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NUTRITIONAL AND SENSORY EVALUATION OF MEAT PRODUCTS EXTENDED WITH TEXTURED PLANT PROTEINS

by

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This thesis is dedicated to the memory

of my mother, the late

Hanna Sokolsky

who instilled in me the value

of knowledge

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A B S T R A C T

The nutritional and sensoric properties of meat products extended with texturized plant proteins (TPP), were studied by evaluating four sources of plant protein at various levels. Fababean protein concentrate (FBPC), soy protein concentrate (SPC) and pea protein concentrate (PPC) were texturized by extrusion to evaluate the effect of heat treatment on the biological value of the protein. Oats were used in the form of flakes (rolled oats). A portion of the FBPC was extracted with ethanol:water (60:40), to remove vicine and convicine which are believed to be anti-nutritional factors. Growth assays were conducted to obtain protein efficiency ratios (PER) for the plant proteins and mixtures of meat plus plant proteins incorporated into rat diets. Organoleptic characteristics of meat loaves, which contained three levels of texturized plant proteins (5, 15 and 25%), were evaluated by five trained panelists using the method of magnitude estimation.

Meat showed a better biological value than plant proteins when fed as the only source of protein. When

formulated meat loaves were the source of protein in the assay diet, meat, supplemented with other sources of proteins, demonstrated a superior biological value and better protein utilization than the pure meat product. Untreated fababean proved to be nutritionally a better source of protein, while ethanol extraction improved water absorption plus water and fat retention capacities. Overall performance of fababean was superior to the other sources of proteins used in the study. A decrease in the level of several amino acids (lysine, cystine, methionine, etc.) in the heat treated samples, indicated a negative effect of heat treatment on biological value of proteins. Supplementation of a protein system by other sources of proteins eliminated this effect.

There were no significant differences in flavor perception between samples, since the spices added to the product masked the beany (bitter) flavor of the protein concentrates. Firmness of the product was affected by the source of the plant protein and not by the level added to the meat loaf. A similar trend was found to be true for chewiness, with fababean and soy concentrates showing a high degree of chewiness. Grittiness was found to be high in samples which contained 15 and 25% of plant proteins, with oats being rated very low in grittiness. Panelists have found the texturized fababean proteins to be acceptable meat extenders when used at levels between 5 and 25%. Generally, meat products extended with 5 and 15% plant proteins were preferred over samples which contained higher levels.

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INTRODUCTION

Changes are taking place continuously all over the world. Constant increase in populations and changes in life styles bring many countries to the verge of shortage of the most basic and essential foods. At the present time, North American food protein sources are in abundance, however, shortages may be a future food issue as it is presently in many other countries. From estimation of supply and demand data on a world basis, it has been projected that there will be a deficit of 30.2 million metric tons of animal protein sources by 1980 (Burrows, Greene, Korol, Melnychyn, Pearson and Sibbald, 1972). An increase in demand and a constant or even decrease in supply drives prices up. Ground meat, one of the cheapest and readily available source of animal protein, is reaching the $2.00 a pound mark (Anon, 1979). This sharp rise in price will eliminate one of the most essential food items from the tables of many North Americans. It has been postulated that in the next few decades, plant proteins will constitute up to two-thirds of the world's high grade protein (Bird, 1974). At the present time, cereal grains account for the major portion of consumed plant proteins. Oilseed meals and legumes offer potential new sources of fairly high quality protein. An immediate increase in the use of soy and other available vegetable protein concentrates was clearly anticipated by the food industry as early as 1973 (McCleary, 1973). Because of the limited region adapted to growing soybeans in Canada, current interest is focused on the use in human foods of high protein crops adaptable to the prairie region. Fababeans (*Vicia faba minor*) and field peas (*Pisum sativum*) offer such a potential (Evans, Seitzer and Bushuk, 1972; Youngs, 1970).

The use of texturized soy product as an extender in ground beef was introduced to Canada in 1973 without prior notice (Vaisey, Tassos, McDonald and Youngs, 1975). Although work has been done by many scientists on the effects of added textured plant proteins to beef (Vaisey *et al*., 1975; Seideman *et al*., 1977) most of it has been done on beef patties. In spite of the work done on the meat extenders, the lack of an extensive picture still exists. Studies on the nutritional aspects of the meat-plant protein mixtures, on the effects of texturization on rat growth performance, on chemical score, limiting amino acid, complementation, amino acid availability as well as functional properties and sensory attributes are needed. An inclusive study which will enable the industry to manufacture high-quality and palatable products and at the same time will educate the consumer to appreciate the benefits of the new products, will prevent only partial acceptance or repulsion by consumers because of lack of product knowledge (Woolcott, Vaisey and McDaniel, 1974).

It has been found that meat products containing high plant protein concentrate in the texturized form are more acceptable than when they were added in the form of flour (Vaisey et al., 1975). During texturization of high protein concentrates and subsequent processing of the product, heat is introduced which will affect the amino acid composition of the protein, plus availability and retention (Sarwar et al., 1975).

One of the new protein sources on the prairies for human consumption, is the fababean. As a legume high in protein, it has attracted the attention of many scientists but there are obstacles to wide utilization of the fababean as food. Bitter flavor is one flavor parameter frequently ascribed to plant proteins and the fababean is no exception (Donaldson, 1978). Another drawback to the more widespread use of the fababeans stems from its toxicity which, in certain circumstances, can give rise to the disease favism (Jamalian et al., 1976), an acute heamolytic anaemia. Whether or not texturization of high protein concentrates and chemical removal of toxins or anti-nutritional factors from the protein source have adverse effects on its nutritional value, has not yet been made clear.

The objectives of the present study were as follows:

1. To observe the performance of plant protein concentrates as meat extenders by means of bioassay, and sensory evaluation.
2. To observe the effects of heat treatment as applied during texturization on the individual amino acids and the protein as a whole.
3. To determine the changes that will occur in the level and availability of several amino acids as a result of vicine removal.

4. To evaluate the nutritional value and protein quality of several plant proteins (namely: fababean, oats, pea, soy) by a biological evaluation.
5. To study the effect of increasing protein level on the sensory perception of flavor and textural parameters.
6. To evaluate the method of predicting protein efficiency ratio as a potentially fast and reliable way for determination of the food quality.

LITERATURE REVIEW

Proteins and Amino Acid Functions

Proteins are peptides of high molecular weight. They are either made of amino acids alone ('holoproteins'), or they may contain, in addition to their peptide moiety, a so-called prosthetic group of various chemical compositions ('heteroproteins', also called 'conjugated proteins'). In the field of food and nutrition, protein and amino acid functions are limited to those directly concerned with (a) digestion processes in the gastro-intestinal tract (b) with anabolic, and (c) with catabolic processes and considered both locally in various body tissues, and more generally, in the living body as a whole in its metabolic exchanges with the environment (Bigwood, 1972). There are several nutritional functions of proteins and amino acids; nitrogen balance of the body, nitrogen and sulfur supply to the body and metabolic processes. A major nutritional aspect of amino acid metabolism concerns the method of evaluation of protein quality of foodsaand diets. The distribution of the amino acid supply to the body tissues varies with the amino acid pattern and the nutritive quality of the protein material available. The closer this pattern happens to be to the amino acid pattern essential to satisfy the requirements of the body, the greater the biological value of the protein source happens to be. This very essential problem of determining biologically the quality of a dietary protein or of a diet has led to very extensive research.

Biological Evaluation of Dietary Proteins

Protein quality relates to the efficiency with which various food proteins are used for synthesis and maintenance of tissue protein. Chemical methods, such as various amino acid scoring procedures, can give a fairly good indication of the protein value of a food (Jansen, 1978). Unfortunately, such methods are of somewhat limited value because they do not take into account digestibility and availability of amino acids. There are several methods of biological evaluation of protein sources (Hartog and Pol, 1972), but since rat growth evaluation is the standard used for regulatory purposes by both the United States and Canadian governments, a great deal of work on protein evaluation was done applying this method. Evaluation of protein quality by utilizing the Protein Efficiency Ratio (PER) method was performed on various sources of proteins such as meat (Wilding, 1974, Brinkman and MacNeil, 1976, MacNeil, Mast and Leach, 1978), nutritional values of plant proteins (Sarwar, Sosulski and Bell, 1977, Womack, Bodwell and Vaugham, 1974), and mixtures of meat and plant proteins (Olson, Sosulski and Christensen, 1978). In spite of the fact that the failure of the PER assay to properly credit protein used for maintenance is a serious flaw (Jansen, 1978), it has been used, as was shown, by many scientists. Results obtained from growth rate experiments give a clear indication of the biological value of proteins from various sources.

Time is another limiting factor in the PER method for evaluation of protein quality. Feeding trial lasts twenty-eight days plus five days of acclimation period, makes the growth trial both lengthy and expensive. Several food standard proposals by the United States Department of Agriculture and Canada Department of Agriculture, require a demonstration of adequate protein quality, but PER is the only method that has been accepted by the Association of Official Analytical Chemists (AOAC, 1975, Jansen, 1978). Therefore, a less expensive and more rapid technique is desirable. Alsmeyer, Cunningham and Happich (1974) proposed an equation which will assist in prediction of PER from amino acid analysis. In-vitro methods to predict PER by using enzymatic digestibility of the proteins, had a significantly high correlation with observed PER values for forty-five different sources of proteins (Satterlee, Kendrick and Miller, 1977, Hsu, Sutton, Banjo, Satterlee and Kendrick, 1978).

Supplementary Effect on Biological Value

Limiting amino acid is a cause for only partial availability and utilization of the other amino acids in the protein. The result of partial utilization is an inefficient exploitation of available proteins. Minimizing this effect can be done by supplementing the diet with other diets rich in the specific amino acid or with the limiting amino acid itself. Supplementation of pea protein concentrate with 0.5% and 1% DL-methionine or methionine hydroxy analog (MHA), proved to be a successful method in improving biological value of the protein. The PER values were higher with 1% of amino acid added to the diet than with 0.5% (Keith, Youngs and McLaughlan, 1977). Methionine supplementation at the level of 0.3%, significantly increased the PER values of soy protein fed to rats (Kapoor and Gupta, 1975). It has also improved the values of net protein utilization and retention. Marquardt and Campbell (1975), reported that chicks fed a ration containing 90% fababeans, grew significantly better when 0.24% methionine was added to the diet. On the other hand, it was established that free methionine will enhance bitterness (Donaldson, 1978) and will adversely affect product palatability (Kies and Fox, 1971). Sarwar et al., (1977) investigated the availability of amino acids in soybean, field pea or fababean and their blends with methionine or wheat. Availability of the sulfur amino acids improved when diets were supplemented with either the methionine or the wheat. It is a well established fact that methionine and cystine are present in low levels in many legumes and oilseeds (soybean, fababean, field pea, etc.) with methionine the first limiting amino acid (Bigwood, 1972, Kakade, 1974 and Blair, 1977). It is also known that proteins from animal sources (meat, egg) contain higher levels of sulfur amino acids (Bigwood, 1972). The utilization of plant proteins as meat extender should lessen the negative affect of the methionine deficiency in plant materials.

Quality of a protein may be estimated from its amino acid composition as compared with the reference pattern of amino acids. Block and Mitchell (1946) suggested that since all amino acids must be present at the site of protein synthesis in adequate amounts for protein synthesis to proceed, an equal percentage deficit of any essential amino acid would limit protein synthesis to a comparable degree. Also, they investigated the correlation of chemical structure and nutritive value of food proteins on rats fed seventeen proteins or food protein mixtures with egg as the reference protein since it was known to have a biological value closely approaching 100. They concluded that, if the comparison of an "ideal protein", i.e., one containing all the essential amino acids in sufficient amounts to meet requirements without any excess, were known, then it should be possible to compute the nutritive quality of a protein by calculating the deficit of each essential amino acid from the amount in the "ideal protein" with the "most limiting amino acid" determining the nutritive value. The World Health Organization technical committee for energy and proteins, adopted a new provisional amino acid scoring pattern based on the level of individual amino acids needed to guarantee optimal growth and maintenance (World Health Organization, 1973).

Effect of Processing Conditions on Nutritive Quality of Plant Protein

The increase in the demand and consumption of plant proteins, forced researchers and industry to study the effects of protein concentration and texturization on nutritive value. The heat treatment involved in autoclaving of a diet or extrusion of the protein source (Marquardt et al., 1975), and oil extraction is a controversial subject. Marquardt et al., (1975) fed to chicks, heat treated fababean and observed an improvement of 16% in growth rates and 19% in feed/gain ratios when fababean was extruded or steam autoclaved. Nitsan (1971) on the other hand, observed a decrease in growth rate among rats fed autoclaved fababean. Bressani, Elias and Gomez

Brenes (1972), claim on the basis of extensive work done on oil extraction from cottonseed and soybean that heat processing causes a decrease in available amino acids in the majority of cases, because of destruction or inactivation. Both effects cause a deficiency of one or more amino acids and a decrease in digestibility. The presence or absence of reducing sugars in the diet can affect the degree of nutritional damage. In the presence of reducing sugars even mild heating results in reactions with free amino acid groups, primarily those of lysine. When reducing sugars are absent, however, severe conditions are necessary to cause nutritional damage, which may result from internal amide formation. Isolation of proteins from soybean meal by 0.2% sodium hydroxide, results in a decrease in availability of lysine by about 18% (Sarwar et al., 1975). In the same study, it was also shown that rapeseed meal autoclaved for four hours reduced the availability by 30%. Womack et al., (1974) have demonstrated that lysine, histidine, methionine, threonine and tryptophan, were affected by autoclaving at 120 C for thirty minutes. Similar work was done on chick peas (*Cicer arietinum*) which are a rich source of lysine