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### X-ray scattering from meat based-food

Thesis submitted for the partial fulfillment of Master Degree in Physics (Biophysics)

#### $\mathbf{B}\mathbf{y}$

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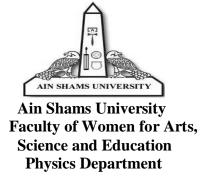
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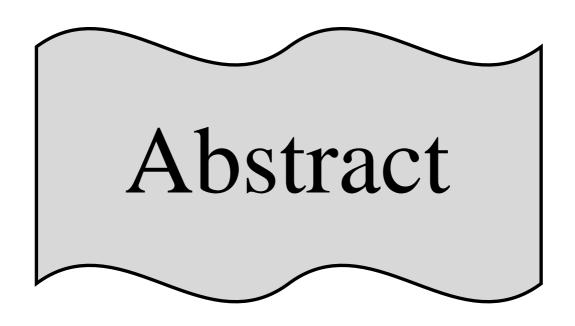
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# $\mathcal{T}_{0}$ My grandmother $\mathcal{T}_{0}$ My parents $\mathcal{T}_0$ My brothers



#### **Abstract**

A widespread concern in the world for a safe and nutritious food supply continues to be a major focus. Several techniques are used in meat products inspection to insure its safety for human consumption. Lipid content and lipid quality are major parameters affecting the quality of meat products. The control of lipid content and lipid quality are therefore crucial for human health keeping in a world where there are increased consumption of high lipid content and low lipid quality (related to structural changes in fat molecules as a result of lipid oxidation) meat products. Unhealthy meat products contribute to some serious diseases such as obesity, diabetes and some types of cancer. This work suggests x-ray scattering as a novel technique in meat products control. X-ray scattering from biological samples provides characteristic profiles, which depend on their molecular structure. Adipose tissue show a sharp x-ray scattering peak at a momentum transfer value of 1.1 nm<sup>-1</sup> due to the highly ordered fat molecules. On the other hand beef muscle exhibits a broad x-ray scattering peak similar to that of water at 1.6 nm<sup>-1</sup>. X-ray scattering measurements are carried out on twenty-one freshly prepared mixtures of fat and beef tissues having different fat content in addition to twelve beef product samples (from three different producer companies). The characteristic parameters  $I_1 / I_2$  and  $A_1/A_2$  (ratio of intensities and areas of adipose to soft tissue, respectively) are calculated for each measurement. The characterization parameters  $I_1$  /  $I_2$  and  $A_1/A_2$  are plotted against fat content of freshly prepared mixtures over the range from 0 g / 100 g to 50 g / 100 g (added fat / pure beef). Both, the x-ray scattering profiles and the fat content of purchased beef products are compared to those of the prepared mixtures with similar fat content.

Results show a high correlation between  $I_1$  /  $I_2$  and  $A_1/A_2$  characterization parameters and fat content of freshly prepared mixtures ( $R^2 = 0.9628$ , 0.9511 respectively). The comparison between the x-ray scattering profiles of purchased meat products and freshly prepared mixtures reflects a high dependence of fat peak position and shape on the deterioration in microstructure of fat. These results are reinforced by the measurements of the FWHM characterization parameter and the RMSD of the x-ray scattering profiles of freshly prepared and products samples. Since, X-ray scattering is rapid, non-invasive, non destructive and does not require any chemical treatment before measurements, it would represent a promising alternative technique to other chemical and physical techniques that are currently in use for fat quality and fat content assessment.

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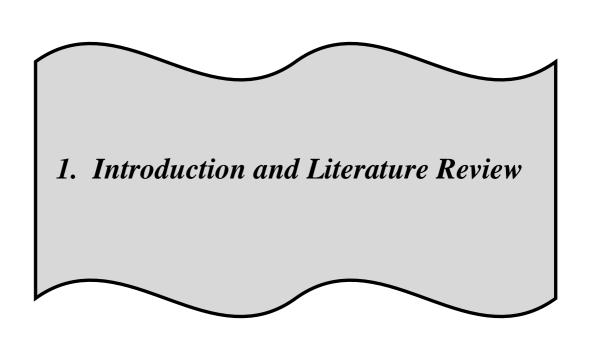
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#### 1.1. Introduction

Like any other food, meat and meat products contain elements which in certain circumstances and in inappropriate proportions have a negative effect on human health. Some of these are constituents (natural or otherwise) present in live animals, for instance, fat, cholesterol. residues from environmental pollution or some pharmaceuticals (Jiménez-Colmenero et al. 2001). The fat content and quality of meat products are very important to consumers due to the reported correlation between high intake of saturated fat and some serious diseases such as cardiovascular diseases, cancer, diabetes and obesity (Wood 2003; Resurreccion 2003; Corrèa et al. 2009; Ferguson 2010). The World Cancer Research Fund report (2007) declared increased warnings against the consumption of meat products and recommended avoiding processed meat consumption. There are a number of possible mechanisms for a link between meat consumption and colorectal cancer. These include the promotion of carcinogenesis by high-fat intake and/or carcinogens generated through various cooking and processing methods (Ferguson 2010). Lipid oxidation is a major cause of chemical muscle spoilage in meats. It occurs during processing and storage when meat is exposed to oxygen, heat, and light. Oxidative rancidity also results in nutritional losses when essential polyunsaturated fatty acids are oxidized and break down into potentially carcinogenic and mutagenic products (Esterbauer 1993; Teets and Were 2008). Thus, the creation of effective techniques is recommended to measure the fat content and ensure the safety of its structure. This work