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# Changes in energy and cholesterol contents of frankfurter-type sausages with fat reduction and fat replacer addition

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**Abstract**

Fat contents of sausages were reduced from 20% to 10% and 5%. Citrus fibre (CF) and soy protein concentrate (SPC) were added to the sausages at the rates of 2% as fat replacers. Changes in energy values and cholesterol contents of the sausages were investigated. Energy values and cholesterol contents significantly decreased with decreasing fat level. Addition of fat replacers increased energy values, but cholesterol contents decreased. There was no difference between sausages treated with CF and those with SPC. Total decreases in energy values and cholesterol contents were 38.6% and 45.7%, respectively.


*Keywords:* Low-fat sausage; Energy value; Cholesterol; Fat replacers

## 1. Introduction

The fat in diet supplies energy, essential fatty acids and fat-soluble vitamins and improves the texture, flavour and acceptability of foods. However, fat has more than twice the caloric value of protein and carbohydrates (Papadima & Bloukas, 1999).

There is evidence that fat-rich diets, as well as causing obesity, are also directly related to the risk of colon cancer. Fat and cholesterol are also associated with cardiovascular diseases. In light of these implications, various international institutions, among them the World Health Organization (WHO), have drawn up the following nutritional recommendations: fat should provide between 15% and 30% of the calories in the diet; saturated fat should provide not more than 10% of these calories, and cholesterol intake should be limited to 300 mg/day (Chizzolini, Zanardi, Dorigoni, & Ghidini, 1999; Jimenes-Colmenero, Carballo, & Cofrades, 2001).

Low-calorie/fat foods were initially introduced to serve specific dietary and sliming needs. This food category was originally developed for diabetics and individuals with specific medical problems, such as obesity and heart disease.

Cholesterol content of some meat products, such as sausages, hamburgers and, in general, those based on ground meat mixed with fat, can vary considerably and the effect of fat on cholesterol content appears to be significant only for the very fatty products. In such products a decrease in fat content can have marked effects on calorie intake and cholesterol content (Hoelscher, Savell, Harris, Cross, & Rhee, 1987) (see Fig. 1).

Although the production and sales of low-fat foods have increased, there are many problems concerning the acceptance of these products (Sandrou & Arvanitoyyanis, 2000), When the fat levels are lowered the products become firmer, more rubbery, less juicy, darker in colour, more costly and less acceptable in terms of

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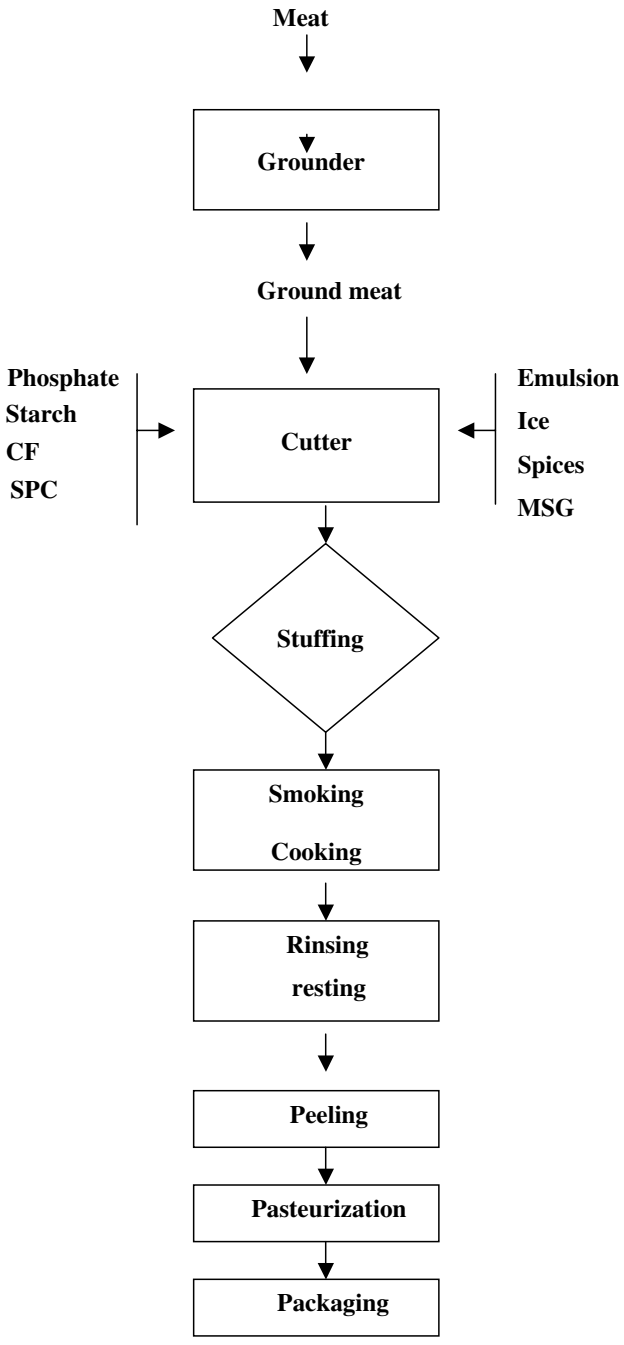


Fig. 1. Flow diagram for sausage manufacture.

skin formation, mouth feel, processing yield and increased purge in vacuum package (Keeton, 1994).

Manufacturers have introduced several modifications in an attempt to offset the detrimental effects of reducing the fat level. These modifications include the selection of meat ingredients, the adaptation or preparation of technologies either to vary the composition of final product or to introduce certain functional characteristics and, finally, the use of non-meat ingredients that can help convey desirable texture and enhance water-holding ability (Garcia, Dominguez, Galvez, Casas, & Selgas, 2002).

Soy protein concentrates (SPCs) and isolates have been used successfully for the reduction of fat levels in comminuted frankfurters (Chempka & Babji, 1996; Katsaras & Peetz, 1994; Yang, Trout, & Shay, 1995). Dietary fibre, also, has been used in meat emulsion products (Claus & Hunt, 1991; Cofrades, Troy, & Hughes, 1995; Grigelmo-Miguel, Abadias-Seros, & Martin-Belloso, 1999).

In this study, fat content of frankfurter-type sausages was reduced from 20% to 10% and 5% and citrus fibre (CF) and SPCs were added to the sausages as fat replacers. The aim of this study was to investigate the changes in calorie and cholesterol contents of the sausages after reducing fat contents and to determine the effects of addition of CF and SPC on calorie and cholesterol contents of the sausages.

## 2. Materials and methods

### 2.1. Preparation of frankfurters

Frankfurters were manufactured in a private processing plant. Fresh beef was minced through a 3 mm plate using a Mado mincer MEW 510-2. The meats were weighed, vacuum packed separately and frozen at −18 °C until use. Frozen meats were thawed at 4 °C for 16 h prior to use. The target fat levels were 5%, 10% and 20%. Formulations were calculated to a 5 kg batter. Nine groups of batters were prepared. Three products were prepared containing 5%, 10% and 20% fat. Citrus fibre (Herbacel AQ Plus, Herbafood Ingredients GmbH, Werder, Germany) and soy protein concentrate (Danprotex H-40, Central soya protein group, Denmark) were added separately to these emulsions at an addition rate of 2%. Compositions of CF and SPC are given in Table 1. Controls without CF and SPC were also prepared, to give a total of nine treatments (3 × 3 factorial design). The nine treatments were given the following codes: 5-C (5% fat control), 5-CF (5% fat + CF), 5-SPC (5% fat + SPC), 10-C (10% fat control), 10-CF (10% fat + CF), 10-SPC (10% fat + SPC), 20-C (20% fat control), 20-CF (20% fat + CF), 20-SPC (20% fat + SPC). Quantity of meat, water and ingredients, except SPC and CF, were initially constant. Only emul-

Table 1
Chemical compositions of citrus fibre and soy protein concentrate

| Contents | Citrus fibre (CF) | Soy protein concentrate (SPC) |
|---|---|---|
| Total fibre (g/100 g) | 92 | 4 |
| Carbohydrate (g/100 g) | 0.5 | 17.6 |
| Ash (g/100 g) | 1 | 5.5 |
| Protein(g/100 g) | – | 64.4 |
| Energy (kcal/100 g) | 2 | 23.9 |

Table 2
Quantities of ingredients used in the formulations of batters (kg)

| Formulation | Lean beef | E | I + C | Starch | SL | MSG | Nitrite salt | STP | Spice mix | CF | SPC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5-C | 3.0 | 0.2 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0 | 0 |
| 5-CF | 3.0 | 0.2 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0.078 | 0 |
| 5-SPC | 3.0 | 0.2 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0 | 0.078 |
| 10-C | 3.0 | 0.6 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0 | 0 |
| 10-CF | 3.0 | 0.6 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0.88 | 0 |
| 10-SPC | 3.0 | 0.6 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0 | 0.88 |
| 20-C | 3.0 | 1.6 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0 | 0 |
| 20-CF | 3.0 | 1.6 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0.1 | 0 |
| 20-SPC | 3.0 | 1.6 | 0.3 | 0.0382 | 0.019 | 0.024 | 0.015 | 0.025 | 0.0146 | 0 | 0.1 |

E, emulsion, I + C, ice + water, SL, sodium lactate, MSG, monosodium glutamate, STP, sodium tripolyphosphate, CF, citrus fibre, SPC, soy protein concentrate.

sions containing 50% fat in varying quantities, according to the required fat levels, were added in the formulations. Ingredients and their rates used in the formulations are shown in Table 2.

Thawed meats were placed in a cutter (Mado, MTK 661) along with the other ingredients. They were mixed in 5 kg batches prior to stuffing. Total mixing time was 10–15 min and the final temperature of batter was 10.0–12.3 °C. Prepared frankfurter mixture was stuffed, using a stuffer (Handtmann, VF100/240), into 14-mm diameter casings. The frankfurters were hanged, smoked and cooked for 25 min at 76 °C. The cooked frankfurters were rinsed with cold water and kept overnight at 4 °C. The casings were removed and products vacuum-packed with a multivac vacuum-packaging machine (R 230/719) after pasteurization. Two replications of the experiment were conducted at separate times.

### 2.2. Analyses

The moisture contents of the samples were determined by drying the sample in an oven at 103 + 2 °C until a constant weight was obtained (Anonymous, 1974a). Crude protein content was calculated by converting the nitrogen content determined by Kjeldahl's method (6.25× N). Fat was determined using the Soxhlet system (Anonymous, 1974b). Ash content was determined by dry ashing in a furnace at 550 °C (Anonymous, 1974c). Carbohydrate contents were estimated by difference.

Total calorie values (kcal) were calculated using the Atwater method. The following equation was used for calculation (Watt & Mersil, 1975):

$$K = [(F_p \times P) + (F_l \times L) + (F_c \times C)],$$

where $K$ is the calorie; $F$ the multiplication factor for each component ($F_p$: 4.27 for protein, $F_l$: 9.02 for lipid, $F_c$: 4.10 for carbohydrate); $P$ the protein content (g/100 g); $C$ the carbohydrate content (g/100 g) and $L$ the lipid content (g/100 g).

Total cholesterol was determined using a spectrophotometric method, as described by Rudel and Moris (1973).

Data were subjected to analysis of variance followed by Duncan's multiple range test using Statistical Analytical Systems (SAS).

## 3. Results and discussion

Proximate compositions of the sausages manufactured in different formulations are shown in Table 3.

Energy values of the sausages are shown in Table 4. Energy values of the sausages ranged from 151 to 250 kcal/

Table 3
Proximate composition of sausages

| | Moisture (%) | Protein (%) | Fat (%) | Ash (%) |
|---|---|---|---|---|
| 5-C | 67.04 ± 0.02a | 17.1 ± 0.45ad | 5.74 ± 0.12a | 3.40 ± 0.01a |
| 5-SPC | 67.28 ± 0.32a | 18.1 ± 1.02a | 5.85 ± 0.07a | 3.44 ± 0.02ad |
| 5-CF | 66.70 ± 0.01a | 16.3 ± 0.85ad | 5.69 ± 0.26a | 3.44 ± 0.03ad |
| 10-C | 65.70 ± 0.11b | 16.3 ± 0.66be | 9.89 ± 0.25b | 3.32 ± 0.08b |
| 10-SPC | 65.32 ± 0.62b | 16.2 ± 0.28b | 10.16 ± 0.28b | 2.83 ± 0.06be |
| 10-CF | 65.40 ± 0.44b | 15.5 ± 0.21be | 10.13 ± 0.16b | 2.88 ± 0.02be |
| 20-C | 60.67 ± 0.14c | 14.0 ± 0.21cf | 19.59 ± 0.01c | 3.29 ± 0.06c |
| 20-SPC | 59.59 ± 0.82c | 15.2 ± 0.24c | 19.37 ± 0.11c | 3.23 ± 0.07cf |
| 20-CF | 60.35 ± 0.49c | 14.0 ± 0.02cf | 19.55 ± 0.13c | 3.13 ± 0.18cf |

All values are means ± SD.
Values in the same column bearing different letters are significantly different ($p < 0.01$).

Table 4
Energy values (kcal/kg) and cholesterol contents (g/100 g) of control and low-fat frankfurters formulated with soy protein concentrate and citrus fibre

| | 5-C | 5-SPC | 5-CF | 10-C | 10-SPC | 10-CF | 20-C | 20-SPC | 20-CF |
|---|---|---|---|---|---|---|---|---|---|
| Energy | 151 ± 0.85aA | 155 ± 0.06a | 155 ± 2.34a | 178 ± 0.96bB | 183 ± 4.13b | 183 ± 2.51b | 247 ± 0.36cC | 250 ± 3.06c | 248 ± 0.59c |
| Cholesterol | 0.201 ± 0.001a | 0.184 ± 0.001b | 0.179 ± 0.001c | 0.252 ± 0.001d | 0.216 ± 0.00e | 0.206 ± 0.001f | 0.371 ± 0.001g | 0.324 ± 0.002h | 0.300 ± 0.001j |

All values reflect means ± SD.
Values in the same row bearing different low case letters are significantly different ($p < 0.01$).
Values in the same row bearing different capital letters are significantly different ($p < 0.05$).

100 g. The effect of fat contents on energy values of the sausages was significant ($p < 0.01$). Energy values of the sausages decreased significantly ($p < 0.01$) with reduced fat levels. Fat reductions in frankfurters of 50% or 75% were obtained with a consequent decreases in energy values of 27.7% and 38.6%. The lowest energy value was found in the 5% fat sausages. These results are in agreement with the results obtained by Grigelmo-Miguel et al. (1999) in low-fat high dietary fibre frankfurters. In previous work, it was reported that fat reduction from 25% to 6% and 10% resulted in approximately 35% reduction in energy value (Garcia et al., 2002). Compared to our results, higher values were found in the low-fat frankfurters by Bloukas and Paneras (1996), Park, Rhee, Keeton, and Rhee (1989) and Paneras and Bloukas (1994). This is probably due to high water losses.

Energy values of the sausages with added CF and SPC were significantly ($p > 0.05$) higher than those of control sausages. But there is no difference between sausages with added CF and those with SPC. Addition of SPC and CF significantly ($p < 0.05$) increased energy values.

Cholesterol contents of the sausages significantly ($p < 0.01$) decreased with decreasing fat levels (Table 4). The highest cholesterol content was found in the 20% fat sausages. When the fat levels were reduced from 20% to 10% and 5% decreases in cholesterol contents were found to be 32.0% and 45.8%, respectively. Cholesterol contents of all groups ranged from 0.18 to 0.37 g/100 g. In a previous study, 20% lower cholesterol content in beef patties was found after reducing the fat content from 20% to 10% (McMindes, 1991). Minerich, Addis, Epley, and Bingham (1991) reported that cholesterol contents in the 12.5% and 19% fat beef patties were 0.075 and 0.079 g/100 g, respectively. Candogan and Kolsarici (2003) reported that reduction of fat from 17.07% to less than 3.0% resulted in a 50–56% lower cholesterol in frankfurters.

Addition of CF and SPC significantly ($p < 0.01$) decreased the cholesterol values. The lowest cholesterol content was found in the sausages manufactured with addition of CF. There were significant ($p < 0.01$) differences between the sausages with added CF and those with SPC. Cholesterol contents of the sausages with added CF ranged between 0.18 and 0.30 g/100 g. Candogan and Kolsarici (2003) found that cholesterol contents significantly decreased after addition of 0.7% carrageenan and 0.7 carrageenan + pectin gel to low-fat frankfurters. Jimenes-Colmenero et al. (2001) reported that reducing the percentage of fat in the product did not seem to be a viable method for lowering cholesterol in meat derivatives and less cholesterol could be obtained by replacing fat and lean meat raw materials (since dietary cholesterol is strictly linked to animal cells) with other vegetable materials containing no cholesterol. Mansour and Khalil (1997) reported that the cholesterol

content of uncooked and cooked beefburgers decreased with addition of wheat fibres.

## 4. Conclusion

Fat level can be successfully reduced by 50% and 75%. Thus sausages with about 30–40% less energy value and about 30–45% less cholesterol content can be manufactured. Addition of CF and SPC results in increase in energy values and decrease in cholesterol contents of the sausages. Sausages manufactured in nine different formulations are nutritionally satisfactory.

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