Antimicrobial Livestock Mat

AGR 1110-Canadian Agrifood Exports Project

Brianna Cox Section 105

TOPIC

Sanitary processing of Nepalese livestock through use of silver nano-particles technologies in the form of an antimicrobial livestock mat

PART I: Product Information

Scientific Technology

Silver nanoparticles (Ag NPs) are an emerging technology with various applications in imaging, chemical reactions, and solar energy absorption due to its' antimicrobial properties (Choi et al., 2008). The inhibitory properties of Ag NPs are attributed to the negative ions (Ag^-) ability to bind and subsequently enter the positively charged cell wall of the bacteria (Choi et al., 2008). The Ag nanoparticles disrupt the cell's regulatory functions, such as enzymatic activity and membrane permeability ultimately leading to bacterial cell death (Choi et al, 2008).

Research suggests that cotton is an effective material for the incorporation of silver nanotechnology while maintaining antimicrobial effectiveness (El-Shishtawy et al., 2011). The results of a study by El-Shishtawy *et al* finds the addition of 1.7mg of silver nitrate per 0.3 gram of fabric to be sufficient in antimicrobial activities against Candida albicans, Escherichia coli, Bacillus subtilis and most relevant to my product, Staphylococcus aureus (S. *aureus*). In addition, these findings are supported by those found by Amato *et al's* 2011 study-indicating that Ag NPs do provide antimicrobial properties towards S. aureus, a gram-positive bacteria as well as *Escherichia coli* (*E. Coli*), a gram-negative bacteria (Amato et al., 2011). S. *aureus* and *E. Coli* are important targets of the Ag NP technology as they pose a health risk to humans and animals as well as encourage meat spoilage (Amato et al., 2011; Gutierrez et al., 2012; Paulsen, 2011; Borch, Kant-Muermans & Blixt, 1996).

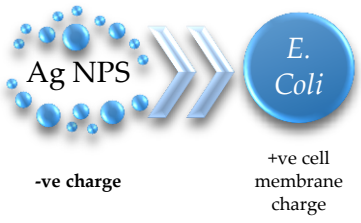

Figure 1: Ag NPs mode of action (Amato *et al*., 2011; Gutierrez *et al*., 2012; Paulsen, 2011; Borch, Kant-Muermans & Blixt, 1996).

Product Description

The antimicrobial livestock mat is a 3-meter by 3-meter reversible mat constituting Ag NP infused cotton for the processing of livestock species common to Nepal. The goal for the livestock slaughter mat is to prevent bacterial contamination and ease transport and storage of the carcass thus maximizing meat yield for the farmers. In comparison to game meat, most evisceration is done at the slaughter site without the use of clean water and proper hygiene tools, which can foster bacterial growth such as S. *aureus* and *E. Coli* (Gutierrez et al., 2012; Liu et al., 2014 and Paulsen, 2011). As such, the Ag NPs within the mat target the bacteria to decrease spoilage not only increasing yields but also decreasing the health risks associated with bacteria (Amato et al., 2011). The mat is water washable with antimicrobial activity expected to exceed the equivalent of 50 North American washings (D. Klein, personal communication, November 12, 2015).

Canadian Company Assessment

Thomsen Research Associates (TRA) is a Canadian biotechnology company responsible for the Silpure Silver Antimicrobial Treatment technology produced under the Ultra-Fresh company name. Based out of Toronto, TRA and the Ultra-Fresh brand takes a global approach and are responsible for a number of technologies being manufactured in more than 40 countries (Ultra-Fresh, 2015). The U.S. Environmental Protection Agency (U.S. EPA) approves TRA technology for use where the manufacturing of these products usually occurs in the United States or the United Kingdom (D. Klein, personal communication, November 12, 2015). Flying products is extremely expensive and because almost all of TRAs products are considered dangerous goods, meaning they are capable of posing a risk to health, property, and safety, they

are shipped by boat to various global Ultra-Fresh warehouses and destinations (D. Klein, personal communication, November 12, 2015 and Internationalshippingusa.com, 2015). Ultra-Fresh warehouses are found in Europe and Singapore; India, China and Taiwan locations are generally used for local market due to high costs of export from these countries (D. Klein, personal communication, November 12, 2015). Consequently, products shipped from Singapore by boat destined for Asia then dock at regional ports to subsequently reach their final destination by truck (D. Klein, personal communication, November 12, 2015. The Toronto location composes 50 employees and due to lack of data, it is estimated that manufacturing and warehouse facilities in the United States and Singapore employ more than 50 employees at each location (Ultra-Fresh, 2015).

Figure 2: Ultra-Fresh Global Locations and contact information (Ultra-Fresh, 2015).

Canadian Livestock Processing versus Nepal

In 2013, Nepal produced 350 thousand tonnes of meat, a meagre amount compared to Canada's production of approximately 4 million tonnes (Faostat3.fao.org, 2015). The need for the an antimicrobial livestock mat is less relevant to Canada then Nepal due to higher standards

of living, however, the technology of Ag NPs is widely used in Canadian products (Ahamed, AlSalhi & Siddiqui, 2010). The nanotechnology industry is reaching many applications in Canada such as water treatment, bio-sensing, medical equipment disinfection and most notably in the treatment of disease (Ahamed, AlSalhi & Siddiqui, 2010).

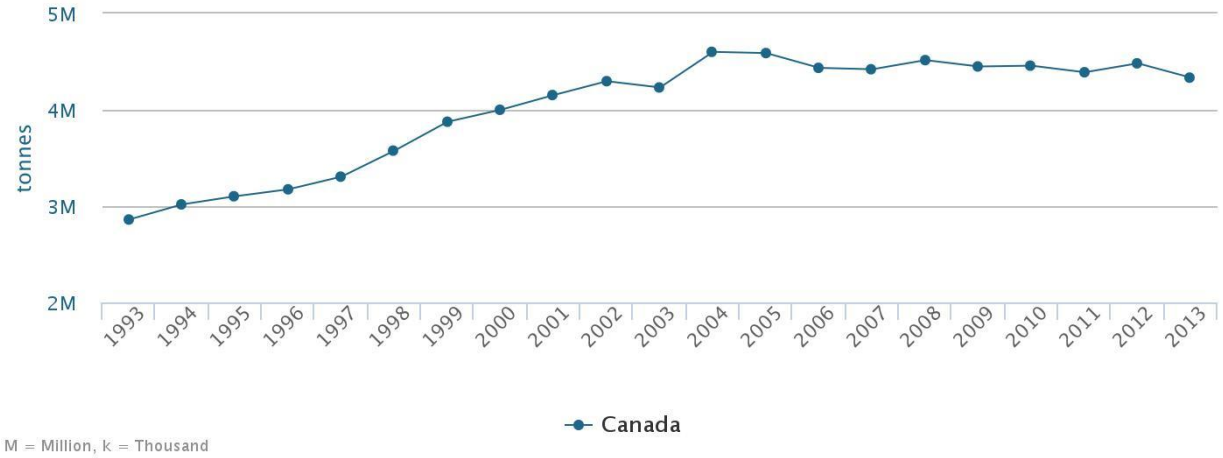

Figure 3: Canadian production of meat, total (Faostat3.fao.org, 2015)

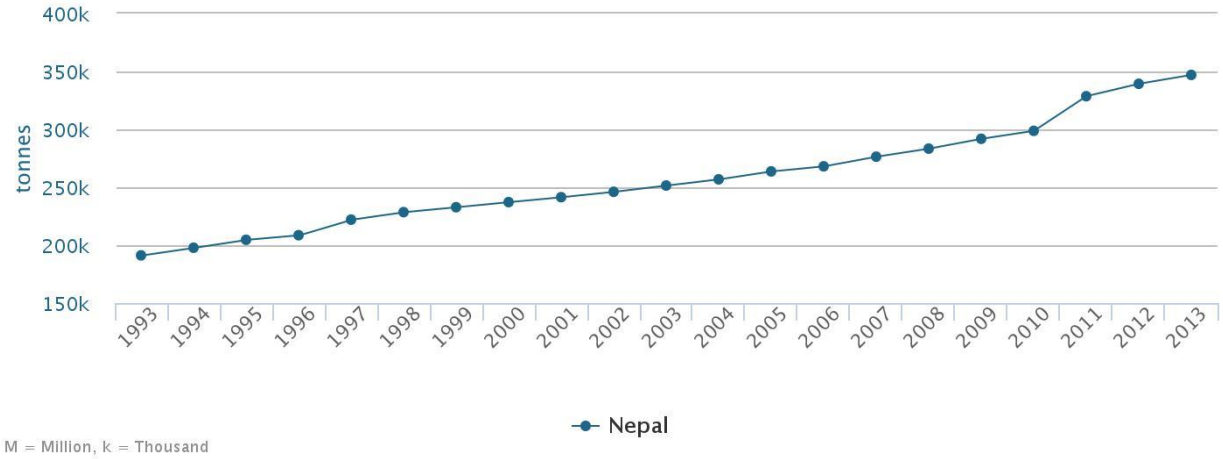

Figure 4: Nepal production of meat, total (Faostat3.fao.org, 2015)

Canadian Production

There are two costs associated with the antimicrobial treatment-the price of the antimicrobial itself and the cost to apply it (D. Klein, personal communication, November 12, 2015).

i. *Production*

Treatment levels are expressed as a percent of the final weight of the material (D. Klein, personal communication, November 12, 2015). For example, cotton fabrics are recommended a 2% owg treatment, which equates to 2% of the final weight of the 3-meter by 3-meter livestock mat (D. Klein, personal communication, November 12, 2015).

ii. *Machinery*

The most common method of applying antimicrobial treatment and textile finishes involves putting the finish into a dip tank solution or water bath where the fabric is the passed through the liquid and subsequently run through a dryer (D. Klein, personal communication, November 12, 2015). Other finishes that may need to be applied in this manner include softeners, water repellents and/or flame retardants, of which requires the manpower and heat, energy or fuel source to run the dryers and associated equipment (D. Klein, personal communication, November 12, 2015). The production procedures of the Silpure technology from the Ultra-fresh is largely unknown, however, this is incorporated into the cost of the antimicrobial (D. Klein, personal communication, November 12, 2015). Procedures likely include lab equipment for the production of the nanoparticles but this cannot be speculated without certainty (D. Klein, personal communication, November 12, 2015).

iii. *Inputs*

As mentioned, the lab method by which the Ag nano-particles are produced is largely unknown. There are many scientific lab methods available in the production of Ag NPS but unknown reputable sources to confirm the technique behind TRA Silpure technology specifically. Inputs associated in the production of silver nanoparticles are presumably reagents

for production of the nano-particles as well as the cost of the cotton material (El-Shishtawy et al., 2011).

3m x 3m 150g/m^2 cotton wt.	**Silpure (Silver, antibacterial)**	**Cost of 1 pair of jeans in Nepal** (Numbeo.com, 2015)
Treatment level (owg)	2%	1790.62 NRs
CAN Cost of Antimicrobial (cents/kg)	$0.90 *[0.67x(150/1000)] x9*	
Estimated CAN Cost of Antimicrobial Application	$1.59 *0.53/linear meter x 3 linear meters*	
Cost of Fabric (Alibaba wholesale)	$16.65 *1.85/ meter x 3^2 mat*	
Combined CAN Total	$19.14	
Nepalese Rupee (NRs) Conversion	$ 1530.46	

Figure 5: Cost of Antimicrobial Livestock with without cost of shipping.
Converted to CAN from US funds (D. Klein, personal communication, November 12, 2015).

Safety Concerns

Almost all of the products manufactured and processed by Ultra Fresh are considered to be dangerous goods (personal communication, November 2, 2015). However, Ultra-fresh products are US Environmental Protection Agency (EPA), Biocidal products regulation (BPD) and Oeko-Tex listed (Ultra-Fresh, 2015). Another concern with this product is the leaching of the Ag NPs into the environment during laundering (Liu et al., 2014). As the textile is washed there is the potential for Ag NPs to enter the environment, water sources as well as the biological systems of human and livestock (Elzey & Grassian, 2009 and Liu et al., 2014). In a study done by Liu *et al*. in 2014, silver nanoparticles are found to remain soluble in aqueous environments,

for example agricultural areas, and result in toxicity in certain varieties of aquatic animal species. Additionally, nanodust is also an area of concern where atmospheric processing can transport and deposit the silver nanoparticles into the atmosphere and surrounding environment (Liu et al., 2014). Conversely, Silpure technology by Ultra-Fresh is described to only release silver ions when bacterial growth exists (Ultra-Fresh, 2015).

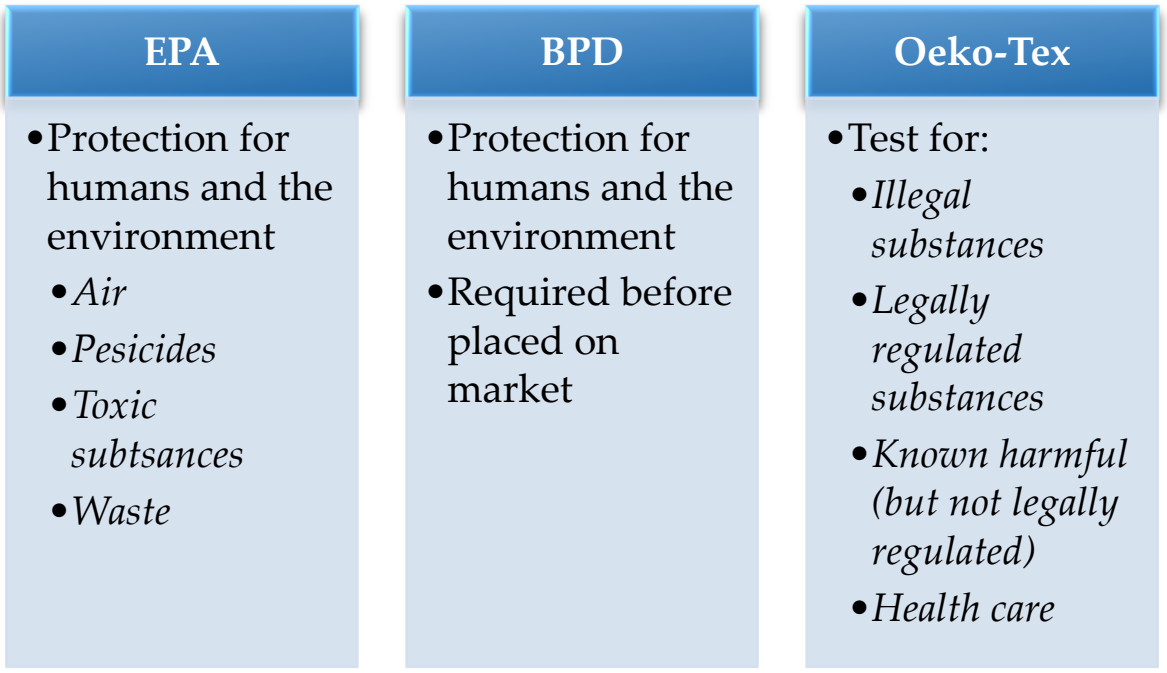

Figure 6: EPA, BPD and Oeko-Tex Approval (Echa.europa.eu, 2015; Oeko-tex.com, 2015 and www2.epa.gov, 2015)

Benefits to Canada

The antimicrobial livestock mat is not currently in production in Canada; therefore the initial start up of production is quite multifaceted and globally involved (D. Klein, personal communication, November 12, 2015 and Ultra-Fresh, 2015). The coordination process at the Toronto Office may only employ a hand-full of individuals, where there is anywhere from 11 to 50 individuals employed at the TRA head office in Toronto, ON at any given time (Ultra-Fresh, 2015). Because the product is being manufactured in the United States, the fabric is not

purchased within Canada nor is the antimicrobial (D. Klein, personal communication, November 12, 2015). Alternately, the revenue from the antimicrobial mat will be returned to the Toronto based company where there is also the potential for further global brand development. If the antimicrobial livestock mat is successful, there is also the potential to expand the applications of the antimicrobial technology within Nepal, Canada and around the globe. Considering Ultra-Fresh is already located across the globe it would be incredibly easy to disperse the livestock mats to developing countries other than Nepal (D. Klein, personal communication, November 12, 2015

As featured on the Ultra-Fresh website, the TRA lab has a wide range of applications for their antimicrobials such as textiles, plastics, foams and flooring (Ultra-Fresh, 2015). To name a few, the antimicrobials can be used in items such as towels, tent fabrics, medical, and carpets where simply changing the fabrics density or size and shape may be beneficial to the Nepalese population and Canada alike (Ultra-Fresh, 2015). An application specific to Canada, is the use of the antimicrobial livestock mat for game hunting to reduce S. *aureus* and *E. Coli* occurrence in the carcass (Gutierrez et al., 2012; Liu et al., 2014 and Paulsen, 2011). Game meat generally contributes a small portion to overall meat and food supply but represents a niche market for those who may be concerned for animal welfare and sustainability or practice hunting as a sport (Paulsen, 2011). Conversely, the use of antimicrobial livestock mat for game hunting may not be practical if the product must be imported to Canada from the Ultra-Fresh manufacturer in the United States.

As the technology wears through washing and use, it will need to be replaced (D. Klein, personal communication, November 12, 2015). The replacement of this product is essential to the functionality of the antimicrobial and represents the need for ongoing production and thus

consistent and predictable revenue for the Canadian company (D. Klein, personal communication, November 12, 2015). Stocking the Singapore warehouse with the Antimicrobial livestock will benefit TRA and Ultra-fresh by cutting down on transport costs (D. Klein, personal communication, November 12, 2015). By consolidating shipments from the United States to Singapore, the company can minimize transport expenses by maximizing container capacity (D. Klein, personal communication, November 12, 2015).

PART II: Export Potential to Nepal

Nepal Agriculture

Nepal is landlocked between China and India and is characterized by its' ethnic diversity and topological regions (Thomas-Slayter & Bhatt, 1994). The three agro-ecological regions, mountains, hills and terai, make up the 147 181 square kilometers of Nepal (Thomas-Slayter & Bhatt, 1994). 80% of the 27 million Nepalese population lives in rural areas outside of urban centers and agriculture accounts for 70% of all employment (Thomas-Slayter & Bhatt, 1994). Considering Nepal is one of the least developed countries in the world, subsistence farming is common practice (Thomas-Slayter & Bhatt, 1994). With 75% of households possessing less than one hectare of land, Nepalese farmers are growing just enough food for to feed themselves and their families (Thomas-Slayter & Bhatt, 1994).

Market Opportunity in Nepal

i. Livestock Agriculture

Subsistence farming is a common practice in Nepal, which relates to an increased likelihood that the farmers will not possess or have specialized tools and procedures to ensure

sanitary slaughter of an animal for meat (Halbrendt et al., 2014). The cooling and transport of the animal is also vital to overall yield where the antimicrobial livestock mat aims to ease and enhance the cooling process while providing a sanitary mode of transportation (Paulsen, 2011). Livestock is incredibly important to subsistence farmers, as these animals function as food, fuel, wealth stores, transport and fertilizer (Fao.org, 2015). As such, market opportunities are present for this relatively low cost intervention to increase livestock animal yields (Fao.org, 2015).

Table 17. Livestock population by ecological zones

Ecological Zones	Cattle	Buffalo	Sheep	Goat
Mountain (16 districts)	867700 (12.46) *	347271 (8.79)	357829 (44.20)	968375 (13.87)
Hills (39 districts)	3285357 (47.16)	2077822 (52.56)	364334 (43.42)	3466271 (49.66)
Terai (20 districts)	2813361 (40.38)	1527561 (38.65)	102024 (12.38)	2545229 (36.47)
Total	6966436 (100)	3952654 (100)	824187 (100)	6979875 (100)

Source :- MOAC (2004)

Figure 7: Livestock populations based by agro-ecological region (Fao.org, 2015)
Note: brackets represent percentage of that species in that region

ii. Subsistence Farming

The antimicrobial livestock mat is designed to accommodate the large size of the buffalo and cow but can otherwise be used for smaller animals such as sheep and goat. By creating a sanitary environment for the processing of livestock, this product aims to decrease bacterial spoilage all while increasing animal yields in terms of meat and byproducts (Paulsen, 2011). By increasing animals' yields due to less spoilage and health risks, farmers can better feed their families and there is the potential for by-products such as hide and skin to enter the market for extra income (Amato et al., 2011). The antimicrobial livestock mat is re-usable and water

washable and thus, not a continuous cost to the farmer (D. Klein, personal communication, November 12, 2015 and Ultra-Fresh, 2015).

iii. Numerical Market in Nepal

Considering livestock is not commercially processed in Nepal, the intended mat to farmer ratio is expected to be 1:1. Being that 75% of households possess less than one hectare of land, the initial marker is targeted at these subsistence farmers as well as those without land holdings as seen in red in **Figure 6** (Cbs.gov.np, 2015, Thomas-Slayter & Bhatt, 1994). However, this information does not take into account the fact that farmers may posses multiple species on their land. This likely leads to an over-estimation of the initial market in Nepal.

Total Area of Holding	**Cattle**	**Yak/Nak/Chauri**	**Buffalo**	**Goat**	**Sheep**
	No. of holdings	No. of holdings	No. of holdings	No. of holdings	No. of holdings
Holding without land	*65,309*	*70*	*34,748*	*61,084*	*1,390*
Holding with land	*2,215,233*	*6,165*	*1,634,072*	*2,291,369*	*94,855*
Under 0.1 ha	107,198	233	58,646	145,746	3,439
0.1 ha and under 0.2 ha	200,980	647	139,741	240,234	8,268
0.2 ha and under 0.5 ha	665,522	2,003	510,115	725,738	28,659
0.5 ha and under 1 ha	679,343	1,982	507,935	671,262	28,770
Total	**1,653,043**	**4, 865**	**1,216,437**	**1,782,980**	**69,136**

Figure 8: Nepal Livestock holdings, adapted from National Sample Census of Agriculture Nepal 2011/12

	Cattle	**Yak/Nak/Chauri**	**Buffalo**	**Goat**	**Sheep**
Total	172,507	303	93,394	206,830	4,829

Figure 9: Livestock holdings targeted for antimicrobial livestock mat, adapted from National Sample Census of Agriculture Nepal 2011/12

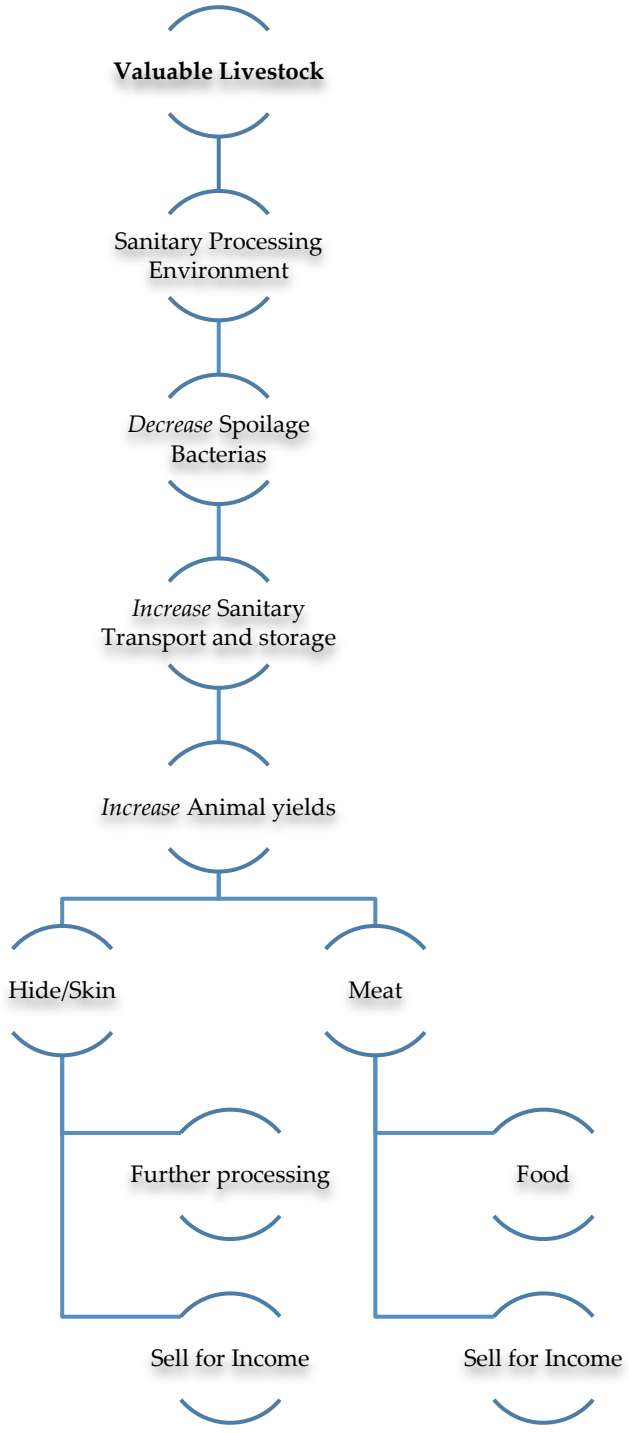

Figure 10: Interpretation of the benefits of the Antimicrobial Livestock mat to Subsistence Farmers (Paulsen, 2011).

Export Logistics

The coordination process beginning in Toronto, ON will then lead to processing of the product in the Ultra-Fresh Manufacturer in the United States (D. Klein, personal communication, November 12, 2015). From the United States, the finished product will make its way by boat to the Singapore Ultra-Fresh Warehouse (D. Klein, personal communication, November 12, 2015).

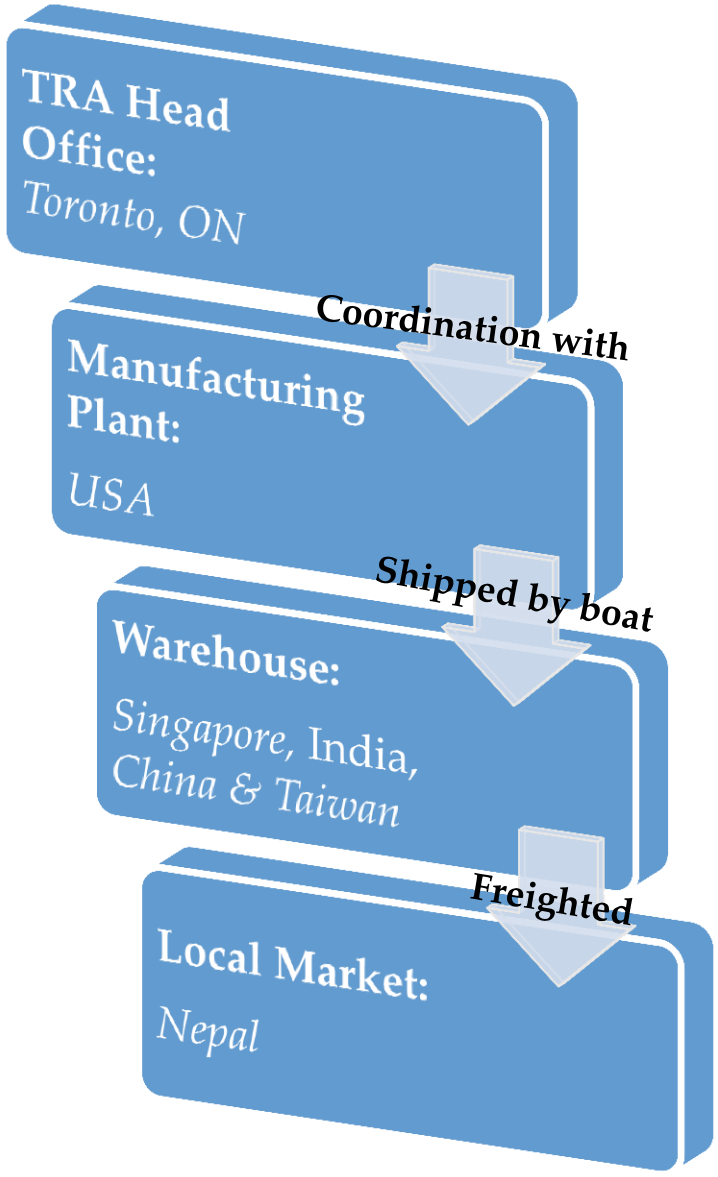

Figure 11: Export Logistics of Antimicrobial Livestock Mat (D. Klein, personal communication, November 12, 2015).

There are currently no local distributers in Nepal and thus the antimicrobial livestock mat will need to be freighted by truck from the Singapore warehouse and into Kathmandu and local markets (D. Klein, personal communication, November 12, 2015). In communication with Dr. Dave Klein, the Vice President of Science and Technology at Ultra-Fresh, the cost of transport is largely unknown. Because Ultra-Fresh is in coordination with their global partners, the cost of transport will vary based on other order receipts, efficiency in consolidating the shipments of other orders and the cost of customs and duties from the importing country of Nepal (D. Klein, personal communication, November 12, 2015). Ultra-Fresh products are not currently being shipped into Nepal but as a reference, shipping to Singapore can induce an increase of 30% in terms of duties and customs to the final cost of the product (D. Klein, personal communication, November 12, 2015). This potentially means that the cost of the livestock mat will become upwards of $24.00 without the inclusion of freight costs into Nepal.

PART III: Unknowns and Recommendations

Unknowns

i. Number of Mats and Cost to Export

The most pressing unknown in the export of the antimicrobial livestock mat is the numerical market value in Nepal. Without knowing the specific number of mats needing imported into Nepal, transport logistics cannot be calculated. As such, the price of the product is an estimation and largely excludes the cost of duties and customs into Nepal as well as the cost of freight from Singapore to Kathmandu. There are numerous regulations to abide to when exporting a product and without a clear number of mats, charges such as customs and duties cannot be calculated.

ii. *Canadian Company Profit*

It is unknown how many employees will be needed for the manufacturing of the antimicrobial livestock mat and as a result, the profit to the Canadian Company is also unknown. Because the manufacturing process is complex, an estimated number of units is needed in order to determine the man-power, energy and material inputs that's are required for the production of the antimicrobial mat.

iii. *Cost of the Antimicrobial Livestock Mat*

The combination of unknowns fosters an overall estimate in the price of the antimicrobial livestock mat. The cost of the cotton material is largely going to depend on the Ultra-Fresh manufactured positioned in the United States and with varying fabric densities it is hard to say that a 150 g/m^2 cotton fabric will withstand the function as a livestock slaughter mat. A heavier density will result in an increase in price for the fabric as well as antimicrobial application, which is also applied according weight (D. Klein, personal communication, November 12, 2015). As mentioned, without knowing shipping units, transportation costs is also unknown and fluctuates cost of the mat an estimated 30% (D. Klein, personal communication, November 12, 2015). This 30% increase ultimately determines the affordability of the mats to Nepalese farmers (D. Klein, personal communication, November 12, 2015).

iv. *Distribution in Nepal*

Another unknown is the distribution of the product once in Nepal. It is determined that there are no Ultra-Fresh distributors in Nepal but whether or not the local market or grocer will carry this product is questionable. Because this is relatively new technology, spreading the word to Nepalese farmers will also be a challenge, especially to nomadic farmers in the hills and mountains of Nepal (Thomas-Slayter & Bhatt, 1994).

Further Research

Further research is needed in the area regarding Ag NPS leaching into the environment. Documents suggest that Ag NPS are toxic to certain aquatic animals but the effect of these particles to indigenous soil, crops, livestock and the human population of Nepal are not currently being studied (Elzey & Grassian, 2009 and Liu *et al*., 2014).

Cost Analysis

The estimated cost of the antimicrobial livestock mat is $1530.46 NRs, or $19.14 CAN. This cost does not include transportation or potential upcharges such as duty upon entry to Nepal. The cost of one mat is roughly compared to the cost of 1 pair of jeans in Nepal (Numbeo.com, 2015). Considering the Silpure technology is estimated to remain active throughout 50 North American launderings, this mat could easily be used throughout 50 animal processing events if cleaned thereafter with water (D. Klein, personal communication, November 12, 2015). Therefore, if one mat is distributed to each farmer the functionality and reusable aspects of the mat is cost effective to Nepali farmers over the lifetime of the product.

Conclusion

In conclusion, there is great potential for the antimicrobial livestock mat to increase livestock meat and by-product yields if introduced to the market of Nepalese subsistence farmers (Amato *et al*., 2011 and Paulsen, 2011). By targeting bacteria with Ag NPS technology Silpure, the antimicrobial livestock mat can reduce the incidence of S. *aureus* and *E. Coli* and thus promote human health and increase carcass and by-product yield as income to Nepali farmers

and families and other developing countries (Gutierrez et al., 2012; Liu et al., 2014 and Paulsen, 2011). However, the market in Nepal needs to be further identified in order to justify the production of this technology in partnership with the Canadian Company Ultra-Fresh by Thomsen Research Associates. The next steps in improving this export idea from Canada to Nepal encompasses the refining of market demand to determine the costs of production, transport and import into Nepal (Amato *et al*., 2011 and Paulsen, 2011). Further research is needed on the environmental impacts of Ag NPs and import regulations into Nepal regarding this technology.

References

Ahamed, M., AlSalhi, M., & Siddiqui, M. (2010). Silver nanoparticle applications and human health. *Clinica Chimica Acta*, *411*(23-24), 1841-1848. http://dx.doi.org/10.1016/j.cca.2010.08.016

Alibaba.com,. (2015). *Wholesale*. Retrieved 12 November 2015, from http://wholesaler.alibaba.com/wholesale/search?fsb=y&IndexArea=forums_en&CatId=&SearchText=100%25+cotton+fabric+by+meter+

Amato, E., Diaz-Fernandez, Y., Taglietti, A., Pallavicini, P., Pasotti, L., & Cucca, L. et al. (2011). Synthesis, Characterization and Antibacterial Activity against Gram Positive and Gram Negative Bacteria of Biomimetically Coated Silver Nanoparticles. *Langmuir*, *27*(15), 9165-9173. http://dx.doi.org/10.1021/la201200r

Borch, E., Kant-Muermans, M., & Blixt, Y. (1996). Bacterial spoilage of meat and cured meat products. *International Journal Of Food Microbiology*, *33*(1), 103-120. http://dx.doi.org/10.1016/0168-1605(96)01135-x

Choi, O., Deng, K., Kim, N., Ross, L., Surampalli, R., & Hu, Z. (2008). The inhibitory effects of silver nanoparticles, silver ions, and silver chloride colloids on microbial growth. *Water Research*, *42*(12), 3066-3074. http://dx.doi.org/10.1016/j.watres.2008.02.021

Cbs.gov.np,. (2015). *National Sample Census of Agriculture Nepal 2011/12 (National Level) | Central Bureau of Statistics*. Retrieved 30 November 2015, from http://cbs.gov.np/sectoral_statistics/agriculture/national_level

El-Shishtawy, R., Asiri, A., Abdelwahed, N., & Al-Otaibi, M. (2010). In situ production of silver nanoparticle on cotton fabric and its antimicrobial evaluation. *Cellulose*, *18*(1), 75-82. http://dx.doi.org/10.1007/s10570-010-9455-1

Elzey, S., & Grassian, V. (2009). Agglomeration, isolation and dissolution of commercially manufactured silver nanoparticles in aqueous environments. *Journal Of Nanoparticle Research*, *12*(5), 1945-1958. http://dx.doi.org/10.1007/s11051-009-9783-y

Fao.org,. (2015). *nepal; country profiles; fao*. Retrieved 30 November 2015, from http://www.fao.org/ag/AGP/AGPC/doc/Counprof/Nepal/nepal.htm#ruminant

Faostat.fao.org,. (2015). *FAOSTAT*. Retrieved 23 October 2015, from http://faostat.fao.org/site/339/default.aspx

Faostat3.fao.org,. (2015). *FAOSTAT*. Retrieved 30 November 2015, from http://faostat3.fao.org/browse/Q/QL/E

Gutierrez, D., Delgado, S., Vazquez-Sanchez, D., Martinez, B., Cabo, M., & Rodriguez, A. et al. (2012). Incidence of Staphylococcus aureus and Analysis of Associated Bacterial

Communities on Food Industry Surfaces. *Applied And Environmental Microbiology*, *78*(24), 8547-8554. http://dx.doi.org/10.1128/aem.02045-12

Halbrendt, J., Kimura, A., Gray, S., Radovich, T., Reed, B., & Tamang, B. (2014). Implications of Conservation Agriculture for Men's and Women's Workloads Among Marginalized Farmers in the Central Middle Hills of Nepal. *Mountain Research And Development*, *34*(3), 214-222. http://dx.doi.org/10.1659/mrd-journal-d-13-00083.1

Internationalshippingusa.com,. (2015). *Dangerous Goods - International Shipping from the USA*. Retrieved 29 November 2015, from http://internationalshippingusa.com/Shipping_Dangerous_Goods.aspx

Klein, D. (2015, November 12th) Ultra-Fresh. B. Cox, email communication)

Liu, H., Lv, M., Deng, B., Li, J., Yu, M., Huang, Q., & Fan, C. (2014). Laundering durable antibacterial cotton fabrics grafted with pomegranate-shaped polymer wrapped in silver nanoparticle aggregations. *Sci. Rep.*, *4*. http://dx.doi.org/10.1038/srep05920

Numbeo.com,. (2015). *Cost of Living in Kathmandu*. Retrieved 30 November 2015, from http://www.numbeo.com/cost-of-living/city_result.jsp?country=Nepal&city=Kathmandu

Oeko-tex.com,. (2015). *OEKO-TEX® | OEKO-TEX® Standard 100*. Retrieved 30 November 2015, from https://www.oeko-tex.com/en/manufacturers/concept/oeko_tex_standard_100/oeko_tex_standard_100.xhtml

Paulsen, P. (2011). *Game meat hygiene in focus*. Wageningen, the Netherlands: Wageningen Academic Pub.

Textilelearner.blogspot.ca,. (2015). *Determination of GSM (Gram per Square Meter) of Woven and Knitted Fabrics - Textile Learner*. Retrieved 12 November 2015, from http://textilelearner.blogspot.ca/2012/02/determination-of-gsm-gram-per-square.html

Thomas-Slayter, B., & Bhatt, N. (1994). Land, livestock, and livelihoods: Changing dynamics of gender, caste, and ethnicity in a Nepalese Village. *Hum Ecol*, *22*(4), 467-494. http://dx.doi.org/10.1007/bf02169389

Ultra-Fresh,. (2015). *Home - Ultra-Fresh*. Retrieved 29 November 2015, from http://www.ultra-fresh.com

Www2.epa.gov,. (2015). *About EPA | US EPA*. Retrieved 30 November 2015, from http://www2.epa.gov/aboutepa