THE EFFECT OF HEAT TREATMENT ON BLOOD.

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TABLE OF CONTENTS

LIST OF TABLES

FIGURES

I. INTRODUCTION

A. Processing of Blood in New Zealand.

B. Consideration of the Utilisation of Blood as an Animal Feedstuff.

C. Production of Dried Blood for Use in Animal Feedstuffs.

D. Effect of Heat on Blood Proteins.

I. INTRODUCTION

New Zealand is a meat producing and exporting country and therefore has a large meat processing industry. In any industry, the utilisation of waste materials from the production of the main product as "byproducts" aids in the reduction of the manufacturing costs of the primary product, because of increased utilisation of overheads, and results in increased profit. During the processing of animal carcases to produce meat, a large amount of waste materials, including offal, skins, hooves, bones and blood, is produced. One of these waste materials, blood, is drained from the animals immediately after their slaughter and is available in large quantities as a raw material for the production of byproducts. Besides the reduction of meat processing costs, the recovery of blood solids considerably reduces the effluent load of the processing plant, blood solids being mainly organic matter. Unfortunately this latter consideration, i.e. the reduction of the Biological Oxygen Demand of the effluent from meat processing plants, is often the prime consideration in blood processing in New Zealand, as the cost of recovery may exceed the value of the final product; the quality and therefore value of blood products being of little importance.

The major products produced from whole blood are animal feedstuffs (blood meal) and fertiliser (dried blood, and blood and bone), although blood may be processed into black puddings, or utilised as a protein binder in sausage manufacture. Blood is also processed by separating the red corpuscles from the plasma, and manufacturing edible and pharmaceutical products from these separated fractions. This improves the value of the final products obtained from blood, but the advantage of this refinement in processing would depend on the cost of the separation process and the individual processing of the two fractions; this would depend to a large extent upon the throughput of the plant.

A. Processing of Blood in New Zealand

Practically all the blood utilised in New Zealand is used as nitrogenous fertiliser (mainly insoluble) in the form of "dried blood" or "blood and bone". Smaller plants include blood in the general waste materials which are treated to form meatmeals; larger plants often increase the protein content of their meatmeals by the addition of blood solids. In New Zealand blood does not appear to have been considered as a suitable animal feedstuff, only a very small amount of blood being utilised in a few specialised feedstuffs. However, although the statistics do not give a clear distinction between the quantities of dried blood exported as animal feedstuff and that exported for fertiliser purposes, it can be estimated that 60 percent of the dried blood exported from New Zealand is utilised as animal feedstuff.

The values for the various blood products (Table I.1) indicate that the utilisation of dried blood in meatmeal results in a product of lower value ($2.7-3.2 per cwt.) than fertiliser ($3.6-4.6 per cwt.). The blood product which is of highest value is the blood meal which is exported mainly as an animal feedstuff ($4.3-5.4 per cwt.).

B. Consideration of the Utilisation of Blood as an Animal Feedstuff

Blood is approximately 20 percent solids and 80 percent water. For economy in storage and transport facilities the removal of the water, e.g. by drying, is the major processing operation. The blood solids have a very high protein content (80 percent). This protein is of good quality and hence it may be utilised as a source of nutritional protein. This is generally used as an animal feedstuff, although it has great potential as a source of protein for humans.

TABLE I.1 VALUES OF SOME MEAT BYPRODUCTS IN NEW ZEALAND

($ per cwt.)

	1963-64	1964-65	1965-66	1967-68
PRODUCTION				
(Calculated from figures given in the "Statistics of Industrial Production", 1965-1966, for the Meat Freezing and Preserving Industry and related industries).				
Fertilisers				
Blood manure	3.6	3.8	4.6	
Blood and bone	1.7	2.0	2.1	
Stockfood				
Meatmeal	2.7	2.9	3.2	
EXPORTS				
(Calculated from Export Statistics)				
Dried Blood	4.3	-	-	5.4

Figures available for the biological value of some of the blood proteins, namely fibrin (83.1,lamb) (Ellis et al.(1956)) and serum proteins (95.4± 0.2, rat) (Periatianu (1957)) were higher than those given for casein in the same experiments (72.7 and 91.4± 0.2, respectively). However, Grau and Almquist (1944) have shown that the serum proteins and fibrin are of much better quality than the blood cell proteins which constitute 70 percent of the total protein in blood and in which isoleucine is the limiting amino acid. Because of this amino acid imbalance, indiscriminate use of blood solids as a feedstuff may produce detrimental results. Blood, however, is an animal protein and therefore a source of Vitamin B_{12} ("growth promoting factor"), as well as being a good source of other vitamins. Its protein is a rich source of lysine, methionine and tryptophane, and as lysine is usually the limiting amino acid in cereals which often make up the major portion of animal feedstuffs, the supplementation of these feedstuffs with blood (as a cheap source of animal protein and lysine) would improve the nutritional value of the protein in these products. The low mineral content of blood is not significant when blood is used for supplementation of feeds.

C. Production of Dried Blood for Use in Animal Feedstuffs

During the collection and processing of blood which is to be used for edible purposes, contamination of the blood must be minimised. A major problem in this respect is the introduction of disease-producing organisms, particularly spore formers such as Bacillus anthracis, through the use of blood from infected animals. This problem can be reduced by avoiding the use of blood from these animals. This would necessitate the collection of blood from individual animals (or small groups of animals) in small containers, the contents of which could be pooled after the carcases have been inspected and found to be free from infection.

The blood from infected animals could be utilised in manure production. As there is a low incidence of condemned carcases in most New Zealand meat processing plants, the size of these batches could be quite large and the risk of contamination of any batch would be very low. Adequate sterilisation of the product must be ensured.

There are two main techniques for the production of dried blood :

1. Direct drying of raw blood without previous coagulation and dewatering.

This may be a continuous or a discontinuous process (generally the latter). This technique requires a large amount of heat energy to remove the large quantity of water in blood (80 percent). Examples of this type of process are spray drying and roller drying, the former being preferable for blood drying because of the tendency of the albuminous proteins to adhere to hot drying surfaces (Hirchberg (1957)) to which they are exposed in the latter process. Concentration of the solution to be dried to 40-50 percent solids, a process which normally precedes spray drying, is avoided in the case of blood because of its viscous nature and the deposition of considerable quantities of sludge during concentration (Hirchberg (1957)).

2. Coagulation, dewatering and drying of blood.

Coagulation (or precipitation) of the blood proteins enables their separation from a large proportion of the water by mechanical means (pressing or centrifuging) before drying, thus reducing the steam requirements of the drying process considerably. This technique is the one which is universally used in New Zealand, and also may be a discontinuous or continuous process.

a. Discontinuous Coagulation.

Batch coagulation of blood in large vessels by the use of indirect (steam-jacketted) or direct (steam injection) heat treatment has been the most common

method of blood coagulation in New Zealand. However batch processing methods are time consuming, have very high labour costs, and often result in low recovery of the blood solids.

b. Continuous Coagulation.

Continuous coagulation procedures have been developed during the last ten years to enable quick recovery of the protein from the ever increasing volumes of blood becoming available for the manufacture of byproducts. In these processes, the blood is generally coagulated by direct steam injection in a specially designed pipe coagulator and the coagulated solids separated by means of a screw press or high speed centrifuge.

c. Dewatering and Drying.

After their separation from the liquid the blood solids may be dried by a wide variety of processes. The most common methods used to dry these solids being by contact driers (such as Iwels or thermoscrews) or by pneumatic driers (such as ring driers).

D. Effect of Heat on Blood Proteins

According to Abrams (1961) the effect of heat on protein di gestibility is as follows :

1. Moist heat treatment of a protein is less destructive than dry heat, other factors being equal (water has a protective effect against high temperatures).

2. The duration of heat treatment influences the digestibility of the protein. Often there is an initial increase in protein digestibility, but prolonged heating diminishes protein digestibility.

3. If high temperatures are attained during heat treatment the protein digestibility tends to decrease (Mitchell (1945)).

Obviously, therefore, the heat treatment which the blood proteins undergo during processing has a profound effect on the quality of the final product (as reflected by the digestibility of the protein). Because of the high temperatures often attained in the preparation of dried blood its protein is often of low digestibility (Hirchberg (1957)). It has been noted that the utilisation of lower temperatures enables the production of a more soluble, digestible product of higher nutritive value (Morrisson (1938)).

By stricter control of the amount of heat used during the processing of blood a higher grade product could be produced.

The main aim of these experiments was to gain a greater understanding of the effect of heat on solutions of blood proteins, in the hopes of ascertaining the conditions of heat treatment which would completely coagulate the blood proteins with minimum deleterious effects (irreversible insolubilisation of the protein and loss of protein digestibility). The later stages of blood processing (separation and drying of coagulated solids) were not considered.

Despite the advocation of increasing use of techniques such as solvent precipitation (Vickery (1968)) and spray drying in blood processing, these methods are generally used economically only in large scale operations, and so it was felt that this study on present processing was justified.