is technically “antibiotic free.” Dairy producers who use antibiotics—often in a perfectly judicious manner—or whose product is not labeled as being free of antibiotics, may be losing a customer base due to misperceptions or lack of knowledge of consumers. Producers may feel pressured to adopt management practices that exclude antibiotics (Flaten et al., 2006; Habing et al., 2016; Ekakoro et al., 2018; Wemette et al., 2020), which are useful tools for animal health and production when used appropriately.

The extent to which consumers are aware of antibiotic use and antibiotic residue avoidance practices on dairy farms is unknown, and it is unclear whether acquisition of such knowledge would affect purchasing behavior and perceptions of dairy farming. It is also unclear which educational methods would be most effective in conveying such information. The objectives of this study were therefore (1) to assess consumers’ perceptions about the quality and production of dairy products in the United States, and (2) to determine whether educational materials providing information on processes that limit the occurrence of antibiotic residues in milk can change consumers’ perceptions of dairy products and purchasing behaviors.

MATERIALS AND METHODS

Survey Development

To inform the development of the survey and educational material, we first collected pilot data on consumers’ perceptions of dairy production and dairy products in the United States. Open-ended questions were posed to 20 consumers recruited via an online survey platform to elicit their thoughts on production methods, safety, and quality of dairy products, and benefits and risks of consuming dairy products. Major themes that emerged from these interviews included concerns about the safety of dairy products (presence of additives, hormones, antibiotics, and bacteria), the environmental impact of dairy farming, the welfare of dairy animals, and a recognition of the health benefits of dairy products as well as some of the potential hazards (allergies, cancer, digestive issues, cardiovascular issues). These themes were used to guide development of the educational material and the final survey.

Educational Material

An informational video and brochure describing the processes in place to ensure the safety of dairy products, especially with regard to antimicrobial residues, were developed by the research team. This educational material also incorporated information on the themes that were considered important to or misunderstood by the consumers interviewed during the pilot phase. The brochure is included as supplemental material, and the video can be found at <https://vimeo.com/518895384>.

Final Survey Development and Administration

A final survey (Supplemental File S1, https://figshare.com/articles/figure/Supplemental_File_S1_-_Survey/15166551; Redding, 2021a) informed by the pilot information was then developed through Redcap (Harris et al., 2009). Consumers of dairy products were recruited through the MTurk platform (<https://www.mturk.com>) to participate in the study. MTurk is a crowdsourcing marketplace run by Amazon, where investigators can recruit survey participants (“workers”) for a fee. Eligibility of participants (i.e., purchasers and consumers of dairy products residing in the United States) was assessed through screening questions asking participants to indicate which dairy products they consumed on a regular basis and their state of residence. A preliminary set of questions was first posed to the participant, including information on (1) types of dairy products purchased regularly, (2) where they purchased dairy products, (3) words on dairy product labels that would make them want or not want to purchase that product, (4) whether and why they purchase organic dairy products, (5) overall impression of the quality of dairy products in the United States, and (6) any concerns related to bacterial or chemical contamination of dairy products. Next, participants were presented with 4 labels, including a “USDA organic” label, an “antibiotic-free” label, a “natural genuine quality ecologically clean milk,” and a nutrition label from a conventionally produced milk product. Participants were then asked to indicate their perception of each label using a 5-point Likert scale. All free-text answers (e.g., “What words do you look for on food labels that WOULD make you buy a particular dairy product?”; or “Please provide your opinion on the quality of milk produced in the United States”; or “What, if anything, concerns you about the way dairy products are produced in the United States?”) were read by the investigators, and answers were assigned to a general category.

Participants were then randomized to 1 of 3 intervention arms based on the first letter of their last name. Participants whose last names began with the letters A

through F were assigned to the control branch, where they were instructed to read the content of the Dairy page of the US Department of Agriculture's myplate.gov website (<https://www.myplate.gov/eat-healthy/dairy>). Participants whose last name began with the letters G through O were assigned to the second arm, where they were instructed to read the educational brochure produced by the research team (Supplemental File S2, https://figshare.com/articles/figure/Untitled_item/15166713; Redding, 2021c). Participants whose last name began with the letters P through Z were assigned to the third arm, where they were instructed to watch the educational video produced by the research team. To verify that the participant engaged with the educational material, they were asked to summarize the content of the educational material.

Following engagement with the educational or control material, participants were again asked to indicate whether they had any concerns about the chemical or bacterial contamination of dairy products and to rate their perceptions of the abovementioned labels. They were also asked whether the interventional material they engaged with would change their comfort level purchasing conventional and organic dairy products. Finally, participant demographic information was captured.

Quality of the participant's survey was verified by manual review of each survey. If the participant did not engage in or understand the educational material (as indicated by their required summary of the educational material), if their free-text answers appeared to be copied and pasted from the results of an internet search, or if they appeared identical to another participant's survey, the survey was rejected. Participants whose surveys were accepted were awarded a payment of \$4 each via the MTurk platform.

Statistical Analysis

Descriptive analyses to characterize participants across the 3 interventional arms were performed. Categorical variables were compared using the χ^2 test, and continuous variables were compared using Student's *t*-test or Wilcoxon rank sum test, depending on normality. The major outcomes that were considered included (1) a reported change in comfort purchasing conventional or organic dairy products following the educational intervention; (2) a change in emotional perception of the food labels; and (3) a change in the reported level of concern about chemical and bacterial contamination of dairy products. The association between each outcome and the type of intervention was first assessed through univariable logistic or linear regression as appropriate. Similar analyses were then performed to assess for

confounding and effect modification by other variables, including participant demographics and purchasing habits. Multivariable analyses were then performed to determine the adjusted strength of the primary associations.

Power and Sample Size

We originally powered our study to be able to detect a 2-fold change in emotional perception (from negative or neutral to positive) about the safety of dairy products with regard to chemical residues in participants who viewed the video compared with participants who viewed the control material. The sample size for this original calculation to obtain 80% power was 124 consumers. However, because of restrictions associated with the coronavirus disease 2019 pandemic, we were no longer able to approach consumers in person at retail outlets. Instead, we used the MTurk platform to recruit participants online. As a result, we were able to recruit approximately 6 times as many participants as originally planned, ensuring more than sufficient power for our original study hypothesis.

This study was approved by the Institutional Review Board of the University of Pennsylvania.

RESULTS

Participant Characteristics

A total of 921 participants completed the online surveys. Of these, 117 (12.7%) were rejected for poor quality, resulting in a final count of 804 complete surveys. Demographic characteristics of the participants are presented in Table 1, and the distribution of states the participants were from is displayed in Figure 1. Comparisons with national statistics are presented in Supplemental Table S1 (https://figshare.com/articles/figure/Supplemental_Table_S1/15165564; Redding, 2021b). With the exception of gender, all demographic characteristics were equally distributed among all 3 interventional branches.

Purchasing Habits

Out of 7 possible dairy products (milk, cheese, yogurt, ice cream, butter, cottage cheese, kefir, and other), participants regularly consumed an average (SD) of 4 (1.3) types of products. The most commonly consumed dairy product was cheese (89% of consumers), followed by milk (85% of consumers). Among 6 possible retail locations (grocery store, bodega or corner store, farmer's market, direct from a dairy farm, co-op, and other), the main source of dairy products was most commonly

the grocery store (94% of consumers), although 284 (35.3%) participants purchased dairy products at more than one type of retail outlet. A total of 559 (70.0%) participants reported purchasing organic dairy products: 87 participants (10.9%) did so exclusively, 209 (27.1%) did so regularly, and 263 (32.8%) did so occasionally. The most commonly cited reason for purchasing organic products was a belief that these products were healthier (44.8% of participants) or chemical-free (43.4% of participants).

Perceptions of Dairy Products

A series of open-ended questions designed to elicit overall perceptions of the quality of dairy products in the United States were posed to the participants. When asked about their overall perception of the quality of milk in the United States, the vast majority (692 participants, 86.1%) thought that the quality of milk was good; 28 participants (3.5%) thought the quality of milk was poor; and 84 (10.5%) had no opinion. When asked about words on the label that would make them want to purchase a dairy product, answers could generally be assigned to 1 of 6 broad categories (Table 2), the most

commonly cited of which had to do with the composition or manufacturing of the milk itself. When asked to describe any concerns they had about the way milk was produced in the United States, participants' comments generally fell into 1 of 4 general categories (Table 3), with the largest proportion of respondents (269, 34.9%) indicating the treatment of animals as their most pressing concern. When asked to rank their level of concern about chemical or bacterial contamination, most respondents were not at all concerned about chemicals or bacteria being present in their milk (Figure 2). Respondents who indicated some level of concern mostly cited antibiotics, pesticides, and hormones as chemicals of concern. Perceptions of the labels varied, with the most negatively perceived label being the nutritional label from the conventionally produced milk.

Interventional Outcomes

A total of 278 (34.6%), 289 (36.0%), and 237 (29.5%) participants were assigned to the control, brochure, and video arms, respectively. Univariable analysis revealed a significant effect of the intervention on the level of concern a participant had about chemicals in their milk

Table 1. Distribution of demographic factors among participants of a survey on antibiotic residues in milk

Variable	All participants (n = 804)	Intervention			Difference among groups (<i>P</i> -value)
		Control (n = 278)	Brochure (n = 289)	Video (n = 237)	
Gender [n (%)]					0.012
Male	480 (59.7)	179 (64.4)	178 (61.6)	123 (51.9)	
Female	324 (40.3)	99 (35.6)	109 (37.7)	114 (48.1)	
Age [mean (SD), yr]	40.1 (11.2)	39.3 (11.4)	40.6 (11.1)	40.5 (11.0)	0.839
Race [n (%)]					0.115
Caucasian	584 (72.8)	206 (74.4)	208 (72.0)	170 (72.0)	
African American	52 (6.5)	23 (8.3)	17 (5.9)	12 (5.1)	
Asian	122 (15.2)	36 (13.0)	39 (13.5)	47 (19.9)	
Native American	12 (1.5)	5 (1.8)	6 (2.1)	1 (0.4)	
Native Hawaiian/Pacific islander	1 (0.1)	0 (0.0)	1 (0.35)	0 (0.0)	
Two or more	25 (3.1)	7 (2.5)	14 (4.8)	4 (1.7)	
Other	2 (0.3)	0 (0.0)	1 (0.35)	1 (0.4)	
Preferred not to say	4 (0.5)	0 (0.0)	3 (1.0)	1 (0.4)	
Highest education level completed [n (%)]					0.254
High school	226 (28.3)	92 (33.1)	73 (25.5)	61 (25.9)	
Bachelor's degree	403 (50.4)	127 (45.9)	152 (53.2)	124 (52.5)	
Master's degree	120 (15.0)	39 (14.1)	44 (15.4)	37 (15.7)	
Doctorate or higher	13 (1.6)	8 (2.9)	4 (1.4)	1 (0.4)	
Trade school/Preferred not to say	31 (3.9)	9 (3.3)	12 (4.2)	10 (4.2)	
Preferred not to say	6 (0.8)	2 (0.7)	1 (0.4)	3 (1.3)	
Location of primary residence [n (%)]					0.182
Urban	267 (33.4)	108 (39.1)	87 (30.2)	72 (30.6)	
Suburban	397 (49.7)	125 (45.3)	151 (52.4)	121 (51.5)	
Rural	135 (16.9)	43 (15.6)	50 (17.4)	42 (17.9)	
Annual income category [n (%)]					0.343
<\$25,000	135 (16.8)	40 (14.4)	51 (17.7)	44 (18.6)	
\$25,000–\$50,000	249 (31.0)	85 (30.6)	87 (30.1)	77 (32.5)	
\$50,000–\$100,000	296 (36.8)	105 (37.8)	105 (36.3)	86 (36.3)	
\$100,000–\$200,000	98 (12.2)	38 (13.7)	34 (11.8)	26 (11.0)	
>\$200,000	16 (2.0)	9 (3.2)	6 (2.1)	1 (0.4)	
Preferred not to say	10 (1.2)	1 (0.4)	6 (2.1)	3 (1.3)	

Table 2. Words and factors that make a dairy product appealing to consumers

Category	Number of participants (%)	Example terms
Composition, manufacturing	305 (38.3)	“Whole milk vs. 2% vs. non-fat” “Expiration date and manufacturing date” “Calories, saturated fat, vitamin D” “Amount of protein” “Probiotics” “Flavor and low sugar” “Pasteurized” “Calcium and minerals”
Production type	229 (28.7)	“Organic” “Non-GMO” “USDA approved” “Free range” “Anti-cruelty” “Food Alliance certified” “Grassfed” “Sustainable”
Freshness, wholesomeness, naturalness	151 (19.0)	“Natural” “Real” “Fresh” “Healthy” “Rich, filling” “Wholesome” “Gourmet”
Provenance	32 (4.0)	“Hormone-free” “Locally sourced” “If it is a local dairy farm” “Cooperatively owned”
Brand	38 (4.8)	“From my home state” “Brands I’m familiar with” “Brand names I trust” “Whether or not the company has been around a long time and has a good reputation”
Price	15 (1.9)	“I look for price” “Cheapest price”
Nothing (consumer does not pay attention to labels)	27 (3.4)	“Nothing in particular” “I honestly don’t look for any particular words” “I don’t really look at labels or worry about it”

Figure 1. Distribution of survey responses in the United States.

Table 3. Participant concerns about the way milk is produced in the United States

Category	Number of participants (%)	Example quotations
Treatment of animals	269 (34.9)	<p>“The treatment of the cows does worry me, I am worried they are given too many drugs to produce milk or are made to be pregnant too much in order to produce milk. I’m not worried about the transfer of anything into the milk so much as I am about if it is humane for the cows.”</p> <p>“Thousands of animals are kept in warehouses or shoved together in small fenced areas. These places smell disgusting. Their living conditions are horrible.”</p> <p>“The animal treatment is abhorrent. I disgrace myself by continuing to purchase the products.”</p> <p>“I don’t like the way cows are treated and housed without going outside. It’s a terrible way to raise animals and I think we can do better on farms and actually not treat animals like prisoners in an inhumane way.”</p>
Concerns related to the quality of dairy products and the potential for milk adulterated with chemicals	230 (29.8)	<p>“I am concerned about the degree of attention and detail that goes into producing, specifically, the risk of contaminants breaching the process. I am also worried about additives being used that are not even publicly known or otherwise used in larger amounts than one might expect.”</p> <p>“I wonder sometimes if purity is an issue, as it was when I was growing up, and Strontium 90 in milk was a concern. The larger producers have to cut corners to maintain profitability, and I wonder how much of that corner-cutting comes at the expense of safety and purity. Plus, ground water is contaminated with chemicals, thus grass is.”</p> <p>“I am concerned about possible steroids and other chemicals introduced. I am also concerned about the effectiveness of the pasteurization process and whether the product was handled and stored correctly.”</p> <p>“Just all the added hormones and chemicals. When you really think about all of the things we inject into these animals, it’s amazing we don’t have humans walking around with 4 ears and 2 noses by now.”</p> <p>“I am worried about all the antibiotics and growth hormones they are giving to the cows. They say girls are going through puberty a lot earlier now because of the growth hormones in cows.”</p> <p>“Pregnant cows’ milk has lots of estrogen, which contributes to the kind of breast cancer I had.”</p>
Sustainability and environmental concerns	62 (8.0)	<p>“Cow farms are a known problem when it comes to climate change.”</p> <p>“The industry is forced to throw out abundance instead of giving it to needy people for free.”</p> <p>“The entire process contributes to global warming and destruction of the Earth in general.”</p> <p>“Factory farming in general is problematic. I grew up with parents working on dairy farms, and have vivid memories of the negatives of such. Would certainly prefer happy cows in lovely meadows tended by happy, well paid workers, but am very aware that isn’t our current reality.”</p>
Concerns about farmers	18 (2.3)	<p>“Factory farms greatly concern me. I am concerned at the loss of family dairy farms. Dairy farmers are often not compensated fairly.”</p> <p>“Too expensive overall as it’s commercial everywhere. Farmers get nothing, middlemen profit, we pay top dollar the market.”</p> <p>“In the USA, farmers produce so much milk that the price paid to farmers for milk has plummeted far below the cost of production.”</p> <p>“The only thing I worry about is that the dairy farmers and how much of their lives they have to dedicate to their cows so we have fresh wonderful-tasting dairy products.”</p>
No concerns	192 (24.9)	<p>“Basically, I feel that that the dairy products produced in the U.S. are safe, so I don’t have any concerns.”</p> <p>“Honestly nothing. Maybe if the dairy cows were given a more free life but to be honest I barely care and would certainly not being willing to pay the upcharge for it 95% of the time.”</p> <p>“Nothing. Maybe I am naive and need to be more concerned? But, I have never had any problems.”</p> <p>“Honestly I don’t think about it too much. I know others do and I’m thinking that conditions for cows are probably improved over what they used to be. As long as the companies do a reasonable job of producing the milk in safe and sanitary environments I have no complaints, as they all seem to be doing that.”</p>

(Table 4). Other variables that were also significantly associated with this outcome were gender, whether the participant believed dairy products were of good qual-

ity in the United States, the number of types of dairy products the participant regularly purchased, and how regularly the participant purchased organic products.

Figure 2. Distribution of respondents' levels of concern about chemicals and bacteria in their milk before the educational intervention.

For the final multivariable model, only the intervention and the frequency of purchasing organic products remained significantly associated with the outcome (Table 4); however, because gender was a confounding variable, we also included it in the final multivariable model to obtain the effect of the intervention on the outcome adjusted for gender. Relative to the control arm, reading the brochure was associated with a 0.20-unit decrease on the Likert scale (i.e., from increasing concern, or a high value on the Likert scale, to decreasing concern, or a low value on the Likert scale), whereas watching the video was associated with a 0.29-unit decrease (Figure 3).

The interventions also had a significant effect on the likelihood that a participant would feel more comfortable purchasing conventionally produced dairy products. Compared with participants assigned to the control arm, participants who read the brochure had 2.1-times greater odds of stating they would be more comfortable purchasing conventional dairy products, whereas those who watched the video had 2.56-times greater odds. In the comments section, a handful of participants even explicitly attributed a change in perception to the educational material:

“My initial concerns was [sic] about antibiotics and possible pesticides in the milk but after the

video I would say that my concerns have almost completely diminished because of the multiple times it is tested. I would have never have guessed it was tested so frequently and also discarded when positive tests come up.”

“The brochure addressed my concerns and the knowledge I acquired gives me a better understanding of the rigorous process milk production goes through.”

Other variables that were significantly associated with this outcome on multivariable analysis included frequency of purchasing organic products and gender (Table 4): women experienced a greater decrease in level of concern about chemicals but were also less likely to feel more comfortable purchasing conventional dairy products, and consumers who purchased organic dairy products were less likely to feel concerned about chemicals and more comfortable purchasing conventional products.

We observed minimal change in the perception of the labels after the intervention (Figure 4). For all 4 labels, between 73 and 85% of participants did not change their perception. However, the greatest negative change occurred for the antibiotic-free label, where perception by of the label decreased by 1, 2, 3, or 4 points on the

Table 4. Variables associated with changes in levels of concerns about chemicals in milk and comfort increasing conventionally produced dairy products following an educational intervention

Variable	Outcome: Change in level of concern about chemicals in the milk ¹			Outcome: Increasing comfort in purchasing conventionally produced dairy products ²		
	Coefficient	P-value	95% CI	Coefficient	P-value	95% CI
Intervention ³						
Control		Referent			Referent	
Brochure	−0.20	0.001	−0.32 to −0.08	2.43	<0.001	1.62 to 3.66
Video	−0.29	<0.001	−0.42 to −0.016	2.94	<0.001	1.92 to 4.49
Organic purchasing habits						
Never		Referent			Referent	
Occasionally	−0.19	0.004	−0.31 to −0.06	1.14	0.533	0.75 to 1.73
Regularly	−0.36	<0.001	−0.49 to −0.22	1.62	0.029	1.04 to 2.47
Exclusively	−0.31	0.001	−0.49 to −0.13	3.61	<0.001	2.06 to 6.33
Gender						
Male		Referent			Referent	
Female	−0.09	0.08	−0.20 to 0.01	0.72	0.057	0.52 to 1.01
Reported belief that the quality of dairy products in the United States is high	—	—	—	4.00	<0.001	2.00 to 7.96

¹Assessed by linear regression.

²Assessed by logistic regression.

³A negative change means the participant went from being more concerned to less concerned.

Likert scale among 18% of consumers. The educational interventions did not have a significant effect on the change in perception of any label.

DISCUSSION

In this study, we evaluated the opinions of consumers on the quality, production, and labeling of dairy products in the United States and assessed whether an educational intervention on the processes that prevent adulteration of milk with antimicrobial residues could affect their perceptions and purchasing habits. We found that consumers overall thought that dairy products were of good quality but had concerns about animal welfare and the possibility of chemicals (pesticides, hormones, antibiotics) in the milk. The composition of the milk (e.g., fat levels, micronutrients) and the production type (e.g., organic, grass-fed, conventional) were labeling attributes that had the greatest effects on consumers' reported purchasing habits. Other studies have also found that consumers deem milkfat content the most important attribute of milk and that an organic designation is highly attractive (McCarthy et al., 2017; Harwood and Drake, 2018).

In this and other studies, the preference for organic products appears to be driven by a belief that organic milk is healthier and more likely to be chemical-free (Van Loo et al., 2013; Schwendel et al., 2015; Harwood and Drake, 2018). However, the nutritional superiority of organic food products has not been demonstrated (Dangour et al., 2010; Forman and Silverstein, 2012; Załęcka et al., 2014), and the composition of milk de-

pends more on farming practices and inputs than on production type (Schwendel et al., 2015). Moreover, no differences exist in the levels of pesticides or antibiotics in organic and conventional milk, as, under the Pasteurized Milk Ordinance, these substances may not exceed certain thresholds. Additionally, the use of hormones in conventional dairy production does not result in any substantial differences in milk that could affect human health: bovine somatotropin (bST) is species-specific and therefore biologically inactive in humans, and naturally occurring hormones such as estrogen and progesterone are found at very low levels in both organic and conventional milk (Pape-Zambito et al., 2010). Thus, contrary to the belief of some consumers, all milk produced in the United States is pesticide and antibiotic free, regardless of the production method or labeling. These beliefs are not benign and can have real consequences for dairy farmers and animals. In one study, dairy farmers attributed (whether correctly or not) expanding regulations in part to misinformed consumer preferences associated with marketing of organic products (Wemette et al., 2020), and another study found that consumers were generally unaware of the potential negative repercussions for animal welfare associated with banning or reducing the use of antibiotics in livestock production (Lemos Teixeira et al., 2021). Ironically, the use of antibiotics to treat sick dairy cows has been found to be one of the most negatively perceived management practices by consumers (Widmar et al., 2017). Because of this apparent discrepancy among consumers—a profound concern for animal welfare but also distaste for the use of antibiotics in sick cows—we

Figure 3. Violin plots demonstrating the distribution of changes in the level of concern a participant had about chemicals in their milk on the Likert scale following the intervention. A negative change means the participant went from being more concerned to less concerned. The white circle represents the median, the vertical bar represents the interquartile range, and the width of the body indicates the density (i.e., frequency of responses).

specifically sought to address some of the misconceptions surrounding the use of these drugs in our educational interventions.

We found that both the brochure and the video were effective relative to the control intervention: participants who read the brochure or watched the video experienced both a greater decrease in the level of concern they had about chemicals in their milk and an increased reported level of comfort purchasing conventional dairy products following the educational intervention. For both outcomes, viewing of the video resulted in greater change than the brochure. This could be due to the time spent engaging with the material—the video is 2 min 46 s in length, whereas it probably takes a minute or less to read the brochure—or because of the different types of media. The ability to deliver one type of media versus the other will depend on the environment and context in which the educational material is to be disseminated, but each is expected to be effective. Additionally, we envisage that this type of educational material could be used to address other types of concerns customers might have about the quality of their milk (e.g., pesticides or hormones in milk). Although beliefs and values drive perceptions and purchasing decisions to some extent

(Krystallis et al., 2008; Harwood and Drake, 2018), our study suggests that education about processes can also be influential. Interestingly, another study interviewing liberal arts college students and agriculture college students found that the agricultural students, who presumably were more knowledgeable about and had more experience with the processes involved in food production and food safety, had polarized opposite perceptions and beliefs about organic and conventional milk relative to the former (Puetz, 2013).

The greatest change in perception occurred for the antibiotic-free label (i.e., from a more positive to a more neutral or negative perception). This could be because, after seeing the educational material, customers realized that the label was misleading in suggesting that this milk was antibiotic free in contrast to milk that did not have this label. However, the interventions ultimately had no significant effects on the perceptions of labels. This could be for several reasons. First, our educational material was about processes rather than labels, and we provided no explanation for the meaning of the different labels. Because of the lack of standardization of production type labels, consumers might not have been familiar with the labels and therefore did

not know how to react to them. Second, it could be because consumers ultimately pay little attention to labels. Although only 3.4% of our respondents said they did not pay attention to labels, the lack of interest in labels appears to be a more widespread phenomenon: in one study of milk consumers, label claims were the least important attribute of dairy products, and the “ideal” fluid milk carton had no label claims (Harwood and Drake, 2018). Nevertheless, labels can affect purchasing choices, and, unfortunately, can evoke a dualistic narrative (i.e., an “antibiotic-free” label suggests that a product without the label contains antibiotics). Explanatory labels, such as those indicating that no difference exists between milk from cows treated with recombinant (r)bST and cows not treated with rBST, may be useful in combating this type of false narrative, in addition to educational material such as those we developed for this study. Addressing consumers’ concerns about animal welfare, which was the most often reported concern in this study, may be more challenging. Although some objective indicators of animal welfare have been proposed (March et al., 2017), these indicators and the benchmarking of animal welfare in general can be problematic (Krieger et al., 2020). Moreover, animal welfare might be perceived to be

inadequate by consumers with specific—and perhaps idealized—visions of what constitutes animal wellbeing, regardless of what they might hear or see. A great deal more research is needed to better understand consumer perceptions of and potential educational interventions on dairy animal welfare.

Some limitations apply to this study. The MTurk recruitment platform provides access to a large number of individuals employed across a range of fields and disciplines and generates relatively high-quality data (Buhrmester et al., 2011; Follmer et al., 2017), but results may not be completely generalizable to the general population. One study found that MTurk participants are more educated, underemployed, and politically liberal than the general population (Goodman et al., 2013). In our study and in another study (Berinsky et al., 2012), Asian individuals appear to be overrepresented compared with African American and Hispanic participants (Supplemental Table S1, https://figshare.com/articles/figure/Supplemental_Table_S1/15165564; Redding, 2021b). Additionally, approximately half of our survey participants appear to belong to the lower or lower-middle income classes, which is greater than the distribution of the general population (Kochhar, 2018). Cultural use and perceptions of dairy

Figure 4. Violin plots demonstrating the distribution of changes on a 5-point Likert scale in the emotional perception of 4 dairy labels following the educational intervention. A positive change means the participant felt increasingly positive about the label; a negative change means the participant felt increasingly negative about the label. The white circle represents the median, and the width of the body indicates the density (i.e., frequency of responses).

products as well as financial considerations may influence purchasing habits more than concerns about the quality of the product. However, because dairy products are such staple products that are regularly purchased by all survey participants, the finding that our educational interventions were effective is likely broadly applicable. Another limitation is that our survey measures reported purchasing intent, not actual purchasing, and our study results could be affected by social desirability bias. However, given that we found a statistically significant effect of the educational intervention on the outcomes, we suspect that social desirability bias was limited.

In conclusion, we found that survey respondents generally believed that quality of dairy products is high in the United States but had concerns about the welfare of dairy animals and the potential for chemical contaminants in their milk. Educational interventions specifically addressing the issue of antimicrobial residues in milk resulted in a significant decrease in the level of concern consumers had about chemical residues in their milk as well as a reported increased level of comfort purchasing conventional dairy products compared with organic products. Educational material may be useful in reassuring consumers about the safety and quality of conventionally produced dairy products. However, more research is needed to determine whether this type of educational material results in sustained alterations in perceptions and changes in actual purchasing habits.

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