A Comparative Analysis of Canadian Consumers' WTP for Novel Food Technologies (Case of Juice Produced by Nanotechnology & Pork Chops Using Genomic Information)

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Abstract

Since novel food technologies (such as nanotechnology, cloning, genomics, etc.) are still in their infancy, communication will be very important in the development of these new technologies to address consumer perceptions and hence market acceptance of these innovations in the agri-food industry. Understanding consumer preferences is key to ensuring that the use of new technologies optimizes use of resources and societal welfare. Two national online surveys (in 2010 for nanotechnology and in 2012 for genomic information) were conducted across Canada to elicit Canadian consumers' WTP for juice produced by nanotechnology or pork chops that are produced from pigs bred using genomic information. Canadian consumers' WTP (i.e. whether or not they are willing to buy the products at a price over the price of goods produced without the use of the technologies), and the effects of demographic characteristics, Canadian consumers' attitudes on their purchase intentions about products created using these novel technologies, were examined. The preliminary analysis shows that the majority of Canadians have little knowledge about use of genomic information or nanotechnology, and hence are not willing to pay a premium for these novel technologies applied to their food.

1. Introduction

The debate over the introduction of new technologies, such as agri-biotechnology, GM food products, cloning, nanotechnology, genomics, etc., in the food and agribusiness industry continues. The content of the debate varies with the different socio-cultural contexts of the novel food technologies. As some novel technologies are still in their infancy, communication about it must address consumer perceptions in order to have market acceptance of the innovation. A wide range of studies have discussed and reviewed public opinion and awareness, acceptance, social values and controversies that face new foods developed with technological innovation (Bouwmeester et al., 2009; Boyce, 2009; Busch, 2008; Dunkley, 2004; Hallman et al., 2003; Ronteltap et al., 2007; Turk et al., 2008; Onyango and Govindasamy, 2004; Parr, 2005), as well

as health and environmental risks, societal risks, benefits, and views of appropriate regulation (Besley et al., 2008). Many studies have shown that consumers exhibit concerns regarding the future of novel food supplies (Baker & Mazzocco, 2002), genetic modification (Hu et al., 2004, 2006; Larue et al., 2004) and the consumption of foods produced with novel technologies (Matin et al., 2012). These studies have indicated that there is a general lack of awareness and understanding of new food technologies, (i.e. nanotechnology, cloning, genetically modified, agri-biotechnology, genomics, etc.) referring to both their presence and applications in food production and in the agri-food industry (Hallman and Aquino, 2003; Matin et al., 2012; Onyango et al., 2006; and Waldron et al., 2006). There are also ethical concerns regarding their acceptance (Sheetz et al., 2005). As a result, most consumers are unable to decide whether or not new foods produced by such technologies are associated with possible risks, and they seem to be hesitant and fearful of accepting and consuming novel foods produced with technologies associated with potential risks without any clear benefits. Information asymmetry can cause issues in the supply chain of foods produced by novel technologies, and it can impact consumers' final decisions about whether the product is safe enough to consume. Without a better understanding of the actual and perceived risks/benefits of new technologies, negative perceptions could lead to a lack of support by the public and, ultimately, set back technological innovation for a significant period of time (Smiley et al., 2008).

In this research, Canadian consumers' preferences, and their willingness to pay for two products: fortified juice produced by nanotechnology applications, and pork which is produced from pigs bred using genomic information, are studied. Evaluation of consumers' WTP (i.e. whether or not they are willing to buy the products), their preferences and demand is essential for producers to decide whether or not these novel technologies are worth adopting. It is also worthwhile to examine whether or not novel technology acceptance differs across product categories in order to be able to provide a better sense of welfare measures across products (Hobbs et al., 2011; Lusk & Marette, 2010). In the study the effects of demographic characteristics and Canadian consumers' attitudes, on their purchase intentions about products created using these novel technologies are also provided. Furthermore, insights for policy makers over future development of these two specific novel technologies will also be provided.

2. Background

2.1 Nanotechnology

Nanotechnology involves the characterization, fabrication and/ or manipulation of structures, devices or materials as discrete entities that have at least one dimension that is approximately 1-100 nm in length. When particle size is reduced below this threshold, the resulting material exhibits physical and chemical properties that are significantly different from the properties of macro-scale materials composed of the same substance (Duncan, 2011).

Nanotechnology will be a key technology for improving peoples' standard of living, in the short-term by significantly improving existing processes and products and in the long-term by providing revolutionary and life-changing advances across a wide variety of industries such as agriculture, engineering, etc. (Helland and Kastenholz, 2008). Nanotechnology is expected to be the dominant general purpose technology of the next decades. Its market potential is immense and not only supply-side but especially demand-side arguments will have far reaching consequences for nanotechnology innovations (Ott et al., 2009). Nanotechnology has a wide range of practical applications, from wine making (Tkac et al, 2007), to its impact on emissions in paper industry (Puurunen and Vasara, 2006) to providing clean water (Street et al., 2009). Nanotechnology is on a similar trajectory to biotechnology, stemming also from basic science breakthroughs (Zucker and Darby, 2005).

The incorporation of nanotechnology applications in the food industry is mainly designed to improve the quality, texture, taste, flavor, odor, consistency, and nutritional value of the food products. For example, by means of nanoscale additives, food nutrition and ingredients such as minerals and vitamins can be enhanced, and hence offer a healthier option to the consumer (Duncan, 2011; Sekhon, 2010).

Over the coming years, social scientists in a variety of fields will continue to employ a diversity of research methods and analytical theories to chart and understand the growing significance of nanotechnology for modern civilization. Many studies have sought the consumer's public opinion and awareness about this newly introduced technology, since analyzing public opinion could play a vital role in the process of the development of nanotechnology (Hallman et al., 2003; Boyce, 2009; Busch, 2008; Ronteltap et al., 2007, Matin et al., 2012).

2.2 Genomics

Genomics is the study of genes and genetic characteristics of organisms such as humans and animals. Genomics is defined as the science that studies the structure and function of genomes and, in particular, genes. Genomics envisions the complete study of the hereditary material of living beings (Lexicon EncycloBio, 2006). Genomic technologies have changed the face of food research (Rist et al., 2006). Genome-food interactions are the paradigm for the interplay between the genome and its environment. Nutrition and food science are stepping into the genomics era, and it is becoming evident that nutrients and other food components are key factors in altering gene transcription, protein levels and functions (Rist et. al., 2006).

The advantage of genomic selection over traditional selection is that animals can be selected accurately early in life, based on their genomic predictions, and for traits that are difficult or expensive to measure; fertility, disease resistance, methane emissions, and feed conversion are prime examples (Hayes et al., 2012; Meuwissen et al., 2001). Modern livestock production uses expensive inputs, such as grain. Both the competition for grain (for human consumption and bio-fuels) and the impact of climate change on grain production are likely to continue to drive grain prices higher (Godfray et al., 2010). These economic factors may change livestock production systems and, consequently, the desired genetic attributes (Hayes et al., 2012).

The wealth of genomic information in pigs in particular, can allow the identification of specific genes which could be linked to disease resistance. There are two current major infectious diseases in pigs: PRRS (Porcine Reproductive and Respiratory Syndrome), and PCVAD (Porcine Circovirus Associated Disease). Selecting pigs with resistance to these diseases could be helpful for animal and producer welfare.

PRRS

Porcine reproductive and respiratory syndrome (PRRS) emerged as a widespread reproductive and respiratory disease of swine in the late 1980s in the USA, and in 1990 in Europe and since then the disease has spread widely throughout many pig-producing countries (Murtaugh & Genzow, 2011; Albina, 1997; Zimmerman et al., 2006). PRRS has caused devastating losses to swine herds in North America and Europe since the early 1990s, and is characterized by

reproduction failure in pregnant sows and respiratory distress in piglets and growing pigs. The clinical signs of PRRS have been linked to reproductive outbreak such as reductions in forrowing rates, increased numbers of stillbirths, abnormal abortion storms, mummy, preweaning mortality in sows and death in pigs (Zhang et al., 2012; Holtkamp et al., 2010). Since its emergence, PRRS continues to impose a significant and tremendous economic burden on the swine industry worldwide affecting all stages of production (Beilage et al., 2009; Dewey et al., 1999; Neumann et al., 2005; Zhang et al., 2012). In the United States, the economic impact of PRRS to swine producers has been estimated to be approximately $560 million in losses per year (Neumann et al., 2005).

PCVAD

Porcine circovirus-associated disease (PCVAD) was first described in the early 1990s and has since emerged as an economically important disease worldwide (Allan & Ellis, 2000). PCVAD is associated with weight loss or decreased rate of weight gain, wasting, increased mortality, diarrhea, respiratory distress, dermatitis, enteritis, reproductive failure, paleness or jaundice and a failure to grow in pigs (Opriessnig et al., 2007; Gillespie et al., 2009). PCVAD can affect a varying percentage of a population (1-50%) (Opriessnig et al., 2009). And eventually due to the contagiousness of this disease all the pigs affected must be destroyed. PCVAD has caused devastating losses on affected pig farms and is arguably among the most economically significant disease facing the global swine industry today (Cecere et al., 2012; Lyoo et al., 2011; Opriessnig et al., 2007; Ramamoorthy and Meng, 2009; Segales et al., 2005).

Economic Impact

Despite vaccination efforts to combat these diseases, PRRS and PCVAD continue to pose a major threat to the swine industry worldwide, and they are both considered to be economically important infectious diseases affecting this industry on a global basis (Segales et al., 2005; Zhao et al., 2012). The costs of these diseases are very high, and they both cause the farmer losses from pig herd productivity declines. It is believed that the use of genomic information for enhancing resistance to these diseases can help farmers to increase their welfare, if the disease spread can be reduced in a herd.

3. Data

Two national online surveys (in 2010 for nanotechnology and in 2012 for genomic information) were conducted across Canada to elicit Canadian consumers' WTP for juice produced by nanotechnology or pork chops that are produced from pigs bred using genomic information. In each case panelists maintained by a market research company were recruited for the respective surveys.

Table 1 provides the summary statistics for survey respondents. The majority of respondents (54% in nanotechnology survey, and 60% in genomic survey) have never heard about these two novel food technologies. In both surveys, Canadian consumers exhibited a high level of agreement that science benefits society (mean response of 6.3 and 7.2 in nanotechnology and genomics surveys, respectively (on a 1-10 scale)), Both samples consists of respondents ranging from 15 to 65 plus (average age is 48-49), with a mean level of education of 14 years (equivalent to having completed college). The majority of respondents (around 80%) live in urban areas (cities and towns). A general trust variable, derived from the General Social Survey used in Canada and the United States exhibits results similar to other national surveys (Statistics Canada, 2008) (Generally speaking would you say that most people can be trusted? Responses: People can be trusted; you can't be too careful in dealing with people; don't know) with around 40% of respondents believe that 'other people can be trusted'.

[Table 1]

3.1 Descriptive Analysis

In both surveys most respondents are very to somewhat confident (88% in nanotechnology survey and 90% in the genomics survey) that the food they purchase is not harmful for them. Figure 1 represents the net agreement percentage regarding trust in Canadian institutions in the food domain. In both nanotechnology and genomic surveys, the net percentage agreement analysis indicates that the majority of Canadian consumers trust farmers most, regarding their responsibilities in the food domain in Canada, and the pharmaceutical industry, the least. The net concerned percentage analysis results (Figure 2) in both surveys, also imply that majority of

Canadian consumers (55%) are least concerned about vitamins and mineral food supplements and foods enriched with vitamins/minerals as compared to other food issues. However, the respondents were extremely concerned about foods grown or treated with pesticides and other chemicals, meat or fish with hormone/antibiotic residues, preservatives or artificial coloring, respectively. Only 25% of the Canadian respondents had concerns over genetically modified food (GMOs), foods made with ingredients that are produced by nanotechnology, or foods packaged in containers produced by nanotechnology. Figure 3 indicates that majority of Canadians agree that for serious animal diseases, farmers are required to vaccinate. Also Canadian consumers believe that there is a good reason for vaccinating certain animals.

[Figure 1]

[Figure 2]

[Figure 3]

4. Methodology

4.1 Questionnaire

In this study, we used contingent valuation (CV) methods to measure Canadian respondents' WTP. Respondents in the CV approach are given a scenario describing a proposed novel food technology option that would alter the quality of the goods of interest, in a binary choice setting. They are then asked to choose the product at particular prices aimed at eliciting their maximum willingness to pay (WTP) (How much they are willing to pay for the cost of the quality change) in dollar amount to secure the discussed innovation. Hanemann et al. (1991), introduced double-bounded CV questions, and showed that there would be an improvement in the statistical efficiency of the estimates over single bounded questions. The double-bounded CV question has a follow-up question which is dependent on the response to the initial WTP amount being offered. If the response to the initial amount is positive, then the follow-up WTP is greater than the initial one, but if the response to the initial amount is negative, the follow-up amount would be less (Alberini et al., 1997). Table 2 and Table 3 show the WTP questions in the nanotechnology and genomics survey, respectively.

[Table 2]

[Table 3]

In the nanotechnology survey, two orange juice price levels of $1.75 and $2.5 per litre, have been chosen. Respondents were randomly given the lower or upper price. If their answer to the first price was positive/negative, then they would receive higher/lower amount in the follow-up question. There is the maybe option in the nanotechnology survey which is considered as "no" option in the analysis. There are two sets of questions in each survey – in the first the respondent is asked to choose a product with higher functionality (higher vitamin content juice) and in the second set they are asked to choose a product with higher functionality, produced by means of the nanotechnology method. In the first set of WTP questions in the nanotechnology survey, respondents are not given any information about the method of increasing vitamins, however, before they were given the second WTP set of questions, the respondents were provided with a short note of information about nanotechnology, as shown below:

"Nanotechnology refers to materials, systems and processes which exist or operate in the range of about 1 to 100 nanometers (nm). One nanometer (nm) is one millionth of a millimeter (mm). Materials at this scale show novel properties that lead to novel applications in diverse fields such as medicine, cosmetics, biotechnology, energy production and environmental science. There is uncertainty regarding how nanomaterials may interact with human health and the environment.
Nanotechnology offers new opportunities for food industry application. Manufactured nanomaterials are already used in some food products, nutritional supplements, and food packaging applications. Nanotechnology allows for the improvement of barrier functions in food packaging to reduce UV-light exposure or microbial growth and thus extend the shelf-life of many food-products. Furthermore, nano-biosensors are able to control the food's level of freshness by indicating spoiled food to the consumers by means of colour change. There is not much known about the effects on Human health and environment."

For the genomics survey, two levels of pork chop prices ($4.37 and $8.74 per Kg) were also selected first, and based on the initial response, the respondents were asked if they wanted the product at the other (higher or lower as appropriate) price level. The respondents were provided with a brief explanation about PCVAD, and PRRS diseases in pork, and their economic costs. Then they were given the first set of WTP questions. The first set of questions asked respondents to choose between basic pork chop and pork chop with lower disease susceptibility. In the second set of questions both pork chops have reduced disease susceptibility produced with

different methods - vaccination or genomic selection. Before the second set of WTP questions, there was brief information about genomics, and its application as below:

"Genomics is the study of the genes and genetic characteristics of organisms like plants, animals, and humans. The study of genomics in pigs can allow for the identification of specific genes that are linked to disease susceptibility. With knowledge of the presence (absence) of these genes, selective breeding can produce pigs with significantly lower probabilities of contracting PCVAD or PRRS. PCVAD and PRRS are both diseases that are spreading rapidly throughout the world. Traditional breeding techniques have not proven successful in enhancing disease resistance in the pigs. Treatments for the diseases, PCVAD and PRRS, currently include vaccination of the pigs."

5. Results:

We used two national surveys (in 2010, and 2012) to elicit Canadian consumers' preference for food produced with novel technologies (in our case, juice produces by nanotechnology, and pork chops by pigs bred using genomics applications). We ran logistic regressions to determine the probability of selecting with product with the functionality and with the product with functionality produced with the novel technology, from which population willingness to pay can be generated. Table 4 represents the regression analyses, which show some consistency across technologies in terms of the significance and signs of variables.

[Table 4]

The regressions indicate that females have more negative views towards Vitamin D fortified juice produced by nanotechnology, and males have more positive views towards use of genomics application in pigs in order to prevent PCVAD, and PRRS diseases. Also people who believe other people cannot be trusted are more in disagreement with both of these novel technologies. People who have a lower level of education are more suspicious about the nanotechnology juice, and the genomic application. People in Quebec seem to have positive views towards use of genomic applications over vaccination against PCVAD/PRRS, however no regional significance is observed in juice produced by means of nanotechnology. People in rural areas prefer to consume pork chops that have a lower possibility of having PCVAD, or PRRS. Those people who have some knowledge about novel technologies prior to the survey, and believe that science and technology will make our lives better off have positive views towards the nanotech produced juice. The WTP dollar amount is reported in Table 5. In the pork survey, the consumers are

willing to pay a premium of $1.3 over the e price of a pork chop without any information on disease susceptibility to have pork chops that are less susceptible of contracting PCVAD or PRRS. However, in terms of the pork chop with reduced disease susceptibility the preference is for the use of genomics over vaccination to achieve that reduction. In the nanotechnology survey, Canadian consumers discount the fortified juice produced by nanotechnology by around 20 cents per litre although they prefer the fortified juice.

[Table 5]

6. Conclusions

Two national surveys provided Canadian consumers with two sets of dichotomous choices to determine their willingness to pay for new technologies in particular food applications (nanotechnology and genomics). The willingness to pay for food produced with each novel technology was estimated. The preliminary analysis shows that the majority of Canadians have little knowledge about use of genomic information or nanotechnology; however they depict different behavior across these two product categories. In the nanotechnology study, they discount the juice produced by nanotechnology over fortified Vitamin D juice without information on the method of fortification, however in the pork survey they discounted vaccinated pork chops by a greater amount than pork chops produced by genomic applications. The design of the two contingent valuation set ups, were different and the results are reflective of these design differences. However the results suggest in each case some concern about the use of these technologies even though the functional attributes of the food products are preferred by the consumers.

References:

-Alberini, A., Kanninen, B., Carson, R.T. (1997) .Modeling response incentive effects in dichotomous choice contingent valuation data. *Land Economics*. **73** (3), 309-324.

-Albina,E. (1997) Epidemiology of porcine reproductive and respiratory syndrome (PRRS): An overview. *Veterinary Microbiology*, **55**, 309-316.

-Allan, G.M., Ellis, J.A. (2000) Porcine circoviruses: a review. *Journal of Veterinary Diagnostic Investigation*, **12**, 3-14.

-Baker, G.,Mazzocco,A.M. (2002). *Consumer response to GMO foods: branding versus government certification. Annual Meeting of Western Education\Extension and Research Activities Committee on Agribusiness*, Las Vegas, Nevada, June 23-25.

-Beilage, E.G., Nathues,H., Meemken,D., Harder,T.C., Doherr, M.G., Grotha,I., Greiser-Wilk,I. (2009) Frequency of PRRS live vaccine virus (European and North American genotype) in vaccinated and non-vaccinated pigs submitted for respiratory tract diagnostics in North-Western Germany. *Preventive Veterinary Medicine*, **92**, 31-37.

-Besley J.C.,Kramer,V.L., and Susanna H. Priest (2008). Expert opinion on nanotechnology: risks, benefits, and regulation. *Journal of Nanoparticle Research*, **10**(4): 549-558.

-Bouwmeester, H., Dekkers, S., Noordam, M.Y., Hagens, W.I., Bulder, A.S., de Heer, C., ten Voorde, S.E., Wijnhoven, S.W., Marvin, H.J. & Sips, A.J. (2009) Review of health safety aspects of nanotechnologies in food production. *Regulatory Toxicology and Pharmacology*, **53**, 52-62.

-Boyce, B. (2009). Knowing nanotech is knowing the future of food and nutrition. *Journal of the American Dietetic Association*, **109**(8):1332-1335.

-Busch L. (2008). Nanotechnologies, food, and agriculture: Next big thing or flash in the pan?. *Journal of Agriculture and Human Values*, **25** (2): 215–218.

-Cecere ,T.E.,Meng , X.J., Pelzer,K., Todd ,S.M., Beach ,N.M., Ni ,Y.Y., LeRoith ,T. (2012) Co-infection of porcine dendritic cells with porcine circovirus type 2a (PCV2a) and genotype II porcine reproductive and respiratory syndrome virus (PRRSV) induces CD4+CD25+FoxP3+ T cells in vitro. *Veterinary Microbiology*, **160**, 233-239.

-Chen, H., Weiss, J., & Shahidi, F. (2006). Nanotechnology in nutraceuticals and functional foods. *Food Technology*, **3**, 30-36.

-Cooper, J.C., Hanemann, M., Signorello, G.(2002) One-and-One-Half-Bound dichotomous choice contingent valuation. *The Review of Economics and Statistics*, **84**(4), 742-750.

-Dewey, C.E., Wilson, S., Buck, P., Leyenaar, JA.,K. (1999) The reproductive performance of sows after PRRS vaccination depends on stage of gestation. *Preventive Veterinary Medicine*, **40**, 233-241

-Duncan, T.V. (2011) Applications of nanotechnology in food packaging and food safety: Barrier materials, antimicrobials and sensors. *Journal of Colloid and Interface Science*, **363**(1), 1-24.

-Dunkley, R.W.S. (2004) Nanotechnology: social consequences and future implications. *Futures*, **36**, 1129-1132.

-Godfray, H.C.J. et al. (2010) Food security: the challenge of feeding 9 billion people. *Science*, **327**, 812-818.

-Gillespie, J., Juhan, N.M., DiCristina, J. Key, K.F., Ramamoorthy, S., Meng, X.J. (2008) A genetically engineered chimeric vaccine against porcine circovirus type 2 (PCV2) is genetically stable in vitro and in vivo. *Vaccine*, **26**, 4231-4236.

-Hallman, W.K., Aquino,H.A. (2003). *Consumer perceptions of genetically modified food. Agricultural and Applied Economics Association Annual Meeting*, Montreal, Canada, July 27-30. [http://ageconsearch.umn.edu/bitstream/22058/1/sp03ha05.pdf]

-Hanemann,W.M., Loomis, J., Kanninen, B.(1991) Statistical efficiency of double bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics*, **73**, 1255–1263.

-Hayes, B.J., Lewin, H.A., Goddard, M.E. (2012) The future of livestock breeding: genomic selection for efficiency, reduced emissions intensity, and adaptation. *Trends in Genetics*, **21**(4), 206-214.

-Helland,A., Hans Kastenholz,H. (2008) Development of nanotechnology in light of sustainability. *Journal of Cleaner Production*, **16** (8-9), 885-888.

-Hobbs, J.E., McDonald, J., and Zhang J.(2011).Consumer acceptance of food authenticity and traceability technologies. *CAEA-WAEA Joint Annual Meeting*, Banff, Alberta.
[http://ageconsearch.umn.edu/bitstream/123881/2/Hobbs_Authenticity%20poster_AAEA2012.pdf]

-Holtkamp, D.J., Yeske, P.E., Polson, D.D., Melody, J.L., Philips, R.C. (2010) A prospective study evaluating duration of swine breeding herd PRRS virus-free status and its relationship with measured risk. *Preventive Veterinary Medicine*, **96**, 186-193.

-Hu, W., Hünnemeyer, A., Veeman, M., Adamowicz, W. & Srivastava, L. (2004) Trading off health, environmental and genetic modification attributes in food. *European Review of Agricultural Economics*, **31**, 389–408.

-Hu, W., Veeman, M., Adamowicz, W. & Gao, G. (2006) Consumers'food choices with voluntary access to genetic modification information. *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie*, **54**, 585–604.

-Larue, B., West, G.E., Gendron, C., & Lambert, R. (2004) Consumer response to functional foods produced by conventional, organic or genetic manipulation. *Agribusiness*, **20**, 155–166.

-Lexicon Encyclo Bio. (2006). Available from http://www.lexicon-biology.com/biology/definition2_57.html [Accessed on March 2013]

-Lusk, Jayson L., Marette, S. (2010). Welfare effects of food labels and bans with alternative willingness to pay measures. *Applied economic perspectives and policy*, **32**(2): 319-337.

-Lyoo ,K.S., Joo,H.S., Caldwell, B., Kim, H.B. , Davies,P.R., Torrison,J. (2011) Comparative efficacy of three commercial PCV2 vaccines in conventionally reared pigs. *The Veterinary Journal*, **189**, 58-62.

-Matin, A., H., Goddard,E., Vandermoere,F., Blanchemanche, S., Bieberstein, A., Marette, S., and Roosen, J.(2012) Do environmental attitudes and food technology neophobia affect perceptions of the benefits of nanotechnology?. *International Journal of Consumer Studies*, **36**, 149-157.

-Meuwissen, T.H. et al. (2001) Prediction of total genetic value using genome-wide dense marker maps. *Genetics*, **157**, 1819-1829.

-Murtaugh, M.P, Genzow,M. (2011) Immunological solutions for treatment and prevention of porcine reproductive and respiratory syndrome (PRRS),*Vaccine*, **29** , 8192- 8204.

-Neumann, E.J., Kliebenstein, J.B., Johnson, C.D., Mabry, J.W., Bush, E.J., Seitzinger, A.H., Green, A.L., Zimmerman, J.J. (2005) Assessment of the economic impact of porcine reproductive and respiratory syndrome on swine production in the United States. *Journal of American Veterinary Medical Association*, **227**, 385-392.

-Onyango, B., Govindasamy, R. & Nayga, R.M. (2004) An application of choice modeling to measure U.S. consumer preferences for genetically modified foods. *American Agricultural Economics Association Annual Meeting.* 1–4 August, Denver, CO.

-Onyango, B., Govindasamy,R., Hallman,W. (2006). U.S. Public awareness and knowledge of and interest in biotechnology: A principal component factor analysis. *Journal of Food Distribution Research*, **37**(01):132-138.

-Opriessnig, T., Meng, X.J., Halbur, P.G. (2007). Porcine circovirus type 2 associated disease: update on current terminology, clinical manifestations, pathogenesis, diagnosis, and intervention strategies. *Journal of Veterinary Diagnostic Investigation*, **19**(6), 591-615.

-Opriessnig T., Gillespie J., Meng XJ, Pelzer K, Buechner-Maxwell V.(2009) Porcine circovirus type 2 and Porcine circovirus-associated disease. *Journal of Veterinary Internal Medicine*, **23**, 1151-63.

-Ott I., Papilloud, Ch., and Zülsdorf, T.(2009) What drives innovation? Causes of and consequences for nanotechnologies. *Kiel Institute for the World Economy*, **7**(1), 5-26.

-Parr, D. (2005). Will nanotechnology make the world a better place?. *Journal of Trends in Biotechnology*, **23**(8):395-398.

-Puurunen, K., and Petri,V.(2007) Opportunities for utilising nanotechnology in reaching near-zero emissions in the paper industry: Approaching zero emissions. *Journal of Cleaner Production*, **15**(13-14), 1287-1294.

-Ramamoorthy, S., Meng, X.J. (2009) Porcine circoviruses: a minuscule yet mammoth paradox. *Animal Health Research Reviews*, **10** (1), 1-20.

-Rist, M. J., Wenzel,U., Daniel, H. (2006) Nutrition and food science go genomic, *Trends in Biotechnology*, **24**(4), 172-178.

-Ronteltap, A., van Trijp, J.C.M., Renes, R.J. & Frewer, L.J. (2007) Consumer acceptance of technology-based food innovations: lessons for the future of nutrigenomics. *Appetite*, **49**, 1–17.

-Segales, J., Allan, G.M., Domingo, M. (2005) Porcine circovirus diseases. *Animal Health Research Reviews*, **6**, 119-142.

-Sekhon, B.C. (2010) Food nanotechnology - an overview, *Nanotechnology Science and Applications*, **3**, 1-15.

-Sheetz, T., Jorge, V.,Pearson,T.D., and Lozano,K. (2005). Nanotechnology: awareness and societal concerns .*Technology in Society*, **27**(3):329-345.

-Smiley, S.E., Hosgood, H. D., Michelson, E.S., Stowe, M.H. (2008) Americans' nanotechnology risk perception: Assessing opinion change. *Journal of Industrial Ecology*, **12**(3), 456-473.

-Tkac, J., Katrlik, J., Szomolanyi, P., and Stredansky, M. (2007) Nanotechnology gets into winemaking. *Nano Today*, **2**(4), 48.

-Turk, V., Kaiser, C. & Schaller, S. (2008) Invisible but tangible? Societal opportunities and risks of nanotechnologies: sustainable nanotechnology development. *Journal of Cleaner Production*, **16**, 1006-1009.

-Waldron,A.M, D., Spencer, and Carl A. Batt. (2006). The current state of public understanding of nanotechnology. *Journal of Nanoparticle research*, **8**, 569-575.

-Zhang,H.B., Wan, X.P., Bai, G.M., Gao, L.F., Chen, C., Zhang, H., Xue-Bing L., Wang, Z., Li, J.L., Gao,R. (2012) Improvement of the immunity of piglets to PRRS vaccine by a porcine IL-4 and IL-6 fusion gene encapsulated in chitosan nanoparticles, *Procedia in Vaccinology*, **6** ,113-124.

-Zhao, Zh., Qin, Y., Lai e, Zh., Peng,L., Cai, X.,Wang,L.,Guo,X., Yang,H. (2012) Microbial ecology of swine farms and PRRS vaccine vaccination strategies, *Veterinary Microbiology*, **155**, 247-256.

-Zimmerman, J., Benfield, D.A., Murtaugh, M.P., Osorio, F., Stevenson, G.W., Tottemorell, M. (2006) Porcine reproductive and respiratory syndrome virus (Porcine Arterivirus). In: Straw, B.E., Zimmerman, J.J., D'Allaire, S., Taylor, D.J. (Eds.), Diseases of Swine, 9th edition. Blackwell Publishing Professional, Ames, pp. 387–417.

-Zucker, L., Darby, M.(2005) Socio-economic impact of nanoscale science: Initial results and nano bank. *National Bureau of Economic Research, Inc.*, Working paper No. 11181.

Table 1: Socio-Demographic Characteristics of Canadian National Survey Respondents

Variable	Definition	Nanotechnology Survey (2010) (N=830)		Pork Survey (2012) (N=1560)	
		Mean	Standard Deviation	Mean	Standard Deviation
Gender	1 if male; 0 if female	0.51	0.50	0.36	0.48
Age	Age in Years	49	14	48	12
Education	Years; 8 if elementary school; 12 if secondary high school;14 if college degree ; 16 if university degree and post graduate	14	1.7	13.8	1.7
Income	Annual household income in $1,000	67.5	32	59.5	30
Child	1 if child under age of 18 living in household; 0 otherwise	0.27	0.44	0.25	0.43
Trust	1 if people can be trusted; 0 otherwise	0.40	0.49	0.45	0.49
Maritimes	1 if resides in Maritimes ; 0 otherwise	0.07	0.25	0.08	0.27
Quebec	1 if resides in Quebec ; 0 otherwise	0.24	0.43	0.25	0.43
Ontario	1 if resides in Ontario ; 0 otherwise	0.38	0.48	0.33	0.47
Manitoba	1 if resides in Manitoba ; 0 otherwise	0.03	0.18	0.05	0.21
Saskatchewan	1 if resides in Saskatchewan ; 0 otherwise	0.02	0.15	0.04	0.18
Alberta	1 if resides in Alberta ; 0 otherwise	0.13	0.33	0.1	0.3
British Columbia	1 if resides in British Columbia ; 0 otherwise	0.13	0.33	0.15	0.35
Urban Areas	1 if resides in a city >100.000 inhabitants/ or 1 if resides in a town > 10.000 inhabitants ;0 otherwise	0.84	0.36	0.8	0.40
Rural	1 if resides in the countryside/rural district;0 otherwise	0.16	0.36	0.2	0.40
Belief in Science and Technology	Scale of agreement from 1 (society is a lot worse off) to 10 (society is a lot better off)	7.2	1.9	6.3	2.1
Extent of knowledge about science and technology developments	Scale of agreement from 1 (you have little knowledge) to 10 (you know a lot)	5.6	2	4.4	2.3
Heard of Nanotechnology *prior to survey*	1 if yes; 0 otherwise	0.46	0.49	-	-
Heard of Genomics *prior to survey*	1 if yes; 0 otherwise	-	-	0.39	0.49

Table 2: WTP questions in nanotechnology survey

Willingness to pay I

In what follows we will present you information about two pure orange juices sold in one litre bottles. On the market, the average price of this type of orange juice varies between $1.75 and $2.50 per litre.

"**Orange juice A**"	**"Orange juice B"**
This orange juice is fortified with vitamin D. According to scientific estimation, many Canadians have vitamin D intakes below recommendations as a result of inadequate intake and inadequate sunlight exposure. (Randomized selection of the price: lower value $1.75 or upper value $2.50) If lower Value Would you buy this product at a price of $1.75 per litre Yes / No IF YES, would you buy the product if it were offered at a price of $2.50 per litre Yes / No	This orange juice is filled in a plastic bottle that is fabricated in a way to reduce the juice's exposure to UV-light. Exposure to UV-light has an adverse effect on important food nutrients like vitamin C. (Randomized selection of the price: lower value $1.75 or upper value $2.50 Would you buy this product at a price of $2.50 per litre. Yes / No IF NO, would you buy the product if it were offered at $1.75 per litre Yes / No

Willingness to pay II

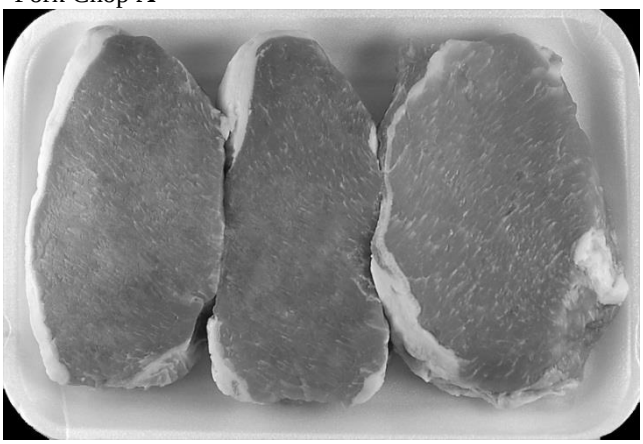
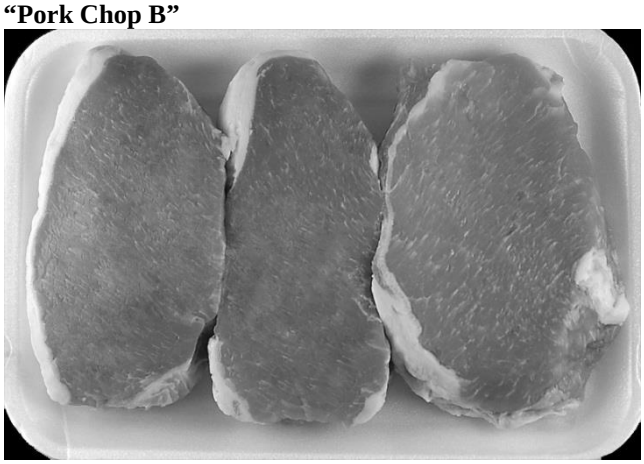
Nanotechnology offers new opportunities for food industry application. Manufactured nanomaterials are already used in some food products, nutritional supplements, and food packaging applications.

"**Orange juice A**"	**"Orange juice B"**
"Orange juice A" is fortified with vitamin D by means of nanotechnology. The vitamin D is enclosed in a nanoscale capsule that allows a better absorption and mobilization of the vitamin. According to scientific estimations, many Canadians have vitamin D intakes below recommendations as a result of inadequate intake and inadequate sunlight exposure. (Randomized selection of the price: lower value $1.75 or upper value $2.50)	"Orange juice B" is produced by means of nanotechnology. The bottle is imbued with nano titanium dioxide particles that reduce UV damage of food nutrients. Exposure to UV-light has an adverse effect on important food nutrients like vitamin C. (Randomized selection of the price: lower value $1.50 or upper value $ 2.50)

Table 3: WTP question in genomics survey

Willingness to Pay I

In what follows we will present you with information about two packages of pork chops, as sold in grocery stores. Currently, the average price of this type of pork chop is $4.37 per kg.

"Pork Chop **A**"	**"Pork Chop B"**
	
This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and are produced with no sub therapeutic use of antibiotics.	This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and are produced with no sub therapeutic use of antibiotics. In addition this hog is raised on a farm where the hogs have a significantly lower probability of contracting PCVAD or PRRS.
(RANDOMIZED SELECTION OF THE PRICE: LOWER VALUE $4.37/KG OR UPPER VALUE $8.74) A. Would you buy this product at a price of $4.37 per kg	(RANDOMIZED SELECTION OF THE PRICE: LOWER VALUE $4.37/KG OR UPPER VALUE $8.74) A. Would you buy this product at a price of $8.74 per kg
Yes / No	Yes / No
B. IF YES, would you buy the product if it were offered at a price of $8.74 per kg	B. IF NO, would you buy the product if it were offered at $4.37 per kg.
Yes / No	Yes / No

Willingness to Pay II

In what follows we will present you with information about two packages of pork chops, as sold in grocery stores. Currently, the average price of this type of pork chop is $4.37 per kg.

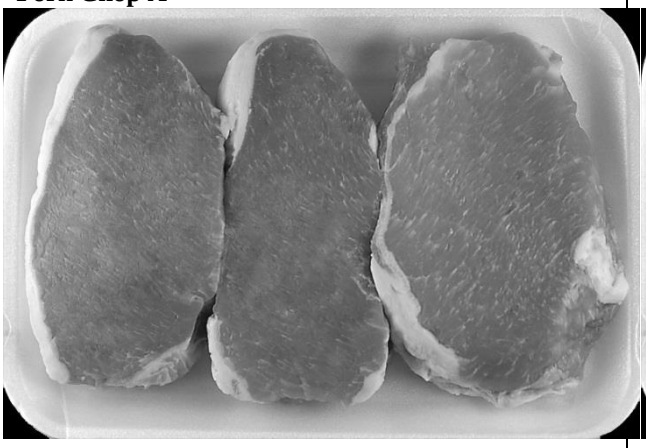
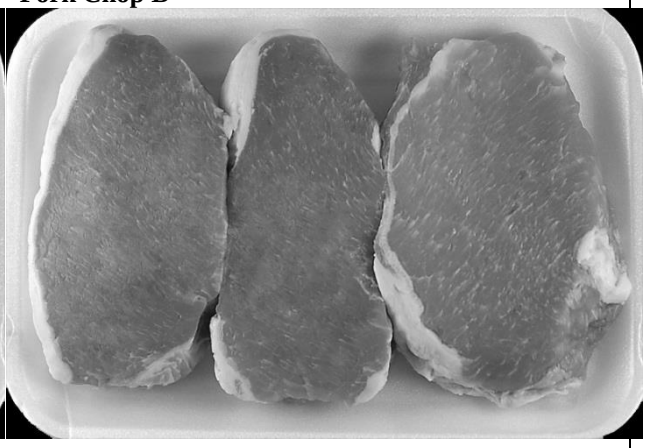
"Pork Chop A"	**"Pork Chop B"**
	
This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as a Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and there was no sub therapeutic use of antibiotics during the animal's life. This pork chop was produced from a pig that was bred using genomic information and is less susceptible to PRRS and PCVAD.	This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as a Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and there was no sub therapeutic use of antibiotics during the animal's life. This pork chop was produced from a pig that has been vaccinated against PCVAD and PRRS.

Table 4: Logistic Estimation of Parameters, Nanotechnology and Pork Survey

Variables	WTP I (Juice I)	WTP II (Juice II)		WTP I (Pork I)	WTP II (Pork II)
			Pork Attribute	1.483*** (0.4804)	0.6674 (0.4556)
Constant	-2.527*** (0.923)	0.198 (0.882)	**Price**	-0.255*** (0.0141)	-0.1023***(0.0118)
Price	2.126*** (0.212)	1.173*** (0.201)	**None**	-1.446** (0.6815)	-0.608 (0.6172)
Gender	0.131 (0.165)	-0.257* (0.159)	**Gender × Pork**	-0.1468* (0.0977)	0.1379* (0.0926)
Age	0.076 (0.061)	0.067 (0.059)	**Gender × None**	-0.3098** (0.1394)	-0.342*** (0.1306)
Trust	-0.274* (0.174)	-0.379** (0.167)	**Age × Pork**	0.0174 (0.0371)	0.0023 (0.0355)
Child	0.034 (0.187)	-0.265 (0.179)	**Age × None**	0.0732 (0.0539)	0.0181 (0.0479)
Education	-0.057 (0.051)	-0.085* (0.049)	**Trust × Pork**	-0.081 (0.0949)	-0.1482* (0.0905)
Quebec	-0.031 (0.281)	0.066 (0.271)	**Trust × None**	-0.207* (0.1339)	-0.2086* (0.1219)
Rural	-0.191 (0.223)	-0.108 (0.217)	**Child × Pork**	-0.134 (0.1114)	0.0799 (0.1078)
Heard of Nanotechnology	0.215 (0.167)	0.005 (0.159)	**Child × None**	-0.1549 (0.1603)	0.0139 (0.1445)
Science & Technology	-0.115*** (0.043)	-0.107*** (0.042)	**Education × Pork**	-0.0051 (0.0289)	-0.072*** (0.0276)
Knowledge	-0.037 (0.044)	-0.067* (0.042)	**Education × None**	-0.0267 (0.0407)	0.0056 (0.038)
			Quebec × Pork	-0.187 (0.1528)	0.3205** (0.1297)
			Quebec × None	-0.3794* (0.2163)	-0.169 (0.1865)
			Rural × Pork	-0.0047 (0.1138)	-0.093 (0.1062)
			Rural × None	0.2436* (0.1521)	0.056 (0.1383)
			Heard of Genomics × Pork	-0.0192 (0.1029)	-0.1135 (0.0977)
			Heard of Genomics × None	-0.1558 (0.1461)	-0.193 (0.1329)
			Science & Technology × Pork	-0.0193 (0.0232)	-0.0093 (0.0221)
			Science & Technology × None	-0.049* (0.0321)	-0.151*** (0.029)
			Knowledge × Pork	-0.0125 (0.0231)	-0.0033 (0.022)
			Knowledge × None	-0.0088 (0.0324)	-0.0351 (0.029)
# of Observations	833	833	**# of Observations**	2934	2864
Log likelihood	-490.69	-517.22	**Log likelihood**	-2502.63	-2631.32
Schwarz B.I.C.	551.21	577.74	**Schwarz B.I.C.**	2634.37	2762.66

Note: 1) Standard Errors are in the parentheses 2) ***, **, *, Significant at 1%, 5%, and 10% level

Table 5: Average Willingness to Pay (*Over the Average Price of Orange Juice and Pork*) **(Logistic Regression Analysis)**

WTP Vitamin D fortified juice	$1.74/1lt***
WTP Vitamin D fortified juice produced by means of nanotechnology	$1.51/1lt***
WTP pork with lower probability of PCVAD/PRRS disease over pork	$5.4/kg***
WTP for vaccinated pork chops over pork chops produced with genomics (both with lower disease susceptibility)	$-3.7/kg**

***, **, *, Significant at 1%, 5%, and 10% level

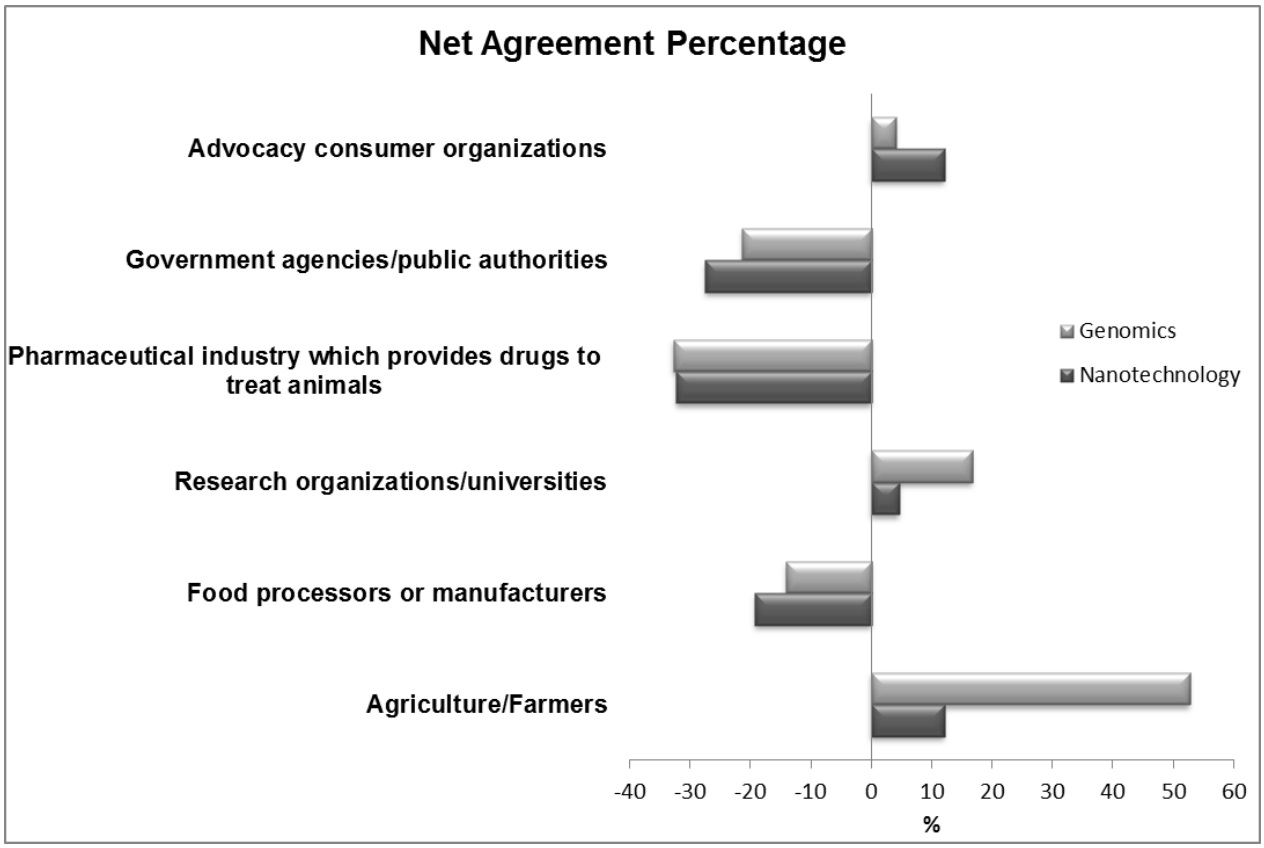


Figure 1: *How much trust do you have in the following groups or institutions regarding their responsibility for food in Canada?* (Net Agreement Percentage)

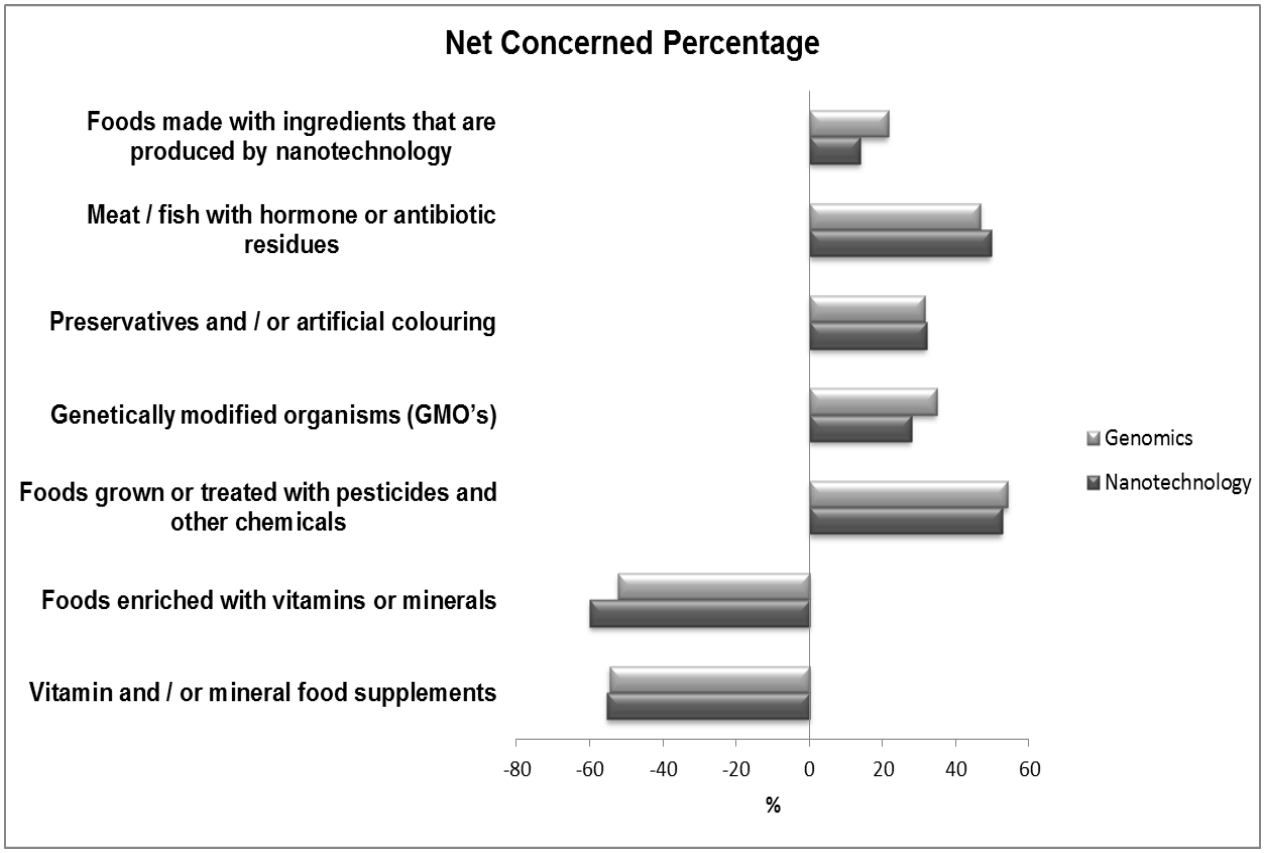


Figure 2: *How do you rate the health risks for consumers of regular consumption of the following?* (Net Concerned Percentage)

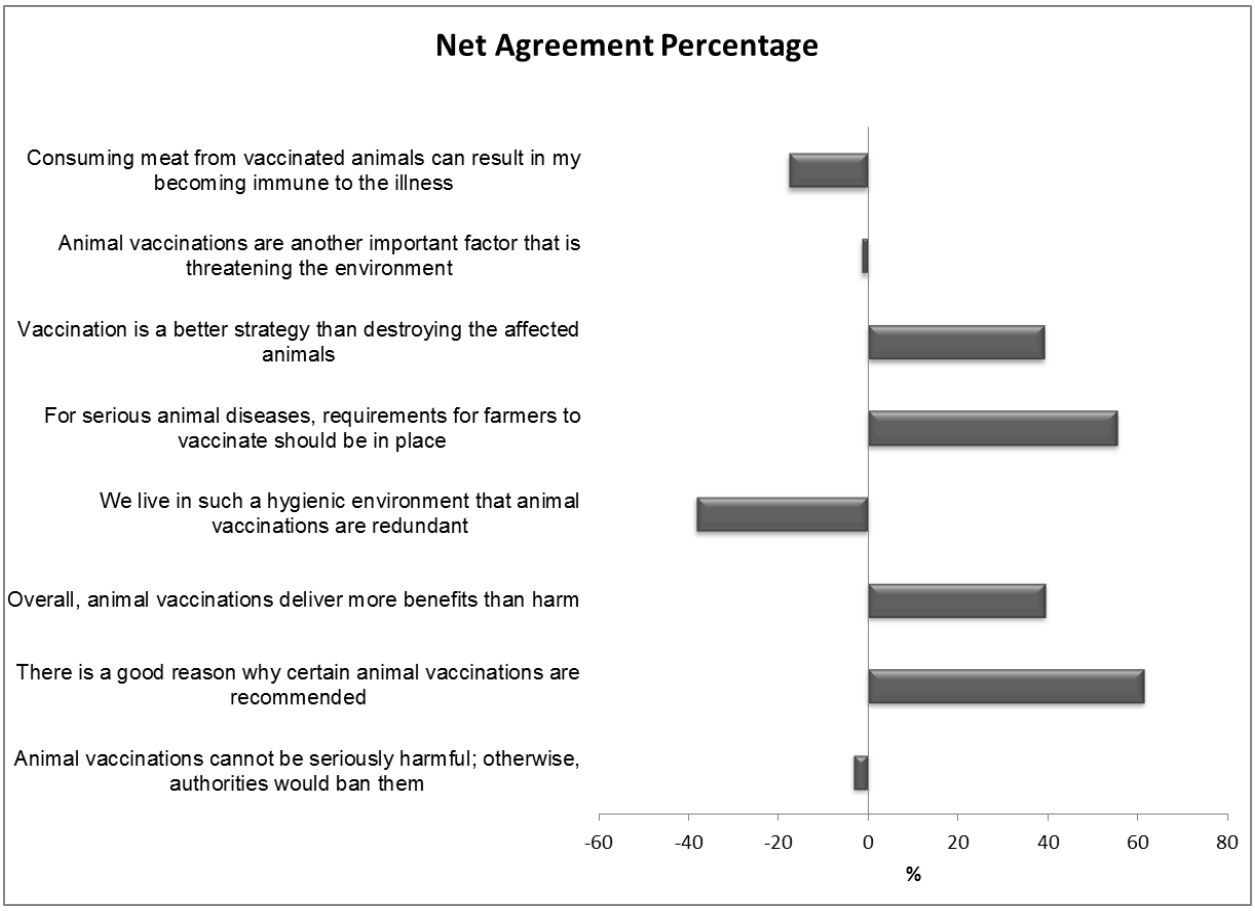


Figure 3: *Animal Vaccination, Genomics Survey, 2012* (Net Agreement Percentage)