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Integration of Resistant Starch in Homemade Pasta

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According to the CDC the leading causes of death and disability in the United States include cancer, coronary vascular disease (CVD), stroke, and diabetes mellitus (DM)[1]. These ailments often go hand in hand with obesity and an energy dense diet. Healthy diets high in fiber can not only serve as prevention for disease but can assist in the management of disease. Fiber comes in two forms: dietary fiber and functional fiber. Dietary fiber is a substance comprised of carbohydrate and lignin found in plants that are nondigestible by human enzymes[2]. Functional fiber consists of the nondigestible carbohydrates that have been isolated, extracted, and processed[2]. While both forms are important aspects of a healthy diet, dietary fiber has been associated with lower risk of CVD, improved bowel function, weight control, and glycemic control stability[3].

According to the Academy of Nutrition and Dietetics (AND), Americans should consume 14 grams of dietary fiber per 1,000 kcal consumed which is roughly 25 grams for adult women and 38 grams for adult men[3]. The average American eats about 15 grams of dietary fiber each day[3]. The AND also states that although many fiber supplements are on the market, obtaining fiber from food sources such as whole grains, beans, legumes, fruits, and vegetables is best[3]. Fiber comes in several forms and has many variations that differ in solubility, water absorbency adsorbency, and fermentability**.**

Resistant starch (RS), a type of fiber, is the fraction of starch that cannot be, or is not easily, enzymatically digested in the gastrointestinal tract or absorbed by humans[2, 4]. RS is comprised of 4 main subtypes: RS 1 - 4. Both RS_1 and RS_2 are considered dietary fibers while RS_3 and RS_4 are considered functional fibers. Each resistant starch has its own reasoning as to why

it cannot be easily digested. RS_1 can be found among cellulose in plant cell walls of whole grains and seeds[2]. Because of its placement, amylase, a digestive enzyme, cannot physically access the starch to digest it[2]. It is partially digested at a very slow rate yet can be totally digested if properly milled[4.] RS_2 is found in tightly packed granules within plant cells. The high amylose content with ungelatinized granules allows for the tight structures present in unripe bananas, legumes, raw potatoes, and high amylose maize[2, 4]. This starch is digested at a very slow rate and can sometimes be totally digested when freshly cooked[4]. RS_3, also known as retrograde starch, can be generated through the process of moist-heat cooking followed by cooling[2]. This includes cooked and cooled rice, potatoes, bread, and high amylose corn[2, 4]. RS_3 can be partially digested at a slow rate which can be improved by reheating of the product[4]. RS_4 is a result of the formation of starch esters and cross-bonded starches through chemical modification and can be found in industrially processed foods including fiber drink supplements, breads, and cake [2, 4]. Due to chemical modification, RS_4 can resist hydrolysis[4].

Although not a soluble fiber, RS has many characteristics similar to those of soluble fibers which provide many physiological benefits. RS can bind several times its weight in water which produces a viscous, slow-moving solution that often traps nutrients and slows down digestion and absorption[2]. This delay in gastric emptying increases satiety for a longer duration compared to other starches which can assist in weight management**.**

RS demonstrates adsorption properties by diminishing the absorption of lipids and increasing fecal bile acid excretion which in turn decreases serum cholesterol concentration[2]. RS consumption also decreases the absorption of other nutrients such as glucose which assists

in stabilizing blood glucose levels[2]. In addition, RS itself has a low glycemic index and can reduce post-prandial glycemic and insulinemic responses which may also be beneficial characteristics in the management of diabetes[5, 6].

Because RS remains mostly undigested, it is left to be fermented in the gut. When fermented, RS can provide carbon as well as energy to the 400-500 bacteria species present in the gut[6]. Fermented RS also generates short chain fatty acids (SCFA) that can be converted to energy. Over 95% of the SCFAs generated can be absorbed and utilized by the body as energy[4]. The acids generated yield about 1.5 to 2.5 kcal per gram[2]. SCFAs activate fatty acid oxidation and inhibit lipolysis which reduces the plasma free fatty acid concentration which may be related to decreased body weight[7]. The SCFAs also improve blood flow in the colon, liver, spleen, and intestines which in turn improves digestive health[2]. The acids present in these SCFAs have the ability to lower the lumen pH which creates an environment less prone to the formation of cancerous tumors[6].

A minimum intake of 5-6 grams per day of RS is necessary for reductions in insulin and >20 grams per day is necessary for the bowel-related benefits, however Americans consume an average of 4.1 grams of RS per day[6, 8]. Because RS is found in a limited number of food sources it is hard to obtain in the diet on a regular basis which is why incorporation of RS into popular foods is important. As a functional ingredient RS offers many advantages compared to fully digestible forms of fiber. RS is a mild white finely ground powder with an inoffensive flavor[9]. RS is lower in calories compared to fully digestible starches with a minimal swelling capacity[6, 9]. Interest in the benefits of RS is increasing and RS has become a popular ingredient in baked

goods such as cakes, cookies, breads, and in some cases pasta. By integrating this low-calorie, functional ingredient into pasta dough, a popular entree lacking nutritional value can become a fiber-rich dish with many physiological benefits[9].

A study conducted pasta production up to 20% RS substitution[8]. The study found no significant differences in swelling index, dry matter data, cooking quality, or sensory attributes between RS products and the control product[8]. Another study assessed the cooking loss, texture, and sensory properties of commercially purchased pasta substituted with RS at 10%, 20%, and 50% variations[9]. This study found that RS has a potential application in the partial substitution of pasta for up to 20% substitution. This study found no significant variation in the cooking quality or textural characteristic of the pastas up to 20% substitution. The study also found that there was no significant difference in the sensory attributes of the pastas yet did note that the uncooked pastas with RS substitution were much less yellow than the control which may have an effect on consumer appeal. The study found a correlation with increased RS content and decreased in vitro starch digestion as well.

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