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Protein and Polysaccharides Extraction from Discarded Asparagus Base

Andrea DiNardo[1], Ping Wu[1,2], Sheng Chang[1]

1. School of Engineering, University of Guelph, Guelph, ON, Canada, N1G 2W1
2. Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, ON, Canada, N1G 4Y2

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ABSTRACT Harvesting and packaging of fruits and vegetables often creates a by-product which is disposed of since it has no commercial value, but may be beneficial towards human health. Freshly harvested asparagus spears are cut into equal lengths before packaging, in which the bottom base is discarded. Up to 50% of the asparagus spear is discarded, which creates a significant amount of waste. Discarded asparagus bases are currently incorporated into manure as crop fertilizer since it has no market value. Asparagus by-products contain fibre compounds, and vitamins, which can be used in the design of functional foods. The food industry may generate more value for disposed food by repurposing them as ingredients in new food products. By evaluating the causes of food disposal, and repurposing these by-products, Canada's agri-food sector can reduce its environmental footprint, reduce its overall food waste each year, and reduce the cost of manufacturing new food products. Protein and polysaccharide extraction was optimized through the use of a water bath at 50°C for 3 hours, 60°C for 1 hour and 30 minutes, and 80°C for 30 minutes. It was found that the 60°C water bath resulted in the highest protein concentration in the soluble and insoluble fibre portions, as well as highest overall protein concentration. No extraction resulted in highest polysaccharides concentration.

Keywords: asparagus, protein, polysaccharides, extraction.

INTRODUCTION It is estimated that Canada's population will continue to grow within the next 50 years, reaching a population of 63.5 million people by the year 2063 (Chagnon et al. 2014). Canada invests a great amount of resources into finding new ways of increasing food production to feed a growing population. However, fewer resources are allocated into finding new ways to feed the population through food which has already been produced. In Canada's food supply chain, between the crops to consumer tables, up to 50% of food products are wasted (Mena et al. 2011). An average Canadian household produces 0.5 kg of waste per day, where fruits and vegetable account for more than half of it (Uzea et al. 2013). The food industry may capitalize on this edible food waste by repurposing it as ingredients within new food products. By evaluating the causes of food waste, and repurposing these wasted foods, Canada's agri-food sector can reduce its environmental footprint, reduce its overall food waste each year, and reduce the cost of manufacturing new food products.

During asparagus processing, approximately half of the asparagus spear is discarded, generating up to 50% of its fresh weight in waste (Fuentes-Alventosa et al. 2009; Rodriguez et al. 2006). Asparagus suffers a quick hardening of the bottom portion of the spears, due to increased fibrousness (Rodríguez et al. 2006). The increased fibrousness decreases the market value of the asparagus, causing it to be discarded (Rodríguez et al. 2006). Since asparagus by-product has no commercial value, it is incorporated into manure piles and used as a fertilizer for crops. Waste produced by asparagus harvesting contains soluble and insoluble fibre compounds, and vitamins which can be used in the design of functional foods. Dietary fibres found in asparagus serves as a functional ingredient since it can prevent diseases, reduce risk of cancers, and improve overall gastrointestinal health (Gibson and Williams 2000; Rodríguez et al. 2006).

The objectives of this study were to determine optimal protein and polysaccharides concentration of asparagus base under different processing conditions, determine how foods with no commercial value can be incorporated as ingredients towards new food products, and reduce the amount of edible food each year.

MATERIALS AND METHODS

Asparagus by-product Asparagus by-product was obtained from Welsh Bros. farm (Scotland, Ontario, Canada) 3 days after being harvested. The asparagus spears were cut into 9 inch lengths after harvesting. The bottom, discarded portion was used for analysis. The by-products were stored in a freezer at 0°C prior to analysis to prevent overheating of the slurry.

Preparation of asparagus slurry 250 grams of the frozen asparagus spears were blended in a homogenizing blender (Cole-Parmer, Vernon Hills, IL) with deionized water in a 1:1, solid: water (w/v) ratio at room temperature for 3 minutes.

Extraction of protein and polysaccharides 100 grams of the asparagus slurry was separated into centrifuge tubes and were placed in water baths set at 50°C for 3 hours, 60°C for 1 hour and 30 minutes, and 80°C for 30 minutes while one sample was not placed in a water bath. Following extraction, the samples were centrifuged in a table top centrifuge (Thermo Scientific Sorvall Legend, Germany) at 10,000 times gravity at 4°C for 10 minutes. After centrifugation, the supernatant was separated from the insoluble fibres and filtered through 1.5 µm filter paper to remove any suspended solids. Protein and polysaccharides analysis was then performed on the filtered supernatant.

Oven drying of solids The solid, insoluble residue was placed on an aluminum tray in an oven (Thelco, GCA/Precision Scientific, Chicago, IL) set at 100°C for approximately 2 hours. The dried asparagus fibres were then ground into a fine powder in a blender (Cole-Parmer, Vernon Hills, IL).

The powder was extracted with deionized water at 23°C in a 1:20, solid: water (w/v) ratio. The slurry was then filtered through a 1.5 µm filter where protein and polysaccharides analysis was performed on the filtered liquid.

Polysaccharides analysis A modified DuBois et al. (1956) method, for carbohydrate analysis, was used. In a vial, 3 ml of the sample along with 1 ml of phenol solution and 5 ml of pure sulfuric acid (96%) were combined. The vials were then incubated at 30°C for 20 minutes in a water bath. The carbohydrate absorbance was read in a HACH DR 5000 spectrophotometer (Germany) at a wavelength of 490 nm.

Protein analysis A modified BCA protein assay method was used for protein analysis. A working reagent was created using a ratio of 50:1 between Reagent A and Reagent B. Reagent A containing sodium carbonate, sodium bicarbonate, bicinchoninic acid and sodium tartrate, and Reagent B contains 4% cupric sulfate. Each sample was prepared using 2 ml of the working reagent and 300 µL of the sample. The vials were incubated at 60°C for 30 minutes in a water bath and then refrigerated until the temperature reduced to 20°C. The protein absorbance was then measured in a HACH DR 5000 spectrophotometer (Germany) at a wavelength of 562 nm.

Statistical analysis The protein and polysaccharides analysis of the raw sample, 50°C water bath, 60°C water bath, and 80°C water bath samples were conducted in triplicates. The average values, median, standard deviations, and confidence intervals were calculated using Microsoft Excel.

Total protein and polysaccharides Total protein and polysaccharides concentration was calculated using Equation 1 which combines the concentration present in the soluble portion with the concentration in the insoluble portion.

$$TC = C_S + C_I \quad (1)$$

Where TC is the total concentration, C_S is the concentration in the soluble portion, and C_I is the concentration in the insoluble portion.

RESULTS AND DISCUSSION Figure 1 illustrates the average measured protein and polysaccharides concentration in the soluble fibre portion for each extraction temperature. It can be seen that the 60°C water bath yielded the highest protein concentration of 62.43 milligrams of protein per gram of asparagus. While the polysaccharides concentration remains relatively the same among all methods, no extraction yielded the highest concentration of 17.12 milligrams of polysaccharides per gram of asparagus.

Figure 2 provides a graphical representation of the average protein and polysaccharides concentration in the insoluble fibre portion for each extraction method. The highest protein concentration, 26.66 milligrams of protein per gram of asparagus, occurs when the 60°C water bath was performed. No extraction yielded the highest concentration of polysaccharides in the insoluble fibre portion which was 15.76 milligrams of polysaccharides per gram of asparagus.

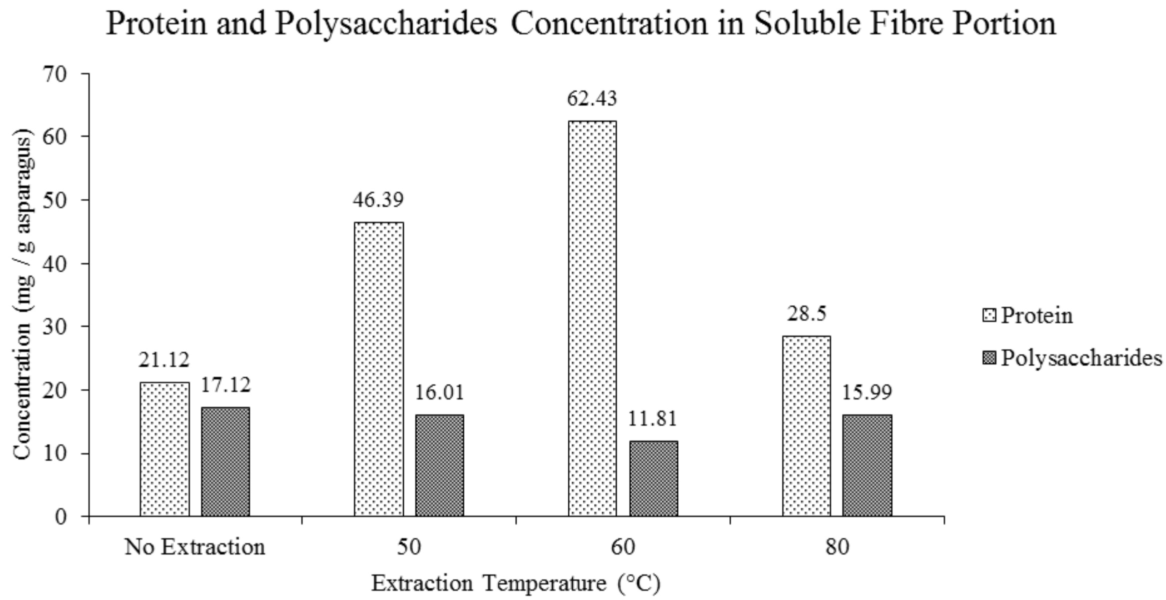

Figure 1. Concentration in milligrams of protein and polysaccharides per gram of asparagus by-product for each extraction method in the soluble fibre portion

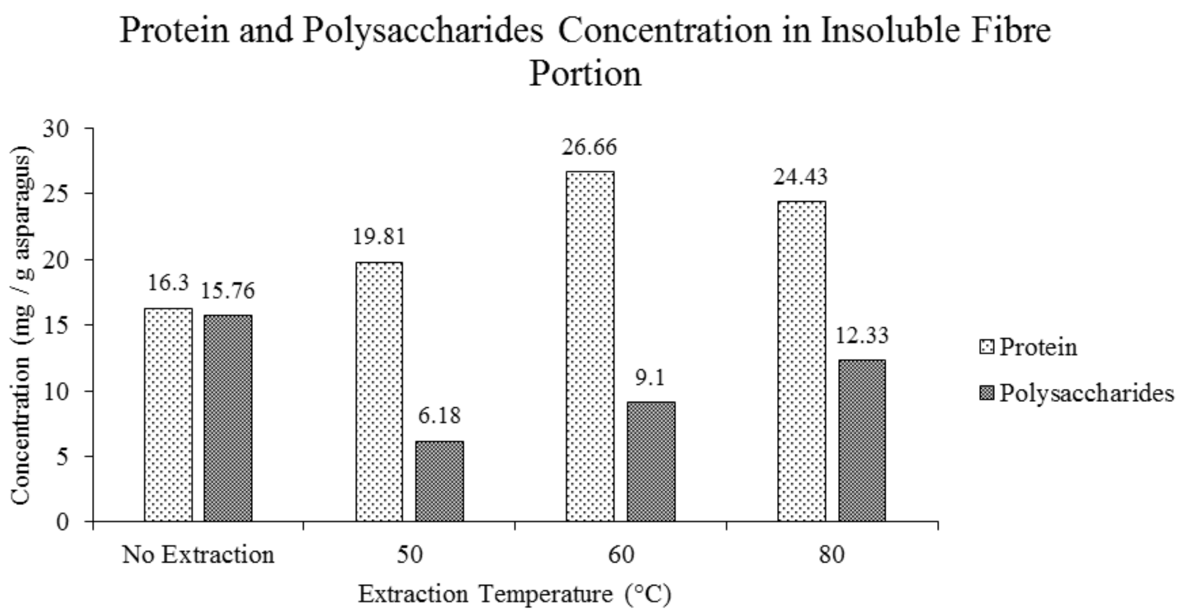

Figure 2. Concentration in milligrams of protein and polysaccharides per gram of asparagus by-product for each extraction method in the insoluble fibre portion

Figure 3 displays the total amount of protein and polysaccharides present in the asparagus by-product. Total protein and polysaccharides was calculated using Equation 1 which totals the concentrations in both the insoluble and soluble fibre portions. The 60°C water bath yielded the highest overall protein concentration of 89.09 milligrams of protein per gram of asparagus. While there is little variation in polysaccharides concentration, no extraction yielded the highest concentration of 32.88 milligrams of polysaccharides per gram of asparagus.

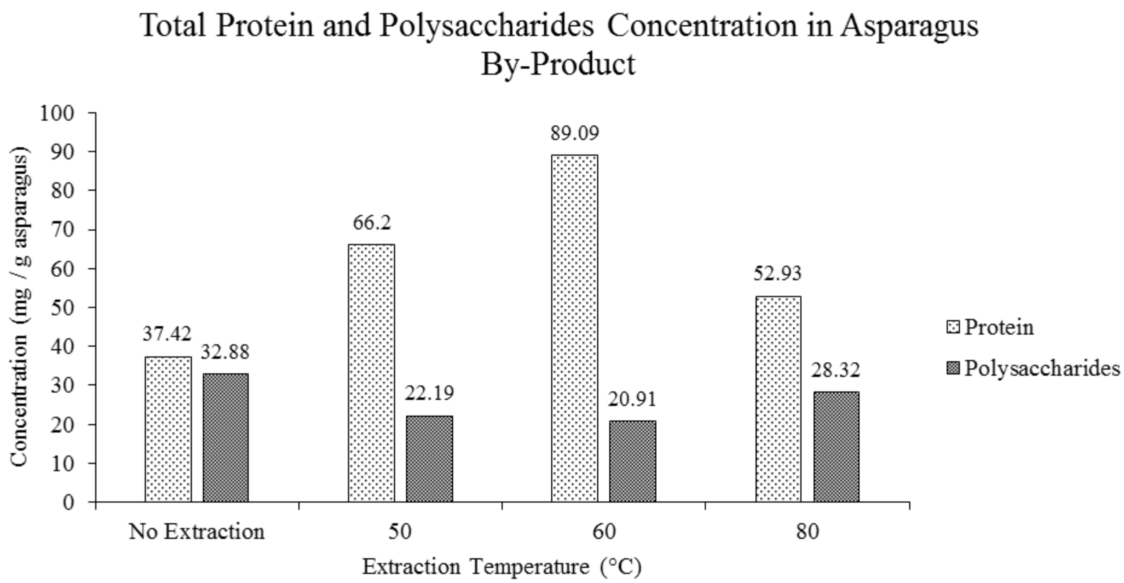

Figure 3. Total protein and polysaccharides concentration, in milligrams per gram of asparagus, in asparagus by-product for each extraction method

CONCLUSION The effects of different protein and polysaccharides extraction parameters on asparagus by-products were studied. The different processing parameters included water bath extractions ranging from 50°C to 80°C. It was found that the 60°C water bath for 1 hour and 30 minutes yielded the highest protein concentration in the soluble and insoluble fibre portions, and the highest amount of total protein per gram of asparagus. Polysaccharides concentration remained consistent among each method, except for the insoluble fibres in the 50°C water bath.

Both the insoluble and soluble fibre portions could be used in a variety of applications such as health supplements, fibre enriched foods and snacks, meat products, fortified animal feed, and beverages.

Further research to be conducted would be to explore more extraction methods, test other fruits and vegetables, and incorporate extracted fibres into new food products. Methods such as ethanol extraction, acetone extraction, ultrasonic circulating extraction (UCE), and freeze-drying extraction should be investigated to determine which method yields the highest protein and polysaccharides concentration. Another area to research is the fibre and protein concentration in other fruits and vegetables. By adjusting this process to other commodities, more value can be generated for other non-marketable food by-products. By incorporating the extracted fibres into new food products, research can be conducted to determine its effects on the product.

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