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The role of pulses in satiety, food intake and body weight management

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ABSTRACT

Increasing worldwide rates of overweight and obesity have prompted the need for new prevention and management strategies. Pulses are low-energy and nutrient-dense foods with great potential to increase satiety, which can decrease food intake and facilitate body weight management. Human intervention studies examining effects of acute pulse consumption on satiety and food intake have produced mixed results, although a recent meta-analysis summarized a significant increase in satiety but not food intake. To connect these measures more directly to obesity risk, observational studies have related pulse consumption to lower body weight and obesity risk, while intervention studies have shown significant reductions in body weight following pulse consumption with or without energy restriction. This overall literature deserves more studies to address the multiple variables, particularly pulse variety and form of consumption, all of which will strengthen the promising relationships between pulse consumption, satiety, food intake and body weight management.

Contents

1. Introduction

As of 2014, over 1.9 billion adults worldwide have been classified as overweight or obese, a number that has more than doubled over the last few decades (World Health Organization. Obesity and overweight, 2016). The World Health Organization (WHO) has attributed this to an increase in consumption of energy-dense foods, along with a decrease in overall physical activity (World Health Organization, 2016). Since correcting this energy imbalance requires individuals to alter their energy intake and physical activity, the two very issues that are causing the rise in overweight and obesity, there remains a need for new prevention and management

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strategies to help combat this rise. To reduce overweight and obesity along with the associated issues and illnesses that may arise, the WHO suggests that in addition to increased physical activity and making healthier food choices, individuals should increase their consumption of legumes (World Health Organization, 2016), which include pulses. Pulses are a nutrient-dense type of dried legume (Pulse Canada. What is a Pulse?, 2016b) that have the potential to influence satiety (McCrory, Hamaker, Lovejoy, & Eichelsdoerfer, 2010), which is defined as the "process that leads to inhibition of further eating, decline in hunger, increase in fullness after a meal has finished" (Blundell et al., 2010, p. 252). Satiety, due to its potential to alter the amount of food and energy consumed by an individual, could be a valuable prevention and management strategy to reduce the rise in overweight and obesity currently being faced (World Health Organization, 2016). This review will examine the relationship between pulses, satiety, and body weight through epidemiological and human intervention studies.

2. Pulses

Pulses, the dried seeds of the legume family, include members such as dried beans, dried peas, chickpeas, and lentils (Pulse Canada, 2016b). They are a group of nutrient-dense foods, providing an excellent source of protein, dietary fibre, complex carbohydrates, vitamins, minerals, and phytochemicals, while remaining low in fat, calories, and glycaemic index (GI) (Pulse Canada. Nutritional Benefits, 2016a; Rebello, Greenway, & Finley, 2014). For this reason, pulses fall under the category of specific foods that could help to reduce obesity as encouraged by the WHO (World Health Organization, 2016). In addition to their nutrient-dense profile, pulses also contain other bioactive components such as phenolic compounds and tannins with antioxidant activity (Amarowicz, Troszynska, Barylko-Pikielna, & Shahidi, 2004), prebiotics such as oligosaccharides (Guillon & Champ, 2002), as well as anti-nutrients such as phytate (McCrory et al., 2010), lectins, and enzyme inhibitors (Lajolo & Genovese, 2002), many of which are thought to play a role in satiety (McCrory et al., 2010).

Some nutritional characteristics of pulses that have gained interest as potential bioactive components with the ability to increase satiety include slowly digestible carbohydrates, protein-starch complexes, and anti-nutrients such as phytate (McCrory et al., 2010). Slowly digestible carbohydrates such as soluble fibre and starches have the potential to increase satiety due to delayed gastric emptying and consequently delayed digestion due to formation of a viscous gel once consumed (Howarth, Saltzman, & Roberts, 2001), along with slowly digestible and resistant starches' ability to delay digestion due to their resistance to and delay of digestion throughout the small intestine (McCrory et al., 2010). Protein-starch complexes have the potential to increase satiety by limiting both protein's and starch's access to digestive enzymes, thereby delaying digestion and possibly delaying the return of hunger (McCrory et al., 2010). Phytate, a phytochemical found in pulses with anti-nutrient activity, has been found to decrease starch digestion *in vitro* (Yoon, Thompson, & Jenkins, 1983), as well as delay postprandial glycaemic response in humans (Thompson, Button, & Jenkins, 1987), which may translate to delaying digestion in humans and possibly delaying the return of hunger (McCrory et al., 2010; Rebello et al., 2014). These mechanisms have provided biological plausibility and rationale for study into the effects of pulse consumption on satiety and food intake.

3. Satiety

Satiety, defined as the means by which further eating is inhibited, hunger decreases, and fullness increases after a meal (Blundell et al., 2010), may play a role in altering the amount of food and energy consumed by an individual (Health Canada, 2012). Satiety can be examined using many different approaches; however, it is commonly measured using self-reported appetite sensations such as hunger, fullness, prospective food consumption and desire to eat after consumption of a meal with scales such as the widely accepted Visual Analogue Scale (VAS) (Forde, Almiron-Roig, & Brunstrom, 2015; Health Canada, 2012). Typical VAS have a horizontal line with the two extremes of the scale as anchors, usually "not at all" and "extremely", where a mark can be drawn for each appetite sensation at preset time intervals and quantified for comparison by measuring the distance from the anchor to the mark (Health Canada, 2012). The satiety response based on the ratings of subjective appetite sensations after consuming a meal can then be measured by calculating the area under the curve (AUC) for each of the appetite sensations (Health Canada, 2012), and can also be combined into a single measure of average subjective appetite. These subjective appetite sensations can also be measured in combination with objective food (energy) intake at a subsequent *ad libitum* test meal (Health Canada, 2012). Since subjective appetite sensations are not proven to be a reliable indicator of energy intake at a subsequent test meal (Holt et al., 2016), including measurement of objective food intake at the *ad libitum* test meal provides an important objective indicator of the potential for a satiating food to reduce energy intake and contribute to the prevention of overweight and obesity.

Studies that have examined foods for their potential to increase satiety have frequently focused on those high in dietary fibre and protein with a low GI (Abete, Astrup, Alfredo Martinez, Thorsdottir, & Angeles Zulet, 2010). Pulses satisfy this composition and have gained scientific interest as foods with the potential to influence satiety (Li et al., 2014; Pulse Canada, 2016a; Rebello et al., 2014).

4. Pulses, satiety and food intake: intervention studies

This section reviews the human intervention studies that have investigated the effects of pulse consumption on satiety-related measures, such as subjective appetite sensations following consumption of the study treatments and objective food intake following consumption of a second test meal. The 14 available studies can be categorized into acute studies which examined whole pulses, pulse fractions and pulse breads, and chronic studies which examined whole pulses incorporated into both uncontrolled and controlled diets.

4.1. Acute intervention studies using whole pulses (Table 1)

Four studies have measured the effects of acute consumption of whole pulses on satiety and food intake at a subsequent test meal. In the first of these studies, Wong, Mollard, Zafar, Luhovyy, and Anderson (2009) used a randomized crossover design in healthy males to examine whether the acute effects of pulses on satiety and food intake depended on processing, inclusion in recipes, or variety. Processing was examined in experiment one (n = 14), which compared three types of processed pulses (consumed in amounts equivalent to 50 g available carbohydrates with 475 mL water) including canned Canadian navy beans (338 g pulses), United Kingdom (UK) navy beans (305 g pulses), and homemade baked navy beans (196 g pulses) served in tomato sauce, compared with a 300 mL glucose drink control. Inclusion in recipes was examined in experiment two (n = 14), which compared four pulse recipes (consumed in amounts equivalent to 50 g available carbohydrates with 475 mL water) including canned Canadian navy beans (338 g pulses), navy beans maple style (259 g pulses), navy