Characterization of structure, physicochemical and physiological properties of starch from Canadian grown pulse crops to develop novel functional food ingredients and functional foods for human health benefits

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SPG Contributions	Project Status	Duration/Timeline of Project (Year to Year)	Co-funders	Total Project Cost
$238,878.00	Completed	April 2013 – March 2018	Agriculture and Agri-Food Canada	$886,111.00

Project Description

Starch is the primary source of calories in the human diet and serves as an important functional ingredient in many food and non-food products. There has been consistent scientific evidence to support the relation between how starch is digested and many chronic diseases including diabetes, cardiovascular disease, and obesity. Therefore, consumers, food manufacturers, and processors have shown increasing interest in low glycemic index food products. Pulse starches are identified as slowly digestible or resistant to hydrolysis compared with cereal starches. This property is attributable primarily to the high amylose content, as well as, molecular structure of glucan components. Many other influences including processing conditions, how the food is cooked, and the bacteria that live in our gut also seem to play a role in our metabolic process. In this context, understanding physicochemical properties of pulse starches and the molecular structure are prerequisite to enhance the required nutritional and functional quality by modification and processing techniques. In addition to starch content, as pulses are rich in protein, fibre, antioxidants, and vitamins, understanding the proteomics and characteristics of other components of pulse flour are key to screen and develop nutritionally diversified food products.

The key challenge to food researchers and the food industry is the production of consumer friendly foods which contain enough resistant starch (RS) and/or slowly digestible starch (SDS) to result in a significant improvement in human health, and how to evaluate or predict the nutritional properties using an effective model. Extensive research on cereal, potato, sweet potato, and cassava starches has made them readily available for use in food and non-food applications. However, there is a dearth of information on the molecular structure of pulse starches and effective processing and modification to manipulate starch structure.

The overall research objective for this activity is to understand how enhanced slowly digestible and/or resistant starch is formed through pulse variety selection and effective processing to manipulate starch structure, and to characterize the microstructure and functionalities of slowly digestible and resistant starch from Canadian grown pulses, using various modern analytical techniques including differential scanning calorimetry, dynamic mechanical analysis, rapid visco-analysis, Fourier transform infrared spectroscopy, optical and electron microscopy, particle size analysis, wide angle x-ray diffraction, 13 C cross-polarization magic angle spinning nuclear magnetic resonance spectroscopy, high performance anion exchange chromatography, and in vitro digestibility.

By investigating pulse starch structure, physicochemical, and physiological properties in this project, we will address the novel applications of pulse and pulse starches, to ensure that pulse crops are viable alternative to corn and potato starch. Other approaches are the identification of existing and newly released Canadian grown pulse crops to identify the source for enhanced resistant starch and slowly digestible starch and other bioactive compounds and modification of processing conditions such as using reactive extrusion to produce novel pulse starch and food with enhanced resistant starch and/or slowly digestible starch.

We expect to deliver new knowledge and a database on the chemical composition, granular and molecular structure, functionality, and nutritional properties of Canadian grown pulse flours and starches. We will also publish research discoveries in peer-reviewed scientific journals and present data at national and international conferences.

Outcome

Canadian-grown pulse varieties were screened as sources of resistant starch and slowly digestible starch. A quick and efficient analytical method for screening new and specialty pulses was developed to determine the best candidates for food ingredients. By this method, pulse starches were identified that had potential to be a good fit within commercial food products. This included analyses of their chemical composition, granular and molecular structure, and functional and nutritional properties, as well as experimenting with them in extrusion cooking and other conventional processing technologies. Pulse flour was modified using single or combined enzymatic, chemical and physical means to enhance the amount of resistant starch and slowly digestible starch. Several pulse starch and flour candidates with different functionalities have been developed as food ingredients. During the five year period, a brand-new database of knowledge about Canadian-grown pulse starches was created, which will serve as an educational resource for the food processing industry. Completing the chain of knowledge from crop, to functional ingredient, to nutritional food product, we invented a gluten-free bread product with enhanced resistant starch and slowly digestible starch from Canadian pulse by adjusting the bread formula, roasting, and alginate encapsulation. The low glycemic index (GI) and gluten-free features of this bread will benefit consumers with diabetes and celiac disease, as well as the general population. An invention disclosure was filed on low GI and gluten-free pulse breads.

Research Objective

OBJECTIVE 1

To identify sources of variation in resistant starch (RS) and/or slowly digestible starch (SDS), and to develop novel functional foods with enhanced RS or SDS by using improved conventional processing technology and using newly released and existing pulse cultivars.

OBJECTIVE 4

To develop novel technologies of biochemical and/or physical modification to enhance RS and SDS as novel functional food ingredients.

SASKATCHEWAN pulse Growers

OBJECTIVE 7
To predict bioavailability of novel pulse starches and pulse foods with enhanced RS and SDS using in vitro GI-tract model and TIM-2 system.

OBJECTIVE 2
To update a database on the chemical composition, granular and molecular structure, functionality and nutritional properties of Canadian pulse starches compared with commercial corn and potato starches.

OBJECTIVE 5
To characterize the kinetics of starch digestion in vitro of pulses, pulse starch and processed pulse foods.

OBJECTIVE 8
To determine the acute glycemic response from newly developed pulse foods with enhanced RS and SDS.

OBJECTIVE 3
To develop novel separation technology to increase the yield and purity of pulse starches.

OBJECTIVE 6
To investigate the interaction between starch and fibre, protein, lipid and phytochemicals (phenolics and saponins) in processed pulse products.