ABSTRACT
To determine the effects of partial replacement of fat and flour in foods with Z-Trim corn and oat fibers, brownies and ground beef patties containing Z-Trim were evaluated for flavor and texture characteristics. A cake-like brownie formulation containing 26% fat (control) was prepared with 0, 25, 50, 75, and 100% fat replacement using four levels of Z-Trim corn fiber at 0.18, 0.36, 0.55, and 0.73% by weight of total ingredients. In samples containing fat replacer, the flour level was half that of the control. The calories per gram of brownie for the full-fat product was 3.4 compared to 1.6 for the brownie with 100% fat replacement and 50% flour replacement. A trained sensory panel reported that replacing either 50, 75, or 100% of the fat in addition to 50% of the flour with the addition of Z-Trim corn fiber significantly increased moistness, density, and cohesiveness compared to the control. The fat content of 89% fat-free ground beef was reduced to 93% fat-free with Z-Trim oat fiber or a Z-Trim/oatrim blend at 1 and 1.5% addition by weight with 10% water. Sensory analysis of flavor and texture of the beef patties showed slight decreases in beef and fatty flavors and increases in texture characteristics of tenderness and juiciness.

In many foods, fat content directly relates to palatability. For example, fat creates more tender baked products, and in ground beef, fat is essential for beefy flavor, juiciness, and tenderness (1). The mouthfeel characteristics attributed to fat are a combination of several parameters including viscosity, absorption, cohesiveness, adhesiveness, and waxiness (2). Americans currently consume approximately 34% of their calories as fat; however, recommendations state that total daily fat intake should not be more than 30% of total caloric intake (3). Taste is generally the number one reason people select a particular food; the poorer flavor quality associated with a reduced fat diet may help explain consumers' inability to adhere to this type of diet (4). To help alleviate this problem, researchers have attempted a variety of methods to decrease fat in foods while preserving flavor. Previous research showed that partial or complete fat replacement caused foods to have unfavorable characteristics such as loss of or imbalance of flavor (5). For example, Sanchez and coworkers (6) found that reduced fat cookies had a chewy texture and low moisture content, whereas Brewer and coworkers (1) reported that ground beef patties with only 8% fat were more rubbery and less juicy than were patties with 20% fat.

Flavor, texture, and appearance of baked products are affected by types and amounts of fat used; therefore, fat replacers in baked products need to be able to act as fat does by aerating the batter, maintaining flavor, and providing a moist mouthfeel. The ideal fat replacer would duplicate all of the functional features of fats without contributing any calories. Of the commercial fat replacers available, 50% are carbohydrate based. According to Bath and coworkers (7), processed (swollen) starches that remain intact could duplicate the mouth sensation of fat. Des (8) reported that carbohydrates imitate fat by binding water to provide lubrication, slipperiness, body, and mouthfeel. Research has been published on effects of carbohydrate fat replacers in a variety of food products. Inglett and coworkers (9) replaced shortening in oatmeal raisin cookies with oatrim gel at 50, 75, and 100% levels. An analytical sensory panel did not find significant differences in flavor and texture between cookies with 50% fat substitution and the control (0% fat replacement) cookies; however, differences were observed between the control and cookies with 75 and 100% levels of fat substitution. Hipple-heuser and coworkers (10) used a carbohydrate-based fat replacer in muffins to compare a commercial full-fat (27%) control with muffins containing only 5% fat (low-fat control) and 5% fat muffins with either 1 or 2% pregelatinized dull waxy corn starch. Results from sensory evaluations indicated that the low-fat muffin formulation with 2% starch was preferred overall to the full-fat control. Crumb structure of the sample with 1% pregelatinized starch was preferred over the 5% fat (low-fat control) muffin, and moistness/softness of the full-fat control was preferred over the muffin with 1% starch. In research on starch-based fat replacers in high-ratio layer cakes, Bath and coworkers (7) found that cakes baked without any shortening had low volume and dense internal structure, but acceptable cakes were made with complete fat replacement using corn or rice starch with or without the addition of protein, guar gum, or emulsifiers.

Research has shown that consumers prefer ground beef containing 15–20% fat for palatability (11). As fat content of ground beef decreases, there is a corresponding decrease in beef flavor intensity, juiciness, and tenderness (1,12,13). Giese (13) reported that textural properties of meat (cohesiveness, hardness, and density) were influenced by fat level for all cooking techniques. Less hardness, lower density, and decreased cohesiveness during initial biting of the samples accounted for the increased tenderness associated with higher fat levels. According to Berry's (12) observations, shear force increased with decreasing fat content; however, more pronounced differences were noted at lower...
fat levels. Patties processed with 0% fat were rated lower in juiciness and flavor compared to all other fat levels. Berry suggested that processing and cooking would probably need to be altered to achieve acceptance of extremely low-fat beef patties.

Optimal reduced fat content for ground meat patties is around 20%, based on consumer acceptability (14). Further reductions in fat are possible by use of extenders, such as nonfat dry milk solids, texturized vegetable protein, and plant starches. To retain desirable characteristics when fat content is reduced, binders are added to meat formulations to improve water and fat-binding properties, as well as to improve cooking yields, slicing characteristics, and flavor (15). Carbohydrates are generally used in the formulation of low-fat meat products to improve cooking yield, enhance water-holding ability, reduce formulation costs, modify texture, and improve freezing stability (16). Giese stated that maltodextrins can give rise to a gel that, when hydrated, displays some characteristics that are similar to those of fat (13).

The objectives of this study were to determine the effects of partial replacement of fat and flour in foods with Z-Trim corn and oat fibers and to evaluate flavor and texture characteristics of a baked product and a meat product containing Z-Trim. Brownies were chosen because of the current increasing consumer interest in packaged brownie mixes; both regular and reduced fat types are advertised as fudgy, thick, rich, and chewy. These flavor and texture characteristics are primarily imparted by fat in the formulation, so brownies containing the fat replacer Z-Trim were analyzed for flavor and for moisture, density, and cohesiveness, which are descriptive texture attributes corresponding to the consumer terms of thick, rich, and chewy. Ground beef was chosen primarily because of the high consumption of this form of meat—40% of beef in the United States is consumed as ground beef. In addition, low-fat ground beef has potential use in school meals. In 1995, USDA published a report (18) on improving commodities in school lunch targeting 23 foods—including ground beef—that could be reduced in sugar or sodium or fat; however, low-fat ground beef is less tender and drier than higher fat meat, so Z-Trim as a partial fat replacer was investigated to determine the effects on texture of reduced fat meat.

MATERIALS AND METHODS

Brownies

A cake-like brownie containing 26% fat was prepared with and without Z-Trim corn fiber (Mountain Lake Specialty Ingredients Co., Mountain Lake, MN) at 0 and 50% flour replacement and at 0, 25, 50, 75, 90, 95, and 100% fat replacement with formulation variations listed in Table I. In all formulations, the following ingredients were added at the indicated level: sugar, 100 g; vanilla, 6 g; eggs, 100 g; cocoa, 30 g; baking powder, 0.75 g, and salt, 0.75 g. Brownies were prepared according to the following procedure: Melted margarine was mixed with vanilla, sugar, egg, and cocoa in a Hobart mixer, model N-50 (Hobart Mfg. Co., Troy, OH). Flour, baking powder, salt, and Z-Trim powder were sifted together and added to the margarine mixture along with the water and mixed. Batter (350 g) was placed in an 8 x 8 in. aluminum pan and baked at 350°F for 10 min. The Z-Trim corn fiber was added at 0.18, 0.36, 0.53, and 0.73% by weight of the total ingredients.

Sensory analysis of flavor and texture of brownie samples was conducted by a 15-member trained, experienced analytical panel. Flavor and taste characteristics of chocolate, sweet, buttery, bitter, stale, and cereal were rated on a 0–10 intensity scale where 0 = none and 10 = strong. Products were evaluated for the following three texture parameters using a 0–10 scale as follows: moistness (0 = dry, 10 = moist); density (0 = light, 10 = compact); and cohesiveness (0 = crumbly, 10 = gummy). All sensory analyses were conducted in a room equipped with individual booths and with red lights to mask the color of samples.

Ground Beef Patties

Fresh ground beef (89% fat free) was prepared with either Z-Trim oat fiber (19) or a 1:1 blend of Z-Trim oat fiber and oatrim-5 (TrimChoice-5, Mountain Lake Specialty Ingredients Co., Mountain Lake, MN) at 0% and 30% replacement levels.
Ingredients Co.). Oat fibers were added either at the 1% level with 10% water or the 1.5% level with 15% water (Table I).

To prepare the patties, 89% fat-free fresh ground beef prepared at a local commercial meat processor (HMR Foods, Inc., Morton, IL) was ground in two stages. The preliminary coarse grind was followed by a second finer grinding in which the corn fiber powder and water were added. Ground beef (114 g) was pressed into a plastic mold (9.2 cm diameter x 2.0 cm height) to obtain uniform size patties. Half of the patties were kept frozen for 24-48 hr in a -10°C freezer. To cook the beef, patties were placed on a preheated (170°C) Toastmaster griddle (model 870G, McGraw Edison Co., Boonville, MO) for 13 min (6.5 min per side) until an internal temperature of 76°C was reached. Eighty-nine percent lean fresh or frozen ground beef was used as internal controls at each testing session. Cooked patties were cut into 20-g wedges and placed in 50-ml glass beakers, covered with watch glasses, and presented to panelists.

Flavor characteristics and texture parameters of ground beef patties were evaluated by a 16-member trained, experienced analytical sensory panel. Panelists used descriptive sensory analysis techniques to identify flavors including beef, fatty, sweet, salty, and cereal/grain and were permitted to add any other characteristics not listed on the scoring scale. Flavor intensities were rated on a 10-point scale where 0 = none and 10 = strong intensity. Samples were rated for the following texture parameters: cohesiveness (0 = crumbly, 10 = gummy); chewiness (0 = tender, 10 = tough); springiness (0 = low, 10 = high); juiciness (0 = dry, 10 = juicy); density (0 = light, 10 = compact); and chalkiness (0 = low, 10 = high). All sensory analyses were conducted in rooms equipped with individual booths and red lights to mask the color of samples.

Statistical Analysis

Data were analyzed by two-way analysis of variance. Statistical significance is indicated at the 95% confidence level unless stated otherwise.

RESULTS AND DISCUSSION

Brownie Flavor

Increasing the percentage of fat replacement affected the intensity levels of flavor/taste descriptors (Fig. 1). Chocolate flavor intensity and sweet taste intensity decreased slightly with lower fat levels. Buttery flavor intensity decreased as expected. Slight increases in bitter taste and in cereal and stale flavors were noted with higher levels of fat replacement. These data show the effects of ingredient replacement without any optimization of ingredient types. In separate trials, natural chocolate and butter flavors were added at low (0.1-0.2%) levels in the formulation with 100% fat replacement, and the intensities of chocolate and buttery flavors were rated higher than the same formulation without the additives (data not shown).

Brownie Texture

Moistness. Panelists rated the control lowest for moistness, which would be expected for this cake-like brownie formulation (Fig. 2). The addition of Z-Trim corn fiber significantly increased the moistness of the brownies compared with that of the control without Z-Trim. The rating of 5.0 for moistness for the control (0% fat replacement, 0% flour replacement) represented a moderately moist product; however, ratings of 7.0 and above represented a fudge-like brownie texture. The percent moisture loss during baking was calculated as 5.8 in the control and 6.3 in the sample with 50% flour and 100% fat replaced; however, this does not fully account for the significant differences in the moistness of the baked products.

Density. The density of the brownies was increased by the addition of Z-Trim to the formulation (Fig. 2). The control was rated a 4.0 on the density scale, indicating a cake-like product. The addition of Z-Trim to the 50, 75, and 100% fat replacement samples increased the density scores compared with the control. Ratings of 7.0 and above represented a fudge-like brownie texture.

CEREAL FOODS WORLD / 823
Cohesiveness. The cohesiveness of the texture of the brownies was increased significantly by the addition of Z-Trim at levels of 50, 75, and 100% fat replacement compared with the control (Fig. 2). Ratings of 7.0 and above represented a fudge-like brownie texture.

Texture scores of brownies containing Z-Trim showed brownies with increased moisture, density, and cohesiveness compared with the control. In consumer terms, the brownies with 50-100% fat replacement by Z-Trim addition might be described as thick and chewy. The effects of Z-Trim fat replacement on the texture and calorie levels in the samples showed that even though the calorie levels decreased, the intensity of the texture characteristics increased (Fig. 3). The control brownie with no Z-Trim had 34 calories per gram. As the fat level was decreased with increasing percent of Z-Trim addition, the calories per gram decreased to a low of 1.6 cal/g in the sample with 100% fat replacement.

Ground Beef Flavor

In fresh ground beef samples, decreasing the fat content to 91% fat-free from the 89% fat-free control showed no significant effect on beef flavor intensity; however, significant differences were observed between the 89% control and the 93% fat-free samples (Fig. 4). Fatty flavor intensity was significantly less in the samples containing either Z-Trim or the blend than that in the control.

Freezing raw patties for 24-48 hr at -10°C before cooking resulted in lower intensities for beef flavor in the control and in the samples containing 1% Z-Trim (Fig. 5) than for the corresponding fresh samples (Fig. 4). However, samples containing 1.5% Z-Trim that were evaluated after freezing had higher intensities of beef flavor than did the same formulation evaluated as a fresh sample. Although the control that had been frozen had less fatty flavor intensity than the fresh control, few differences in fatty flavor intensity were noted between frozen and unfrozen patties containing Z-Trim. In comparing samples frozen before cooking, no significant differences in either beefy flavor intensity or fatty flavor intensity were noted between the control and the samples with the fat replacers.

Ground Beef Texture

All additions of either Z-Trim or the Z-Trim/oatrim blend in the unfrozen patties produced significantly less chewiness and more juiciness than the control (Fig. 6). However, samples containing 1.5% fat replacer had significantly higher ratings for chalkiness than that of the control. Freezing the patties before cooking increased the chewiness for all samples and decreased juiciness of all samples except the 1% Z-Trim compared to the unfrozen samples (Fig. 7). Samples frozen before cooking and containing 1% fat replacer were less chewy and more juicy than the control. Chalkiness ratings were the highest for the samples with 1.5% fat replacers.

In summary, replacing 50, 75, or 100% of the fat in addition to 50% of the flour with the addition of corn fiber Z-Trim in brownies significantly increased the texture characteristics of moisture, density, and cohesiveness compared to the control. Intensities of chocolate and buttery flavors decreased slightly with higher levels of fat replacement. A 90-g portion of the control brownie contained 350 calories and 24 g of fat; whereas a 90-g sample of the brownie with 100% fat replacement had 175 calories and 3 g of fat. Addition of oat fiber Z-Trim or Z-Trim/oatrin-S blend to 89% fat-free ground beef decreased chewiness and increased juiciness compared to the control. Intensities
of fatty flavors decreased with increasing fat replacement. At 1.5% fat replacement, beef flavor intensity was lower than that for the control. A 90-g cooked control patty had 190 calories and 10 g of fat; whereas a 90-g cooked patty with 1.5% Z-Trim and 10% water had 140 calories and 6 g of fat.

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REFERENCES

Fig. 5. Flavor intensity scores for frozen cooked ground beef with partial fat replacement and 1-1.5% Z-Trim or Z-Trim:Oatrim 5 addition.

Fig. 6. Texture scores for fresh cooked ground beef with partial fat replacement and 1-1.5% Z-Trim or Z-Trim:Oatrim 5 addition.

Fig. 7. Texture scores for frozen cooked ground beef with partial fat replacement and 1-1.5% Z-Trim or Z-Trim:Oatrim 5 addition.