A Canadian Export Opportunity to Nepal: Aluminum Framing for a Passive Convection Solar Food Dryer

Kerin Hudson
AGR*1110
Monday, November 24, 2014

Kerin Hudson
AGR*1110
Monday, November 24, 2014

Brief Introduction to Nepal

As of 2014, Nepal is both the home of approximately 31 million people and a developing nation neighbouring with China and India to the north and south respectively (CIA, 2014). Approximately 83% of these people live in rural area and so, naturally, agriculture accounts for a significant portion of the Nepalese GDP, 36.8% as of 2013 (CIA, 2014). Nepal is divided into three ecological regions known as the Terai, Hill, and Mountain regions; the region occupied dictates agriculture practiced therein (CIA, 2014). The Mountain region is restricted mainly to grazing livestock as the less favourable climate results in very low plant agriculture yields (Pariyar, 2008). The Hill region is characterized by farming crops like maize, millet, wheat, and mustard on terraced hillsides, while the Terai region is distinguished as the most fertile and productive region with its higher yields of rice, sugar cane, and jute across its vast plains (Pariyar, 2008). Rural dwellers are commonly subsistence farmers and, in 2012, gross national income per capita was $656.2 US (UN, 2014). In addition, there is limited transportation and electrical infrastructure throughout rural areas, limiting access to resources and trade movement between a great portion of the Nepalese population (CIA, 2014). Despite the lack of modernization and infrastructure and prevalence of poverty, there is great potential for the people of Nepal (CIA, 2014).

PART I – Product Information

Product Information/Technology Description

To diversify the Nepalese diet, a passive solar convection dryer to dehydrate meat may be a solution. Aside from the initial capital cost for the unit, to operate a solar food dryer is free, as it harnesses the energy of the Sun to heat and dry its contents (Heinz and Hautzinger 2007). There are a number of models designed all having similar components. The model of choice that

is discussed in the following report is illustrated in Figure 1. The Sun's rays strike the solar collector: a shallow, transparent box inclined towards the Sun, whose bottom is painted black inside and whose end has an inlet for air to enter. The energy from the Sun heats the air inside the solar collector. The solar collector is attached to a transparent cabinet which is filled with 3-5 stacked, netted trays used to hold food. At the top of the cabinet there is a chimney or a ventilator. In combination with the rising, sun-heated air, this outlet creates a low pressure system at the top of the dryer, thus creating a natural, convective current of air that is pulled across the meat in order to dry it. It requires about 48 hours of drying, including nighttime, to dry meat (Heinz and Hautzinger, 2007).

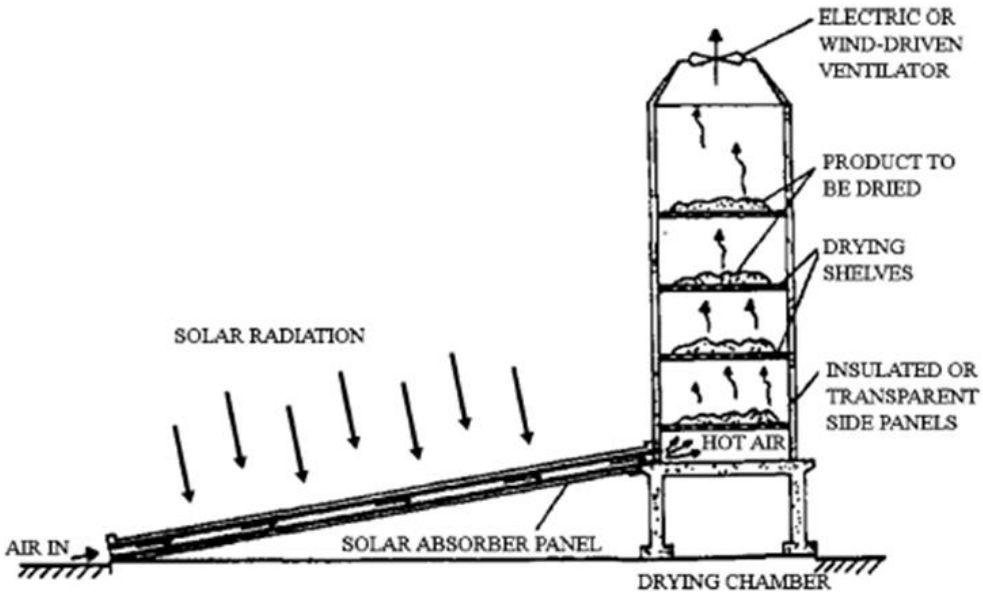

Figure 1: A passive convection solar food dryer. This is the model of choice that is discussed through the remainder of this report. (Figure 4 in Janjai & Bala, 2012). The drying chamber measures about 5 feet tall 3 feet wide by 3 feet deep. The solar collector or solar absorber panel measure about 5 feet long.

Unfortunately, there are no Canadian companies that manufacture entire solar food dryers; however Canada is highly capable of exporting components to build solar food dryers

once in Nepal. Canada has a global reputation of quality metal products and has a history of more than 100 years of aluminum production (AAC, 2012). The framing of a passive convection cabinet solar dryer as illustrated in Figure 2 may be constructed with aluminum, and Canada is highly competent to provide a sound, durable foundation for this technology (Oskam, pers. com., 2014). For example, Oskam Welding & Machine, Inc. located in Guelph, Ontario is just one of many custom sheet metal fabricators capable of manufacturing aluminum framing for a solar food dryer (Oskam, pers. com., 2014).

Market opportunity

According to Dr. Raja Khanal, the Nepalese diet is characterized by what is in season and by limited meat consumption, usually only on special occasions (R. Khanal, personal communication, October 3, 2014). As a result, many Nepalese are chronically low in protein consumption and suffer from several micronutrient deficiencies, like iron, especially among women (Parajuli et al. 2012; Christian et al. 2006). Canadian exporters may seek to explore other countries with similar nutritional deficits and find more export opportunities in other developing countries in addition to Nepal.

In providing an electricity-free method of preservation, this technology can benefit the Nepalese diet by introducing more meat, a quality and nutrient-rich product, to enjoy year-round. Also, solar drying is a highly versatile technology as it may be used to dry fruits, vegetables, spices, herbs, and grain crops, allowing the Nepalese to have access to a variety of foods, regardless of the season (Janjai & Bala, 2012).

Any patent/intellectual property constraints

After searching the Canadian Patents Database, nearly all food dehydrators were electrically powered (CIPO, 2014). One application (CA 2173509) submitted by a Canadian, Gerry Manus,

was filed May 1996 and opened to public inspection November 1997 for his "Quatizing Photon Dehydrator": "a new kind of solar powered food dehydrator". Of the food dehydrators listed in the database, this was the only found to operate solely on the energy radiating from the Sun (CIPO, 2014).

Benefits to Canada

Evidently, in supporting and stimulating the Canadian economy, jobs would be created. In creating a higher demand for aluminum products, like aluminum framing for solar food dryers, more jobs will be created at all levels of the production system: fabrication to management, mining to design, and distribution to extension. In further developing the Canadian metal fabrication industry and a stronger trade relationship with Nepal, other countries with similar needs as Nepal may seek to import Canadian aluminum products, further building the Canadian aluminum industry and creating more jobs for Canadians. The majority of Canadian products currently exported to Nepal are mainly aerospace parts, machineries and appliances, papers, optical instruments, and vegetables (Government of Canada, 2013).

Environmental sustainability in manufacturing in Canada

Although there is vast potential for the Canadian aluminum industry, there are a number of environmental impacts surrounding bauxite extraction and aluminum smelting (Hydro, 2012). Bauxite, the main raw material for primary aluminum production, is for the most part extracted from surface mines. Because of this, large land areas are disturbed, destroying habitat of many living organisms. Furthermore, many bauxite deposits contain clay, which is washed from the bauxite and deposited in tailing ponds. Waste disposal as well as erosion and run-off from the mines can pose negative environmental effects on surrounding biodiversity (Hydro, 2012).

After the extraction, the bauxite is transported to refineries where bauxite residues are removed and alumina is produced (Hydro, 2012). Typically two to four tonnes of bauxite are required for every one tonne of alumina. Disposal of the bauxite residue, also known as red mud, poses a challenging obstacle – there is a great volume of it and both the red mud and run-off water are alkaline. In the past, industry would store red mud as a slurry in lagoons or dispose of the red mud in the ocean. Now, storage is changing direction and moving to dry stacking, which is essentially piling up the residue in large heaps (Hydro, 2012).

In the primary metal production phase, there are another number of environmental issues (Hydro, 2012). Aluminum smelting is largely completed using hydroelectric power, and secondly using coal, so evidently disturbance of aquatic and shoreline habitat as well as greenhouse gas emissions are of concern. Also, emissions of fluoride, SO_2, dust, and PAH, a carcinogenic group of tar compounds, are another risk associated with aluminum production (Hydro, 2012).

PART II: Export Potential to Nepal

Marketing strategy

As mentioned earlier, solar food dryers are a versatile technology. “Buffalo or yak jerky” may be sold as a high-protein, high-calorie snack to European mountain trekkers (Raizada, pers. com., 2014). The Nepalese may season it as they please and could develop a popular North American snack into a more exotic and cultural experience. The solar food dryer can also be used to dry fruits, vegetables, spices, herbs, and grain crops in an attempt to reduce post-harvest waste and shipping weights for larger commercial production systems (Janjai & Bala, 2012).

Kerin Hudson
AGR*1110
Monday, November 24, 2014

Health and nutritional information associated with solar drying

Nepalese meats best-suited for drying are buffalo, goat, and yak; mutton and pork may also be dried however they are less desirable as they have more inter- and intramuscular fat, rendering them more prone to spoilage (Heinz and Hautzinger 2007). Some important health information to consider is food-borne illnesses like *Salmonella* and *E. coli* and their potential for persistence in the meat as it dries. According to Maharjan et al. (2006), of a group of raw meat samples from a market in Kathmandu, 80% showed coliform contamination. In their study, they also found that *Salmonella* was most prevalent from April to May, suggesting that meat should not be dried at this time of year. Prior to dehydration, the United States Department of Agriculture (USDA) (2013) recommends that meat be heated to 160°F and poultry to 165°F in order to rid bacteria. After this priming, they also recommend that the dryer temperature be maintained between 130-140°F in order to prevent bacterial regrowth and spoilage. This is a challenge with a solar dryer, as cloud cover can create some variability in irradiance as the day progresses (USDA, 2013). To be able to safely eat dried meat, longer drying and cooking briefly before consuming or after drying are both found to result in higher bacterial lethality and safer jerky (Dierschke et al., 2010). Additionally, according to Sant et al. (2012), pre-soaking in vinegar and marinating the meat have also been found to reduce pathogenicity as the acid and heat together eliminate any present bacteria. However, the USDA does not recommend that meat be solar dried due to the inconsistency in heat source and its consequent inability to kill germs (USDA, 2013). A possible solution to this could be a thermostat system to maintain the heat within the dryer amid the varying solar energy. This, however, would require access to electricity, which may not be available to all potential customers in Nepal.

Kerin Hudson
AGR*1110
Monday, November 24, 2014

Nepalese weather and its effects on solar drying

Nepal is characterized by dry winters and hot summers with temperatures varying from 2 to 30°C over the course of the year (BBC Weather, 2011). Moreover, the daily number of sunlight hours varies from about 2 to 10 hours, where it is sunnier in October-November and less so in June-July (BBC Weather, 2011). In addition, relative humidity in Nepal generally ranges from 53 to 87%, where it is driest in March-April and most humid from July-September. Relative humidity and sunlight hours are two of the most atmospheric conditions to consider when evaluating solar food dryers (Blair et al., 2005). High heat and low humidity are both essential for the most efficient drying (Blair et al., 2005). The seasonally-variable Nepalese weather conditions pose another obstacle when solar drying food, as more consistent drying conditions lead to more uniform products and to more reliable food supply (USDA, 2013).

Transportation logistics

Nepal's location and economic situation compounds yet another obstacle onto the task of exporting Canadian products. They are a land-locked nation, and so Nepal must have goods imported via sea barge to India and then trucked from India to Nepal; alternatively, they can be flown from Canada to Nepal via cargo plane (CIA, 2014). Once the goods have arrived in Nepal, they must be trucked as far as their road infrastructure can take them and the remainder trekked on dirt paths with draft animals. Figure 2 outlines the steps taken from Guelph, Ontario, Canada, where the framing is fabricated, to Nepal, where the framing will be distributed to manufacturing companies who complete construction of the dryers.

Figure 2: A general outline of logistical steps taken for product to travel from Guelph to Nepal

Canadian companies and Nepalese buyers

As mentioned above, no Canadian companies manufacture entire solar food dryers. However, many Canadian companies are more than capable of manufacturing and exporting components for solar food dryers. For example, Oskam Welding & Machine Inc., located in Guelph, Ontario,

is one of many Canadian custom sheet metal fabricators capable of crafting quality aluminum framing for a solar food dryer (Oskam, pers. com. 2014). Oskam Welding & Machine Inc. currently employs 44 people and has been in the business for 58 years, and therefore has developed a portfolio of quality projects and knowledge. The cost of aluminum framing for the legs, cabinet, trays and solar collector of the solar food dryer is estimated to be $4,600 CAD plus HST, for a grand total of $5,198 CAD (Oskam, pers. comm., 2014).

Regional and global competition

There are a number of neighbouring countries that manufacture entire solar food dryers, toughening the competition for Canadian products (Alibaba.com®, 2014). First is Wuhan HT New Energy Technology Co., Ltd. in Hubei, China: their dryer model is a “mixed-mode dryer”, meaning that in addition to the heat supplied by the Sun, there is an electrically-powered fan to keep the air circulating. Their dryer is also of more of an industrial scale, priced at a competitive price of $360-800 US per unit (Alibaba.com®, 2014). Yet another company from Manila, Philippines known as PMS Trade Center sells their food dryer, model PMSSFD, for $8,250-$8,500 US per unit. Their dryer is equipped with a large biomass stove port as an additional heating source (Alibaba.com®, 2014). Table 1 below shows a brief comparison in price between the Canadian aluminum framing and the competing Asian solar food dryers.

Kerin Hudson
AGR*1110
Monday, November 24, 2014

Table 1: A brief price comparison between Canadian-produced solar food dryer framing and two competitive products within Asian manufacturing markets. Each is price based per one unit. Prices of the Asian products were converted from US to CAD dollars on November 23, 2014. Prices retrieved from personal communication with President Jonathan Oskam of Oskam Welding & Machine, Inc. and Alibaba.com.

Product	Aluminum Framing for Solar Food Dryer	Industrial Food Dehydrator Fruit Dehydrator Solar Machine Tray Dryer	Solar Food Dehydrator
Company	Oskam Welding & Machine Inc.	Wuhan HT New Energy Technology Co. Ltd. (China)	PMS Trade Center (Philippines)
Dimensions	152.4 cm x 91.44 cm x 30.48 cm	200 cm x100 cm x15cm	Irretrievable
Weight	150 lbs.	88 lbs.	Irretrievable
Price	$4,600 + 13% HST **= $5,198 CAD**	**$404.26-$898.35 CAD**	**$9,264.26-$9,544.99 CAD**

Cost analysis to achieve profitability

In my opinion, the current cost of the Canadian aluminum framing, in addition to the cost of shipping as outlined in Table 2, is too expensive for the Nepalese. It is important to note that the Canadian product is *only* the framing of the dryer and not the entire solar food dryer; more components will need to be sourced to complete the model. These include and are not limited to a chimney pipe or ventilator from which humid air escapes, a glass or polycarbonate panel for the top of the solar collector, insulation for the cabinet and solar collector, and trays on which food rests while drying. With these additional components that remain to be sourced, costs continue to accumulate, which leads to the conclusion that, in my opinion, a place for a solar food dryer in Nepal, as depicted in Figure 1, is not realistic.

Table 2: An *estimation* of the approximate transportation costs associated with shipping 25 units of aluminum framing for solar food dryers from Ontario to Nepal. Shipping quotes from trucking

companies in Kathmandu were unable to be retrieved. Remaining prices retrieved directly from the official Purolator and A1 Freight Forwarding webpages.

Guelph, ON → Pearson International Airport, Mississauga, ON	**PUROLATOR:** Base Cost: $2,656.75 Special Handling: $400.00 Multipiece: $1,673.75 Fuel Surcharge: $385.23 GST/HST: $665.04 **TOTAL= $5,780.77 CAD**
Pearson International Airport, Mississauga, ON → Kathmandu, Nepal	**A1 FREIGHT FORWARDING:** 25 units: 152.4 cm x 91.44 cm x 30.48 cm Weight: 75 kg Air Freight Rate: $3.10 CAD/KG ALL IN Actual Weight: 1698.75 kg Volume Weight: 1806.27 kg Chargeable Weight: 18206.27 kg Air Freight: $5,599.43 Terminal & Screening Fee: $406.25 Processing Fee: $75 Export Declaration: $0 Surcharges: $0 **TOTAL= $6,080.68 CAD**
Kathmandu, Nepal → (???????)	**Option 1: NEW YORK CARGO (P) LTD.** for trucking across Nepal **Direct quotes remain to be needed **Telephone**: +977-1-4238317, 4222885 **Cell:** +977-985-1015039, 9801015039 **E-mail:** nyccargo@wlink.com.np; info@cargo.com **Option 2: NEPAL SHIPPING & AIR LOGISTICS PVT. LTD. (NPSAL)** for trucking across Nepal **Direct quotes remain to be needed **Telephone:** +977-1-4784572/ 4785415/ 4781303 **E-mail:** info@nepal.com
GRAND TOTAL (before shipping costs from Kathmandu to final destination)**:**	**= $11,861.45 CAD**

The model discussed in this report is unrealistic, however there are a number of other plausible models that may be more cost-effective. According to the FAO, the cost to build a simple tunnel solar dryer, illustrated in with a solar panel-powered fan is estimated at approximately $1,000 US (Heinz and Hautzinger 2007).

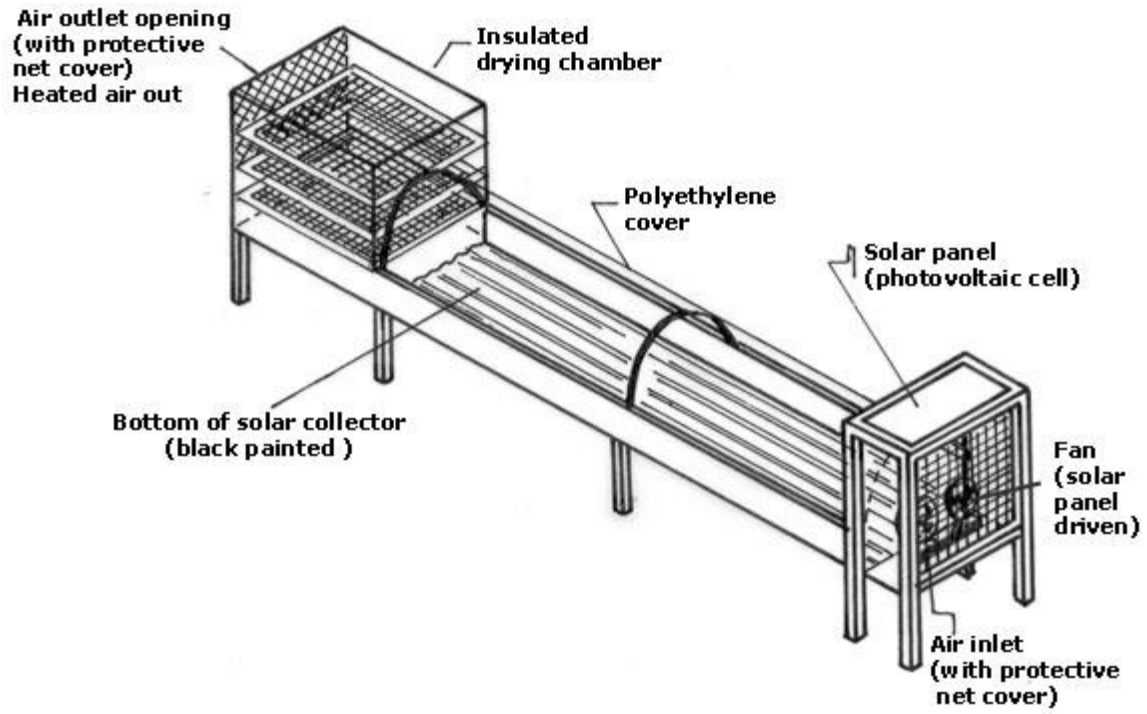

Figure 3: Low-cost simple tunnel dryer. Dimensions are unknown. (Fig. 286 in Heinz & Hautzinger, 2007).

Supplementary funding

A project known as the Global Agriculture and Food Security Program (GAFSP) with the Canadian federal government provides grants, loans, and equity investments to developing countries in order to boost the income and increase food security for their people (FATDC, 2014). Nepalese manufacturing companies who complete the fabrication of solar food dryers could be eligible for this funding.

Another project known as the AgriInnovation Program may also be another source for funding, but for Canadian companies (AAFC, 2014). This five-year program ending March 2018 aims to stimulate and accelerate agri-innovations in supporting Canadian research and development projects, thereby enhancing Canadian agriculture and supporting agri-based products (AAFC, 2014).

Future studies

In addition to the solar dryer, the Nepalese will need additional miscellaneous tools like knives to cut raw foods into pieces for drying as well as storage containers after foods are dried. A Hi Mountain Jerky Board and Knife set sold by Canadian company Cabela's®, but manufactured in USA, currently sells for a retail price of $59.99 CAD (Cabela's Retail Canada Inc.®, 2014). This kit is not necessary but it ensures even cutting, and therefore even drying, and can be used for more than just meat, similar to the solar food dryer (Cabela's Retail Canada Inc.®, 2014). Dried meats should be stored in a cool, dark and dry environment and so airtight plastic bags or jars are both plausible solutions (Sant et al., 2012). Currently, a dozen 1L mason jars by Bernardin®, a Canadian company, is sold by Canadian Tire® for a retail price of $11.29 CAD (Canadian Tire Corporation®, 2014). Determining whether the Nepalese already have these products and whether they are realistically priced requires further research.

Further research into the most efficient and most cost-effective design for Nepal is required. It is also important that Nepal's climate and its favourability to solar drying also be determined.

Kerin Hudson
AGR*1110
Monday, November 24, 2014

Reference List

Agriculture and Agri-Food Canada (AAFC). (August 21, 2014). *AgriInnovation Program*. Retrieved from http://www.agr.gc.ca/eng/?id=1354301302625

Alibaba.com® (2014). Solar Food Dehydrators. Date accessed: November 17-19, 2014. Retrieved from http://www.alibaba.com/trade/search?fsb=y&IndexArea=product_en&CatId=&SearchText=solar+dehydrator

Aluminum Association of Canada (AAC). (2012). *110 years of History in Canada*. Retrieved from http://www.thealuminiumdialog.com/en/aluminium--2/history/110-years-of-history-in-canada

BBC Weather. (2011). *Weather Kathmandu: Average Conditions*. Retrieved from http://www.bbc.com/weather/1283240

Blair, R., Calota, G., Crossman, A., Drake, F., & O'Keefe, K. (April 10, 2005). *Northeastern University Mechanical Engineering Undergraduate Capstone Projects: Design of a solar powered fruit and vegetable drier*. Retrieved from http://iris.lib.neu.edu/cgi/viewcontent.cgi?article=1043&context=mech_eng_capstone

Cabela's Retail Canada Inc®. (2014). *Hi Mountain Jerky Board and Knife.* Date accessed: November 20, 2014. Retrieved from http://www.cabelas.ca/product/3097/hi-mountain-jerky-board-knife

Canadian Intellectual Property Office (CIPO). (November 19, 2014). *Patent Summary: Quatizing Photon Dehydrator*. Retrieved from http://brevets-patents.ic.gc.ca/opic-cipo/cpd/eng/patent/2173509/summary.html

Canadian Tire Corporation®. (2014). *Regular Mason Jars, 1L*. Date accessed: November 20, 2014. Retrieved from http://www.canadiantire.ca/en/pdp/regular-mason-jars-1-l-0422525p.html#.VG66j_nF8Z5

Central Intelligence Agency (CIA). (June 20, 2014). South Asia: Nepal. *The World Factbook.* Retrieved from https://www.cia.gov/library/publications/the-world-factbook/geos/np.html

Christian, P., Srihari, S., Thorne Lyman, A., Khatry, S., & Leclerq, S. (2006). Eating down in pregnancy: Exploring food-related beliefs and practices of pregnancy in rural Nepal. *Ecology of Food and Nutrition, 45*(4), 253-278.

Foreign Affairs, Trade and Development Canada (FATDC). (2014). *Project Profile: Global Agriculture and Food Security Program (GAFSP)*. Retrieved from http://www.acdi-cida.gc.ca/cidaweb%5Ccpo.nsf/projEn/M013185002

Government of Canada. (August 2013). *Canada-Nepal Relations*. Retrieved from http://www.canadainternational.gc.ca/india-inde/bilateral_relations_bilaterales/canada_nepal.aspx?lang=eng

Heinz, G & Hautzinger, P. (2007). *Meat processing technology for small- to medium-scale producers* No. 20). Bangkok: Food and Agriculture Organization of the United Nations.

Hydro. (2012). *Aluminium, Environment and Society*. Retrieved from http://www.hydro.com/upload/Aluminium/Download/Aluminium_environment-and-society.pdf

Janjai, S & Bala, B. K. (2012). Solar Drying Technology. *Food Engineering Reviews, 4*(16), 16-54.

Maharjan, M., Joshi, V., Joshi, D., & Manandhar, P. (2006). *Prevalence of salmonella species in various raw meat samples of a local market in kathmandu.* New York,: New York Academy of Sciences.

Nepal Shipping & Air Logistics Pvt. Ltd. (NPSAL). (2012). *Nepal Shipping & Air Logistics Pvt. Ltd.* Retrieved from http://www.npsal.com/index1.php?option=feedback

New York Cargo (P) Ltd. (2009). *New York Cargo (P) Ltd*. Retrieved from http://www.cargo-nepal.com/

Oskam, J. (2014). Personal communication by e-mail & phone. November 19-21, 2014. J, Oskam is the president of Oskam Welding & Machine, Inc.

Parajuli, R., Umezaki, M., & Watanabe, C. (2012). Diet among people in the terai region of nepal, an area of micronutrient deficiency. *Journal of Biosocial Science, 44*(4), 401-15.

Pariyar, D. (2008). *Country Pasture/Forage Resources Profiles: Nepal*. Retrieved from http://www.fao.org/ag/AGP/AGPC/doc/counprof/Nepal/nepal.htm

Sant, L. L., Hampton, C. & McCurdy, S.M. (April 2012). *Making Jerky at Home Safely: A Pacific Northwest Extension Publication*. Retrieved from http://extension.oregonstate.edu/fch/sites/default/files/documents/pnw_632_makingjerkyathome.pdf

United Nations. (UN). (2014). *Nepal*. Retrieved from https://data.un.org/CountryProfile.aspx?crName=Nepal