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SOLUBLE-FIBER INGREDIENT FROM OATS: USES IN FOODS AND SOME HEALTH BENEFITS

A b s t r a c t

Soluble-fibers are considered important dietary substances for good health and disease prevention. Oat soluble fiber, β -glucan, is known to lower blood cholesterol in animals and humans. The fat substitute, Oatrim, is enzymatically derived from oats and contains the soluble β -glucan which retains its hypocholesterolemic properties. Many reduced fat and fat-free foods now use Oatrim for fat replacement. Among the many foods are low-fat meats; fat-free cheeses, and low-fat bakery products. Some sensory parameters of Oatrim usage in cookies and truffles are examined by an analytical sensory evaluation panel.

Introduction

American eating habits should be drastically changed to reduced the \$950 billion in annual health-care spending according to many medical and nutritional scientists. Perhaps 10 to 20 percent of these health-care costs could be reduced if all Americans were to modify their diets based on existing knowledge of nutrition. Oatrim is a soluble-fiber containing fat substitute that is helping companies focus on foods being generated for Americans seeking a healthy life-style with increased longevity and less chronic disease.

Oatrim was discovered [6, 13] and patented [7] by the U.S. Department of Agriculture with licenses granted to Mountain Lake Manufacturing (ConAgra/A. E. Staley Manufacturing joint venture) and Quaker Oats/Rhone-Poulenc (a partnership). The process involved the α -amylase conversion of starch in the oat flour or bran to amy-

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lodextrins. The product, soluble-fiber (β -glucan) and amyloextrins from the oat flour, was referred to as oat β -glucan-amyloextrins or Oatrim. Barley and other cereal grains were used to prepare other amyloextrins containing soluble-fibers [10].

The composition of Oatrim is mainly amyloextrin and β -glucan with small quantities of lipid, protein, and minerals. Replacing fat in foods with Oatrim is possible because the combination of β -glucan and amyloextrins produce an excellent fatty textured material. It can be converted to a shortening-like gel by heating and cooling a 25 % Oatrim dispersion. The fat-like gel has one calorie per gram compared to nine calories for fat [8]. It replaces shortening in food recipes on a cup for cup substitution bases. The powder can also be used in recipes and its quantity modified based on intended function and properties desired. Both powder and gel give the sensory attributes of natural taste and fatty texture to foods as it replaces fat, lowers calories, and adds soluble-fiber to the diet. These properties make it possible for the reduced-fat foods to look-like, taste-like the traditional higher-fat foods.

Oatrim or its gel has heat stability in food applications, such as processed meats, pasteurized cheeses and baked products. Currently, Oatrim is found in a nationally distributed extra lean ground beef which is 96 % fat-free meat which has the natural taste and texture of a 80 % fat-free hamburger. A 112 gram portion has 130 calories compared with 300 calories from an equal weight of the 80 % beef. It is also used to replace fat in 97 % fat-free franks, fat-free cheeses, and various deli meats. New products containing Oatrim are appearing frequently and many major reduced-fat or fat-free products under active development which include reduced-fat meats, frozen desserts, salad dressings, sauces, gravies, soups, mayonnaise, margarine, breads, waffles, granola bars, muffins, cookies, brownies, beverages, and cakes [11]. Oatrim usage in a food item is noted on the ingredient label as hydrolyzed oat flour or hydrolyzed oat and corn flour. The ingredient is sold as TrimChoiceTM by A. E. Staley or QuakerTM Oatrim by Rhone-Poulenc.

In addition to eliminating or substituting for fat in foods, Oatrim's soluble-fiber content gives a hypocholesterolemic property of lowering total blood cholesterol and LDL cholesterol levels [15]. Since dietary fat-reduction and caloric intake are considered important factors in maintaining good health, people with high blood cholesterol levels are considered to be at risk for heart disease. Oats have been recognized to be effective in lowering serum cholesterol since 1963 [1]. A recent meta analysis of several studies has shown the consistent efficacy of oats as a hypocholesterolemic agent in humans [12]. The effectiveness of oats in lowering cholesterol is dependent on consuming a sufficient quantity of oatmeal or oat bran over an extended period of time. Hence Oatrim, a purified, water-soluble nearly tasteless white powder derived from oat flour, can be easily incorporated into commonly consumed foods, such as meats,

dairy, and baked items. Its wide potential for food applications makes a sustainable consumption of oats possible.

Oatrim's blood cholesterol lowering properties were first found in chick studies by Professor Rosemary Newman [15] at the Montana State University. In the first clinical trial by humans, Oatrim received a "Two Thumbs Up for Oatrim" review in the December 1993 issue of *Agricultural Research* published by the USDA [14] which reports on some of its health benefits.

Materials and methods

Oatrim-5 was obtained from A. E. Staley Manufacturing Company, Decatur, IL (tradename of TrimChoice-5TM). The reported composition and properties are: moisture, 4.0–8.0%; ash, 2.0–3.0%; fat (ether extraction), 0.5% maximum; protein (nitrogen x 6.25), 5.0% maximum; pH (10% solution), 5.5–6.5; dextrose equivalent (DE), 3.0–5.0; β -glucan, 4.5–5.5; and gel strength, 10–14 mm.

Preparation and sensory evaluation of cookies

Oatmeal raisin cookies prepared from a commercial bakery recipe were selected to study shortening replacement with Oatrim. The formulation required the creaming of granulated sugar (4 lb), brown sugar (9 lb), salt (5.5 oz), baking soda (3 oz), (fine sugar Numoline or Numolina 1 lb), and margarine (9 lb). To this blend, the following ingredients were mixed in well: rolled oats (14 lb), cake flour (7 lb), regular flour (2 lb), raisins (12 lb), and eggs (2 lb and 2 oz). The yield was about 60 lb of cookies. No product development was attempted to add or avoid moisture loss during baking. Oatrim-5 and water were substituted for 50%, 75%, and 100% of the margarine. Oatrim was added as a dry powder and the water was the only liquid added to complete the recipe. The formulations for cookies using margarine or Oatrim-water are shown in Table 1.

Table 1

Fat and Oatrim quantities used to prepare oat raisin cookies

Control	9 lb fat in 60 lb formula
50% Oatrim	1 lb 2 oz Oatrim-5 3 lb 6 oz water 4 lb 8 oz fat
75% Oatrim	1 lb 11 oz Oatrim-5 5 lb 1 oz water 2 lb 4 oz fat
100% Oatrim	2 lb 4 oz Oatrim-5 6 lb 12 oz water

An analytical sensory panel with 20 members trained and experienced in testing cereal-based products evaluated the oatmeal raisin cookies for the following flavor characteristics: sweetness, graininess, toasted, buttery, cardboard and the texture properties of density, cohesiveness, and moistness. Judges also rated the cookies for overall

quality. The control sample of cookies (no substitution) was rated in preliminary blind sensory tests.

Preparation and sensory evaluation of reduced-fat chocolate truffles

Chocolate truffles were selected to study replacement in their centers of whipping cream fat with Oatrim gel. To prepare a 10 lb size batch containing 25 % whipping cream, finely chopped milk chocolate (7 lb and 8 oz) was placed in a small pan; whipping cream (2 and 1/2 cups) was heated to boiling in a separate pan and poured over the chocolate. After standing 3–4 min, the mixture was stirred until smooth and glossy, cooled in a refrigerator 15 min, rounded teaspoonfuls of center were made into balls, chocolate covered, and chilled.

Oatrim-5 gel containing 30 % solids was substituted on a volume (cup-per-cup) basis for 50 % and 100 % of the whipping cream. A 50 % fat substitution required 30 % Oatrim gel (1 and 1/4 cups) and whipping cream (1 and 1/4 cups) heated as previously described. The 100 % fat substitution required the complete elimination of cream and adding only the gel (2 and 1/2 cups). Oatrim gel was prepared by blending 30 % Oatrim-5 with 70 % water and heating to boiling before allowing it to gel in a refrigerator overnight. An analytical sensory panel with 20 members evaluated the chocolate truffles for the following flavors: bitter, creamy/buttery, chocolate, sweet, and for texture properties of smoothness, chewiness, and density.

Oatrim hypocholesterolemic property in chicks

A pilot study to test the hypocholesterolemic property of Oatrim was done at Montana State University [15]. In a larger followup study to confirm earlier results, forty-eight day-old broiler chicks were fed a basal corn and casein diet containing vitamins, minerals and 0.50 % cholesterol for one week to make them hypercholesterolemic. Oatrim and other major diet components were analyzed for protein (Kjeldahl N x 6.25), fat [3], starch [4], and dietary fiber [5]. Chicks were wing-banded with identification numbers and divided into three groups of eight chicks for each diet treatment. The basal diet was continued as a control for 24 chicks, and the remainder were placed on a diet containing 38 % Oatrim. Chicks were fed diets for 14 days, then fasted overnight, weighed and blood samples were drawn. Plasma was analyzed for total cholesterol, triglyceride and HDL-cholesterol on a Kodak DT 60 analyzer (Eastman Kodak, Rochester, NY). Plasma LDL-cholesterol was calculated as described by Friedwald [2].

Results and discussion

Sensory evaluation of cookies

Results of the evaluation of fat substitution by Oatrim revealed that graininess and toasted flavor intensities were not significantly affected by the addition of Oatrim to the cookies. Cookies with 100 % Oatrim substitution for fat had significantly ($P < 0.05$) less sweet taste and buttery flavor and significantly ($P < 0.05$) more cardboard flavor than the unsubstituted sample. The texture characteristics of density and cohesiveness were not significantly changed by the addition of Oatrim; however, moistness of the cookies containing 75 % or 100 % Oatrim substitution of fat was significantly ($P < 0.05$) less than the no-fat substituted control.

Overall quality of the cookies was not significantly changed by the use of 50 % Oatrim substitution for fat; however, the quality of the cookies containing either 75 % or 100 % Oatrim substitution was lower ($P < 0.05$) than the no-fat substituted control.

Sensory evaluation of reduced-fat chocolate truffles

The 100 % substitution of Oatrim for fat only affected the creamy/buttery flavor characteristics by significantly ($P < 0.05$) decreasing its flavor compared to the 0 % and the 50 % Oatrim samples. The 50 % Oatrim substitution for fat caused no significant changes in flavor intensities compared to the no-fat substituted control.

The chewiness and density texture characteristics were not significantly affected by Oatrim substitution for fat in the truffles. The grittiness levels of samples with the 100 % and 50 % Oatrim substitutions for fat were significantly ($P < 0.05$) higher than in the no-fat substituted control.

Since some textural changes were noted in the sensory evaluation, the surfaces of the different truffle centers were examined by scanning electron microscopy (SEM). Samples of the truffle centers were mounted on aluminum stubs, coated with a layer of gold-palladium (60–40) alloy, and then examined and photographed in a JEOL model JSM 6400V scanning electron microscope. The surface areas of the truffle centers at 500 μm resolution show some differences in the surface areas. The pictures cannot be directly related to mouthfeel, but they do indicate that differences in the truffle matrix can be observed.

Oatrim provides an easy way of replacing fat and increasing soluble-fiber content in many foods, especially meats, dairy, and bakery goods where it has found considerable commercial use. This study on fat substitution by Oatrim in oatmeal raisin cookies and chocolate truffles was made to determine some of the parameters on Oatrim usage as evaluated by analytical sensory evaluation and SEM in the chocolate truffles. The study was not made as an attempt to find optimum product or conditions for producing such foods. The guidelines established in this study indicates that Oat-

rim replacement can readily be used for 50 % of the fat in oatmeal raisin cookies and chocolate truffles for shortening and whipping cream, respectively. It would be expected that greater Oatrim replacement could be made, but product formulation changes also would be necessary.

Hypocholesterolemic property of Oatrim

Recent nutritional evaluation of the hypocholesterolemic property of Oatrim powder confirmed Dr. Newman's earlier conclusions [15] of a very significant reduction in total and LDL cholesterol levels. Chicks with previously elevated blood cholesterol levels were fed Oatrim and compared with the control chicks. Chicks fed Oatrim gained significantly less body weight than the controls, and there was a significant difference in feed/gain ratio between the two groups. This is a typical response when chicks are fed high soluble-fiber diets, and is usually accompanied by a corresponding fecal excretion of fat [9]. Chicks fed Oatrim had highly significantly lower ($P < 0.0001$) total and LDL-cholesterol than controls (Table 2). The chicks that were fed Oatrim showed a 40 percent decrease in blood cholesterol compared to controls with a drop in low-density lipoprotein (LDL) cholesterol of 61 percent. There were no differences in HDL-cholesterol or triglycerides between the two groups. This experiment provides further evidence for the healthful beneficial character of Oatrim. The soluble fiber of Oatrim retains its hypocholesterolemic quality in a concentrated, bland-flavored form that can be incorporated into many foods and beverages.

Table 2

Blood plasma lipids of chicks fed Oatrim or control diets (mg/dl)

Diet	n	Plasma cholesterol			Triglycerides
		Total	HDL	LDL	
Oatrim	24	239 ^a	123	99 ^a	84
Control	24	400 ^b	131	251 ^b	87

^{a,b} Columns with different superscripts are statistically different ($P < 0.0001$)

The recent review, "Two Thumbs Up for Oatrim" [14] reports on some of Oatrim health benefits in the first clinical trial by humans. Two different Oatrim products containing 1 percent or 10 percent β -glucan were investigated. Dietitians incorporated about one-half cup of each powder in various foods that were consumed by 24 volunteers with high levels of blood cholesterol. For 10 weeks the volunteers consumed Oatrim-enriched diets ranging from hamburger, cookies, and pancakes to spaghetti sauces, muffins, and fruit juices. Midway during the study, the volunteer groups were

switched to the other Oatrim-enriched diet. Both products reduced blood cholesterol levels by 8 percent with a 10 percent drop in LDL cholesterol. Additionally, their blood glucose levels decreased by 7 to 12 percent which can prove beneficial for diabetics. The largest surprise was the influence on volunteer's weight. They lost on an average of 4.5 pounds each despite a slight increase in calorie intake with no one complaining of being hungry. The future for replacing fat in the diet and reduced overall calorie intake without loss of safety appears promising for health concerned Americans.

Conclusions

A nutraceutical and nutritional evaluation of the hypocholesterolemic property of soluble-fiber containing Oatrim suggests that it could have a health benefit in foods. The hypocholesterolemic property of Oatrim in humans and chicks indicates a significant reduction in total blood cholesterol and LDL cholesterol levels. Oatrim should continue to play a larger role in healthcare and healthy life-styles with increased longevity and less chronic disease as more people realize the direct relationship of diet and health. Perhaps its greatest significance will be its long term influence on preventive heart and cancer diseases with the reduced human suffering and reduced health-care costs. It can be used in many foods. Its applications as a fat replacer was illustrated in oatmeal raisin cookies and in making reduced-fat truffle centers.

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ROZPUSZCZALNE SKŁADNIKI BŁONNIKA Z OWSA: ZASTOSOWANIE W POKARMACH I KORZYŚCI ZDROWOTNE

Streszczenie

Rozpuszczalne składniki błonnika są ważnymi składnikami pokarmowymi zapewniającymi zdrowie i chroniącymi przed pewnymi chorobami. Rozpuszczalny błonnik owsa, β -glukan obniża poziom cholesterolu we krwi zwierząt i ludzi. Zamiennik tłuszczu Oatrim otrzymuje się enzymatycznie z owsa. Zawiera on rozpuszczalny glukan, który zachowuje swe właściwości hipocholesterolemiczne. Szereg pokarmów o obniżonej zawartości tłuszczów i zupełnie beztłuszczowych zawierają Oatrim. Wśród takiej żywności należy wymienić niskotłuszczowe mięsa, sery fermentowane i wyroby piekarnicze. Sprawdzone sensoryczne parametry Oatrimu w ciasteczkach i truflach posługując się tablicami do analitycznych ocen sensorycznych. 