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06607

Distr.
LIMITED

ID/WG.212/3
14 July 1975

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Symposium on the Prospects for
Industrial Meat Processing in
Developing Countries

Vienna, 13 - 17 October 1975

by product/s

THE UTILIZATION AND PROCESSING OF BLOOD 1/

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id.75-6453

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ID/WG.212/3 Summary
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THE UTILIZATION AND PROCESSING OF BLOOD

R. Nilsson*

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id.75-6454

Distr. LIMITEE
ID/WG.212/3
14 juillet 1975
FRANCAIS
Original : ANGLAIS

Organisation des Nations Unies pour le développement industriel

Colloque sur les perspectives de traitement industriel de la viande dans les pays en voie de développement

Vienne (Autriche), 13-17 octobre 1975

RECUPERATION ET TRAITEMENT DU SANG

Résumé[1/]

R. Nilsson*

La quantité de sang provenant des bovins, porcins et ovins abattus au cours d'une année (Union soviétique et Chine non comprises) contient environ 624 000 tonnes de protéines.

Les protéines extraites du sang ont une valeur biologique moyenne, en comparaison avec les protéines de soya; elles ont une teneur élevée en lysine, valine, thréorine, phénylalanine et tryptophane mais peu élevée en méthionine.

Le sang peut être récupéré par un équipement de conception simple composé d'une palette creuse, de pompes, d'une table réfrigérante et de tuyaux.

Le pourcentage de sang obtenu dépend principalement de la durée de la saignée qui devrait être de 35 à 40 secondes pour les porcins et de 90 secondes pour les bovins.

Les protéines de sang peuvent être fractionnées par centrifugation en protéines de plasma et protéines globulaires, ces dernières pouvant être séparées en hémine et en globine incolore au moyen d'acétone acidifiée.

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1/ Les vues et opinions exprimées dans le présent document sont celles de l'auteur et ne reflètent pas nécessairement celles du Secrétariat de l'ONUDI. Le présent document est la traduction d'un texte anglais qui n'a pas fait l'objet d'une mise au point rédactionnelle.

id.75-6455

The blood [illegible] year (except the [illegible] protein.

Blood protein has a [illegible] protein, with a high [illegible], phenylalanine and tryptophan. [illegible] however, low.

The blood may be [illegible] hollow knife, pump, [illegible] and pipelines.

The percentage of [illegible] depends mainly on the bleeding time, which should be [illegible] for cattle.

Blood protein could be [illegible] centrifugation into plasma proteins and corpuscular protein. The latter fraction could be split by acidified acetone into [illegible] colourless protein.

Whole blood or different blood proteins are easier to handle and will have a better keepability if they are dried. At present there are two types of drying systems for [illegible] on the market; spray drying and belt drying. Of these, belt drying seems to give products with better sensoric and technical quality than spray drying. Other methods which could be used are [illegible] belt drying and a combination of ultra filtration and freeze drying.

Blood or blood proteins could be used in human food in many ways e.g. the following ways: in traditional blood containing products as blood sausage etc., as substitute for, and as a complement of meat in different meat products and meat dishes, as a complement to vegetable proteins in bread and products with high starch content and in beverages. The field is also open for an extensive product development.

Blood born diseases seem not to be any health hazard.

Le sang et les protéines de sang sont plus aisément utilisables et se conservent mieux s'ils sont désséchés. Deux procédés de dissécation sont actuellement employés : le séchage par pulvérisation et le séchage par centrifugation, ce dernier semblant donner un produit d'un goût et d'une qualité technique supérieurs. On peut aussi avoir recours à un agent desséchant fluidisé ou à un procédé fondé à la fois sur l'ultrafiltration et la lyophilisation.

Le sang et les protéines du sang trouvent plusieurs utilisations dans l'alimentation humaine, par exemple dans la préparation de produits courants à base de sang tels les boudins, dans la préparation de divers produits et mets carnés pour remplacer ou compléter l'élément viande, comme additif aux protéines végétales dans le pain et les produits contenant un pourcentage élevé d'amidon, ainsi que dans la préparation des boissons. De nombreuses autres utilisations peuvent également être envisagées.

Les maladies transmises par le sang des animaux ne semblent pas présenter de risques pour la santé de l'homme.

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CONTENTS

INTRODUCTION

One question which often is raised in the debate on the global food production is if one can justify the use of resources for the production of beef, pork, mutton, poultry etc. Many people look upon this production as a misuse of raw material that could be used directly for human consumption. There may be some justification in this criticism, but there are also many exaggerations as there will always be land with vegetation suitable only as feed for different types of ruminants.

Referring to the conversion of energy pork production might be more susceptible than other meat production but even in this case it has recently been shown in China that pigs could be fed on waste materia with no direct use for human consumption.

Whatever production policy will be in the future there is today a large production of meat in the world which probably will go on for a considerable time. And when we have this animal production it is of great importance to use the products obtained entirely for human consumption, to 100% if possible. To achieve this it is necessary to use as much as possible of slaughter byproducts for food production. Qualitatively and quantitatively blood is an important by-product. In most countries it is nearly exclusively used for animal feed and for technical purposes and only to a small extent for food products. This misuse may have many causes: they may be of religious origin, they may have hygienic grounds but it may also be as simple as a lack of knowledge and experience of how to handle and utilize blood. This paper will give a survey of the nutritive properties of blood, of collecting and processing methods and also of suggestions for the use of blood and blood components.

I. COMPOSITION AND NUTRITIVE VALUE OF BLOOD AND BLOOD PROTEINS

A. The protein content of blood and blood fractions

Blood is composed of 77-81% water, 18-23% protein, 0.06-0.09 carbohydrate and 0.4-0.8% lipid. The protein content is nearly the same as in skeletal muscle and higher than in many retailed meat cuts.

As in muscle the protein fraction is made up of a complexe mixture of many components. A crude fractionation could be obtained by centrifugating the blood in a dairy type centrifuge. This process yields as primary components plasma and a cellular fraction in the proportions 60:40.

The cellular fraction is composed mainly of red blood corpuscles which contain hemoglobin in an amount of 30-40%. Thus gives a mean value of 16% in whole blood. The concentration varies somewhat with species.

The plasma contains about 7% of proteins classified as albumins, globulins and fibrinogen.

B. The amino acid composition of blood proteins

Whole blood protein may be considered a complete protein in that all the amino acids are present (table 1). But nutritionally speaking there may be some limitations as the concentrations of the sulphur containing amino acids, methionine and cysteine, are rather low. Besides, the relation between isoleucine and leucine is very bad as the concentration of leucine is about 10 times higher than that of isoleucine. As shown by table 1, the most suitable relationship between these two amino acids is thought to be 1:1.

Blood proteins are, however, an excellent source of lysine which very often is the limiting amino acid in proteins. The levels of other essential amino acids, threonine, valine, phenylalanine and tryptophan are also greater in blood proteins than the levels proposed by FAO/WHO (1).

The amino acid composition of the two separate protein fractions, hemoglobin and plasma protein, is, however, not identical. The plasma proteins have a better relationship between leucine and isoleucine than hemoglobin but the latter has a higher concentration of histidine, an amino acid which is required by infants.

C. Nutritive value of blood proteins

The very special amino acid composition of blood proteins gives them a lower biological value or net protein utilization value than i.e. egg protein and protein in some dairy products. In these respects they could be com-

pared with soy protein but it should be pointed out that their true digestability is nearly 100%. Preferably the blood proteins should be combined with proteins low in lysine and leucine but with a high content of methionine and isoleucine. By using them in this way as complements, the vast amounts of blood proteins available would have a significant impact in alleviating nutritional problems arising from protein shortages. When discussing the nutritive value of blood it should be mentioned that it is a good source of iron since it contains 400-500 mg of this metal per litre.

II. AMOUNT OF BLOOD AVAILABLE

An estimation of the available amount of blood and of the amount of protein which can be extracted from it is shown in table 2.

The number of animals slaughtered yearly are taken from the FAO Statistical Yearbook 1972 (2) which may give the most accurate figures. But it should be pointed out that this publication does not include the numbers of animals from the Soviet Union and from China.

To obtain the blood volumes it was estimated that the theoretical recovery of blood was 15 l per animal for cattle, 3 l for pigs and 2 l for sheep. x) From these values the total protein amount was obtained by taking 20% as a mean value of the protein content of blood. The amount of plasma protein was calculated by using 7% as a mean protein content for plasma and assuming that 60% of the blood consists of plasma.

By using all these assumptions and calculations it was found that the total amount of blood protein from cattle, pigs and sheep will be about 624,000 tons per year; with 60% coming from cattle, 30% from pigs and 10% from sheep. About 20% of the amount or 130,000 tons consists of plasma proteins.

It is quite obvious that the numbers given are only very rough estimates as they are subjected to various sources of error, they do not take into account e.g. the variation of blood volume with live weight. Nevertheless, they point out that blood is a substantial source of proteins with a reasonably high nutritive value. Today most of these proteins seem to be wasted as it is only in Sweden that blood and plasma proteins are used in the food industry to any larger extent. How this can be achieved with rather simple equipment and methods will be shown in the following chapters.

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x) These values do not include the blood which is left in spleen, liver, muscle etc. and which cannot be removed by normal slaughtering.

III COLLECTION OF BLOOD

A. Equipment

The equipment for collecting blood is in principle the same both for cattle and pigs. It consists of the following items:

1. Sticking knife. A hollow knife (trocar knife) is used. For cattle the knife should have an opening with a diameter of 38 mm otherwise some of the blood will be lost outside the knife. To increase the opening of the sticking wound it is advisable to use knives with blades at right angle to each other (Figure 1). The cattle knife could be provided with a hook for fastening the knife in the sticking wound. The same operator could then be used both for stunning the animals and for collecting blood.

The knife used for bleeding pigs has only one blade. It should have an opening with a diameter of 30-32 mm to assure a good recovery of the blood.

2. Plastic tubes for the transport of the blood from the knife. They could partly be replaced by stainless steel pipe lines of dairy quality.

3. Vacuum system. The blood could be collected by gravity which is the system generally used today, but in slaughter lines with high capacity it is necessary to use vacuum to get a good blood recovery. The vacuum systems consist of a stainless steel container, a vacuum pump and a pump to transport the blood through a chiller to the storage tank. The container is fitted with a course filter to remove particles which otherwise could plug the plate chiller. It should be pointed out that the vacuum systems available today are suited only for pigs.

4. Automatic injector for anticoagulants. To avoid coagulation of the blood an anticoagulant is injected into the blood in the base of the sticking knife. The injector could be working continuously or be synchronised with the bleeding time.

5. Plate chiller. To get a good microbial standard of the blood it is necessary to chill to 2-4°C immediately after the bleeding of the animals. The most appropriate way to perform this step is to pump the blood through a plate chiller of appropriate capacity. From a hygienic point of view it is better to have a closed system than the open type often used for milk.

The chilling should be carried out by a medium with a temperature not lower than -1°C. Appropriate ones are a mixture of water and glycol or a solution of salt in water. Chilling media as freon or ammonia should not be used as they may cause a local freezing on the plates. Such a freezing increases the risk for hemolysis.

6. Storage tanks. Stainless steel tanks could be used but plastic ones are to prefer because they are easier to handle. The volume of them could be discussed and may be determined after that the risk for contaminating blood from healthy animals with blood from sick animals has been ascertained.

7. Cleaning system. Cleaning of pipelines, tanks etc could be carried out by hand but also automatic systems for CIP-cleaning could be installed.

B. Methods for collecting blood

1. Use of anticoagulants. In some instances when blood is used immediately in food products anticoagulants are not used, instead the coagulated blood is chopped in a silent chopper as ordinary meat. But in most cases an anticoagulant is added either by hand or by an automatic procedure as shown in the preceding section. Several substances could be used as anticoagulants but the most common one is trisodiumcitrate. The recommended concentration of citrate in blood is 0.4% and this is obtained by adding 1% of a solution containing 40% of sodium citrate.

The solution should be made up every day and it is necessary to use water with a very low bacterial content. The solution should also be cooled down rapidly after preparation.

2. Recovery of blood. The amount of blood obtained is mainly dependant on the bleeding time but also to a certain extent on the construction (diameter of the opening) of the sticking knife. How the bleeding time effects the recovery of blood in cattle is shown in table 3

To obtain a complete bleeding of the animal, that is to have 15 l from a cattle with a slaughtered weight of 250 kg, it is necessary to have a bleeding time as long as 120 seconds. But only a slightly less recovery of 14.7 l is obtained when the bleeding time is reduced to 90 seconds, a time which might be realistic on a slaughter line with medium capacity.

For pigs the maximal blood amount, 3 l, is obtained with a bleeding time of 35-40 seconds as shown by Figure II. Such a long bleeding time is, however, too long in slaughter lines with medium or high capacity. Often a bleeding time of only 15 seconds could be allowed with a reduction of the recovery with 20% to 2.4 l. This problem could be overcome by collecting the blood with a vacuum system as this will reduce the bleeding time considerably. With a vacuum degree of 50% the amount of blood will be 2.8-2.9 l in 15 seconds.

The time necessary to get a good bleeding may also to some extent depend on the time between stunning and bleeding. The shorter this time is the more efficient will the pumping action of the heart be and the shorter the bleeding time. Ten cases highest figures for the time between stunning and sticking is 12-15 seconds for pigs and 45-60 seconds for cattle. The stunning method seems not to be of any importance for the blood recovery or the bleeding time.

3. Procedure for bleeding cattle. After stunning the animal is hoisted in the back legs to a hanging position. The fore legs are secured by loops of rope so that the neck is exposed in a fixed position. The sticking operator removes a 15 x 20 cm of the skin over the jugularis vein. This is then pierced by the hollow sticking knife which could be held in place with a hook on the base plate of the knife.

Blood is collected for at least 90 seconds. It is possible for one operator to bleed two animals at a time just by using the sticking knife with a hook.

When the blood is collected an anticoagulant is added and the blood is after passing a filter chilled in a plate chiller down to 2-4°C and then pumped to a collecting tank for further handling.

4. Procedure for bleeding pigs. After stunning the pig is hoisted on to the rail in a hanging position and bleeded within 15 seconds by piercing to jugularis vein by the sticking knife. At the moment there is not any knife construction which allows a fixation of the knife on the pig. The blood should be collected for at least 15 seconds if vacuum collection is used otherwise for at least 35-40 seconds. The procedure is thereafter the same as for cattle.

It should be observed that if a vacuum system is used the operating vacuum degree should not exceed 30%. If it is higher the wound tissue will contract and diminish the blood recovery.

C. The microbial quality of blood

1. The bacterial count in blood. Blood from healthy animals is practically sterile. But during the sticking it could be heavily contaminated with bacteria from the skin or the wound. The infection is minimised in cattle by cutting out the skin in the sticking area. This procedure leaves a blood with the rather low total bacterial count of about 200-300 per ml.

The same method cannot be used on pigs, therefore the bacterial load will be much higher in pig's blood. It generally amounts to 2,000-3,000 per ml, but may in some instances be as high as 10,000 per ml.

One has tried to reduce the contamination of pig's blood by disinfecting the sticking area of the neck with chemicals but the effect was very small. On the contrary, in some cases the infection was increased by the transmission of dirt particles by the disinfecting agent. It was neither practical to disinfect the sticking knife between the animals.

The bacterial load which could be allowed depends on how the blood is to be used. When the blood is to be further processed as by freezing or drying an upper limit of 10 000 per ml is found to be satisfactory. To keep this level it is necessary to chill the blood immediately as described above.

2. Cleaning procedure. Even if the bacterial level is relatively small it is necessary to have a thorough cleaning and disinfection of the blood collecting equipment at least once a day. This could of course be carried out by hand using hot water, cleaning agents, brushes etc., but it could also be carried out by automatically working CIP systems. But even with such a system it is necessary to take the plate chiller apart once a week to remove deposits on the plates. The sticking knives should be sterilized in steam rather than by chemicals.

3. Control system. To ensure a good hygienic standard of the blood it is necessary to work out control systems. This should include an appropriate sampling of the blood and of the cleaning of the equipment.

IV. PROCESSING OF BLOOD

Part of the blood is or could be used directly after chilling or after storage for a day for sausages or other products but a large part of it has to be processed to a form in which it is more easy to handle and in which it has a better keepability than liquid blood. This processing includes one or more of the following processes:

- Separation of plasma proteins and blood cells
- Freezing
- Drying
- Splitting the hemoglobin molecule

A. Separation of plasma protein and blood cells

Separation is a simple process which is common to most of the subsequent processing steps. It is carried out with the type of centrifuges generally used for milk, but which have been modified somewhat to suit the density difference between plasma proteins and blood corpuscles. The centrifuge then should be carried out with the blood cooled down to 0-2°C to keep down the risk for bacterial growth and also to minimize the risk for hemolysis.

It might suffice with one centrifugation but the quality of the plasma is improved if it is put through a second centrifuge of a type called bactofuge. This has a higher gravitational field than an ordinary milk centrifuge and therefore removes particles left over and also some microorganisms. The plasma obtained by double centrifugation has a good appearance and it also has a better sensoric quality than plasma centrifuged only once. It can therefore be used in feed in higher concentrations without giving an off-flavour.

The products of centrifugation could be used as such for feed items but most of them had to be submitted to further processing to increase the keepability and the field of use.

B. Freezing

One way to increase the keepability of plasma is to freeze it. The freezing can be carried out in different ways. The plasma can be frozen in large blocks or in smaller pieces. But the most appropriate method is to freeze it in flakes which are easy to handle and pack. Even if freezing is a simple method and also is relatively cheap it is, however, not a method to recommend for general use. The reason for this is mainly the high storage and transportation costs caused by the necessity of keeping the product at a temperature below -18°C.

C. Drying

Drying is an excellent way to increase the keepability of products which are susceptible to microbial activity. It also removes the bulk of the products thus making them easier to handle and more economic to transport. Drying can be carried out by many methods among other the following ones:

- Spray drying
- Fluidized bed drying
- Ball drying
- Freeze drying

The processes could be used for whole blood, for the plasma fraction or for the blood corpuscle fraction.

1. Spray drying. This process is used for many different purposes and may therefore be well known. The principle is simple. The liquid to be dried is forced with high pressure through a nozzle into the top of a spray tower. By the passage through the nozzle the liquid is dispersed to very fine particles which on their way down meet a stream of hot air. The water evaporates and the dried particles fall to the bottom of the tower where they are continually removed. The capacity is partly regulated by the temperature of the air stream, which usually lies between 140 and 200°C.

The high temperature is a drawback of the method when plasma proteins are dried as it gives the dried product a slightly burnt flavour which might be transferred to food items. Another slight disadvantage is that the dried products consist of very fine particles which could cause dust problems when the product is to be used.

2. Fluidized bed drying. Another type of drying and very much different from spray drying has recently been tested in New Zealand by Haughey et al. (3). The principles of the method are shown in Figure III. The equipment consists of an air heater, a fluidized bed with a feed in nozzle, a cyclone, a bag filter and a fan. It works in the following way.

A mixture of hot air is sucked through a distributor plate into the fluidized bed section where it maintains a bed of granular dried blood particles in a fluidized state - i.e. particles moving around in a random turbulent motion without a significant fraction being blown out of the bed. On one side of the bed an atomizing nozzle is mounted flush with the bed wall. The blood is fed to the nozzle by the combined effect of gravity and air suction. The fine atomized spray of blood produced impinges on the dried blood particles moving around in the bed and coats them with a thin layer of blood which because of contact with the hot air in the bed, dries almost instantaneously, building up the granular size. New particles are created by abrasion and fracture of bed particles, by direct drying of blood droplets, by return of fines carried over to the cyclone and, if required, by addition of smaller seed particles to the bed.

The system is made continuous by having the excess of particles required to maintain given bed height overflow into a stand pipe in the bed linked to a container outside. There is a certain carry over of fine particles which are removed in a cyclone. A bag filter is also installed to remove fine particles not taken out in the cyclone before the air passes the fan and is exhausted to atmosphere.

The inlet air temperature can be varied to a large extent, it can be as low as 75°C and as high as 280-300°C. The actual temperature depends on the desired capacity. The main advantage with the method compared with spray drying seems to be that the dried products are obtained as rather coarse particles which are dustless and thus very easily handled.

In the paper of Haughey et al. (3) the method has been used for whole blood but there should not be any objection for using it also for the plasma fraction.

C. Fluid drying. A method which in some way is similar to the fluidized bed has recently been patented and is now used to dry many liquid and semi-liquid solutions. A rough outline of the process is shown in Figure IV. The fluidized bed is divided into four zones, one loading zone, one drying zone, one separation zone and one recirculation zone.

The drying is carried out on plastic balls with a diameter of about 5-6 mm. They are coated with a thin layer of the liquid to be dried in the loading zone. They are then transferred by an air stream to the drying zone where the water is evaporated. A part of the air stream takes thereafter the balls to the separating zone where the now dry powder is detached. The clean plastic balls are subsequently transferred to the loading zone and coated again with liquid.

An advantage with the method is that the air temperature is so low that the temperature of the product does not exceed 60°C. There will therefore be only a very limited denaturation of the proteins which will retain their functional properties nearly intact. Another advantage is the very good thermic efficiency which makes the method more economic than other similar methods.

D. Freeze drying. One of the mildest processes to remove water is freeze drying. A product obtained by this type of method generally retains all its native properties. But freeze drying is an expensive way to remove water and for products like blood or blood plasma with a low commercial value it may only be used if the bulk of the water first is removed by another method.

Recently freeze drying has been combined with ultrafiltration which removes about 70% of the water. The [illegible] by ultrafiltration is transferred to a steam operated freeze dryer where it is dried to a moisture content of 8-10%.

This combination seems to be economically competitive with other methods. It also gives a product consisting of rather coarse particles, compared with ball or spray dried products, and therefore dustless. Another advantage is that the ultrafiltration step removes not only water but also most of the added citrate and salts normally present in blood.

D. Splitting the hemoglobin molecule

The major part of the blood proteins is the red cell, protein hemoglobin. This protein gives the food items to which it is added a colour which many consumers are not used to. This property therefore reduces the possible applications of the protein and its suitability for human consumption. Consequently, the field of use ought to be expanded if the hemoglobin could be decolourized.

Principally, this is easy done by treating the blood with acidified acetone and a continuous process based on this reaction has recently been worked out at the Texas A & M university in U.S.A

A schematic lay out of the system is shown in figure V. The principal steps as described by Tyler et al. [9] are the following ones:

The red cells are collected by centrifugal separation of the blood. They are hemolysed by adding an equal amount of water. An ascorbic acid solution is then added to bring down pH to 4.0. The suspension obtained is pumped to mixer no. 1 where an air stream is passed through. The hemoglobine is converted to green choleglobin by the mixed action of ascorbic acid and oxygen in the air. The choroprotein solution is then passed into a second mixer where acidified acetone is added at a 4:1 ratio. This step removes the porphyrine moiety and precipitates the globin proteins. The protein slurry is collected by filtration washed with acidified acetone, resolubilized in water and thereafter dried with some appropriate method.

The acetone is recovered by destillation and pumped back to the acetone reservoir.

E. Special problems

When processing blood there is one general problem which is not easely solved namely if the blood should be processed at the slaughterhouse or at specialized central blood processing plants.

The drawback with central plants are the high transportation costs. It is much unnecessary water that is transported. Furthermore the transportation has to be carried out with refrigerated lorries to avoid bacterial growth in the blood. There is also a certain risk for hemolysis even if this risk could be minimized if the blood is held in large and completely filled containers. Experiments in Sweden have shown that transportation up to 400 km on good roads not cause any hemolysis during such conditions.

The advantages of central plant processing are obvious. It is possible to have large scale operations with all the economical advantages they have. It is also possible to have a more sophisticated and diversified processing which might widened the field of application for blood proteins.

However, some of the processes described above may succesfully be carried out at practically every slaughterhouse. The drying of blood and blood fractions seems to be the most important process to be carried out and for this there are both spray drier and belt drier which would suit every slaughterhouse. Furthermore it is advisable to centrifuge the blood

immediately after collection if it is to be centrifuged. A second centrifugation could then be carried out in a bactofuge at the central plant.

Which policy, central processing plant or not, is to be followed has to be determined according to the local conditions.

V. UTILIZATION OF BLOOD PROTEINS

The most important part of the whole blood problem is the utilization of the proteins because it is of no use to produce a large amount of them if there is not any market.

When looking into the market for whole blood and the different blood proteins one has to consider traditional products which normally contain blood, traditional products into which blood proteins could be incorporated - this product could be of animal or vegetable origin - and also the development of entirely new products. Besides this use of blood proteins for human food one should also look into the medical use of blood, of blood as raw material for a pharmaceutical industry.

A. Use of blood proteins for human consumption

1. Use in blood-containing products. Many communities have by tradition blood-containing dishes as sausage, paté, soup etc. in their diet. The change from home slaughtering to slaughter at abattoirs might have decreased the consumption of the dishes as it became more difficult to obtain blood.

One goal in these communities must be to increase the consumption of blood-containing food items. This could be achieved by putting dried blood powder on the market so that the consumer could make dishes according to their own recipes. It could also be done by producing the blood-containing products in sausages plants etc. and selling them in shops. By these two actions it ought to be possible to reach a large part of the population living in cities and larger villages.

2. Use in meat products. The plasma proteins and the globin isolated from hemoglobin could be included into praticallly all type of meat products and meat dishes to substitute more or less of the meat. But the most appropriate use of them seems to be in sausages and luncheon meat type of products. The discussion will therefore be concentrated to this group.

These products consist of an emulsion or suspension of protein, fat and water cooked to an internal temperature of more than 65°C. To get a good technical quality in these products it is necessary to have a protein with good fatbinding and waterbinding capacity. It is well known that plasma proteins have these properties. Furthermore by these proteins it is also possible to regulate the consistency of the food product within wide limits by the amount of protein added and the selected internal temperature. The characteristics of the globin isolated from hemoglobin is not yet fully known but the result reported hitherto (4) indicate that they are similar to those of the plasma proteins.

When dry plasma proteins obtained by different methods are compared certain differences are found. As mentioned previously the spray dried plasma may sometimes have a burnt flavour which could be transferred to the food product if it is used in higher concentrations. Some of the burnt off-flavour could of course be covered by use of spices. The ball dried plasma does not have this disadvantage and may consequently be used in higher concentrations. There is also some difference in waterbinding capacity between the two types of dried plasma. The ball dried plasma is able to take up 12-15 times its own volume of water whereas spray dried plasma is a little inferior in this respect. The difference depends probably on the more severe heat treatment of the spray dried plasma.

However, with both types of plasma proteins and with the globin prepared from hemoglobin it should be possible to obtain nutritionally and technically satisfactory emulsion products by combining them with water and with fat of animal or vegetable origin. Eventually also soy protein could be incorporated. The protein content of such a product would preferably be about 15 %.

3. Use in vegetable products. Another appropriate use of blood proteins is in different cereal products as the high lysine content of the blood proteins is a good complement to the cereal proteins. Both the hemoglobin fraction and plasma fraction could be used in bread. Large scale experiments carried out in Sweden have shown that it is possible to add at least 1.5 % of dried hemoglobin to bread without any risk for off-flavour. Contrary some of the sensoric properties as juiciness was improved and the bread also kept fresh longer. It was calculated that the biological value of the bread increased about 50 % by the addition.

The blood proteins could also be used to increase the nutritive value of other vegetable products or dishes specially those heavy in starch. A good knowledge of local products is however necessary to be able to give detailed suggestions. There is much room for product development

4. Use in drinks. An application for some of the blood proteins might be in beverages of different types. It is true that experiments have not been performed hitherto but some knowledge ought to be obtained from the work done with fish protein concentrate for the same purpose.

5. Use in new product. As blood proteins have good technical properties in different aspects there ought to be a wide field open for development of new products based entirely or partly on them. When exploring this field it is felt that the greatest problems will not be the development of actual products but to market them which eventually will imply a change in eating habits. To get as smoothly as possibly over these difficulties it is necessary with an extensive knowledge of the eating habits and social life of the communities in question.

B. Blood as raw material for medical and pharmaceutical products

The main aim of this paper is to discuss blood for human food but it might also be appropriate to briefly discuss the use of blood as a raw material for the pharmaceutical industry. In this respect blood yields many products. Serum albumin could be purified from aseptically collected blood and used as reagent for certain factors in blood, in antibiotic sensitivity tests as a stabilizer in vaccines and other sensitive biological products.

An important group of proteins which could be isolated from blood are the immunoglobins. They have a very wide use from research purposes to use in practical medicin as prophylaxis against certain infections or as an addition to infant food. Enzymes which could be isolated from blood are e.g. catalase and cholinesterase.

This list could be made much longer and could also include non-protein constituions as prostaglandines but the mentioned examples may be sufficient to show which possibilities blood has also in these respects.

VI. BLOOD BORN DISEASES - A PROBLEM?

One problem which may be of importance for the use of blood for human consumption is if there exist blood born diseases which could be transferred directly to man, if consumption of blood is a health hazard.

There are two types of harmful organisms to consider, blood parasites and microorganisms and viruses. Regarding the parasites they are not a hygienic risk as they are not transferred directly from the blood to man but need another host in between to be able to infect humans.

As regards bacteria and viruses some of these organisms are found in blood even if blood in principle is nearly sterile. Among the organisms found in blood are e.g. those which cause anthrax and foot and mouth disease. But these diseases should not be a blood born health hazard as animals carrying these diseases will be rejected during inspection of the live animals.

This inspection is the first barrier to prevent blood and other parts of unfit animals to reach the consumer. The second one is the veterinarian inspection on the slaughterline, which will condemn carcases displaying sign of diseases or infections.

The batches containing the blood from condemned animals will be condemned too. This means that blood from several healthy animals will be lost, but this is a loss which has to be taken. It can be minimized by using rather small containers for collecting the blood, but this may increase the costs. As pointed out earlier the size of the containers may practically be determined by the frequency of rejections.

The third barrier to protect the consumer is the heat treatments products are submitted to in the production plant and in the kitchen.

The discussion of the problem has of necessity been superficial but hopefully sufficient to show that there is not any hygienic justifications for not using blood and blood fractions for human consumption.

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3. Hughey, D.P. and Eng, C. Fluidized bed drying of blood. 13th Meat Industry Research Conference. p. 87. Hamilton, 1971.

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Table 1. Amino acid composition of blood proteins.
a. Value taken from Tybor (4). b. FAO/WHO (1)

Amino acid	Amino acid composition			
	Whole blood	Globin a.	Plasma a.	FAO provisional pattern of essential amino acids. b.
	g/100 g of protein			
Essential				
Lysine	9.3	10.5	9.2	6.2
Threonine	3.7	3.8	6.3	2.8
Methionine	0.8	1.7	1.8	2.2
Valine	9.7	9.4	7.0	4.2
Phenylalanine	7.9	7.9	5.6	2.8
Leucine	13.7	13.8	10.1	4.8
Isoleucine	1.4	0.2	2.9	4.2
Tryptophan	-	2.0	1.9	1.4
Histidine	7.2	7.8	3.5	-
Nonessential				
Arginine	4.8	3.6	5.0	
Aspartic acid	11.6	10.0	10.7	
Serine	6.5	3.0	5.5	
Glutamic acid	10.0	6.8	13.7	
Proline	3.6	3.5	3.8	
Glycine	6.6	3.7	3.6	
Alanine	8.2	8.6	5.3	
Cysteine	1.1	0.1	1.2	
Tyrosine	3.2	2.5	3.6	

Table 2. Available amounts of blood and blood proteins

Area	Cattle			Pig			Sheep		
	No. millions.	Blood mill. l.	Protein th. tons	No. millions.	Blood mill. l.	Protein th. tons	No. millions	Blood mill. l.	Protein th. tons
Europe	28.3	425	85	156.8	470	94	39.6	47	3
North America	43.5	652	130	103.1	309	62	12.1	24	1
South America	26.6	399	80	16.9	51	10	19.1	38	1.5
Asia	5.0	75	15	29.9	90	18	27.7	55	2.5
Africa	12.6	189	39	3.8	11	2	31.3	63	2.5
Oceania	7.4	111	22	4.6	14	3	31.2	62	2.5
Total	123.4	1851	371	315.0	945	189	159.0	318	13

Table 3. The influence of bleeding time of blood recovery

Bleeding time secs.	Blood volume l.
15	6.9
30	10.2
45	12.0
60	13.1
75	14.0
90	14.7
105	14.9
120	15.0

Figure I. Knife for bleeding cattle

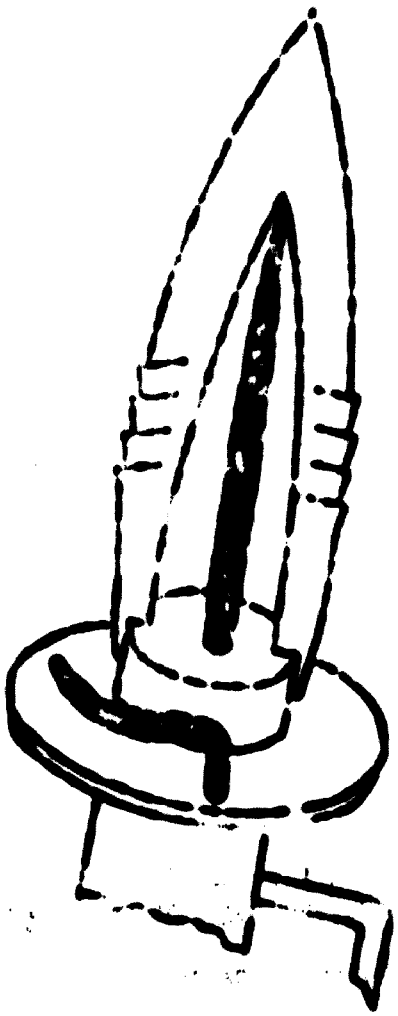


Figure I. Influence of bleeding time on blood recovery

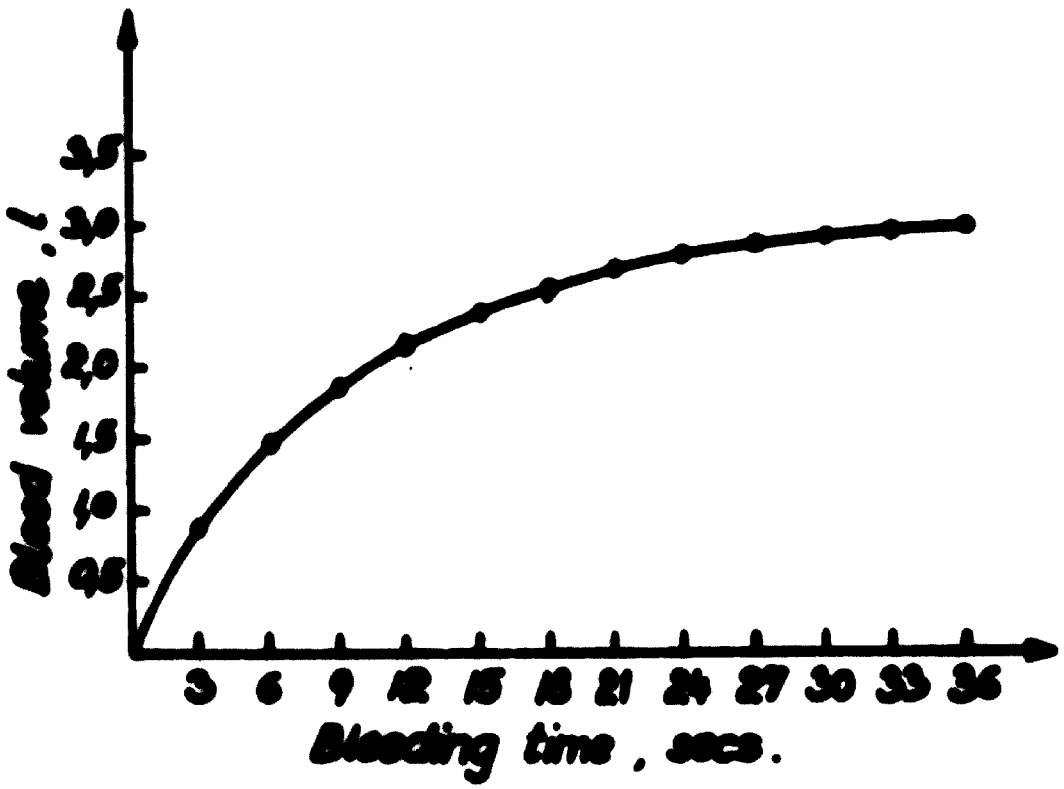


Figure III Schematic layout of fluidized bed drying system

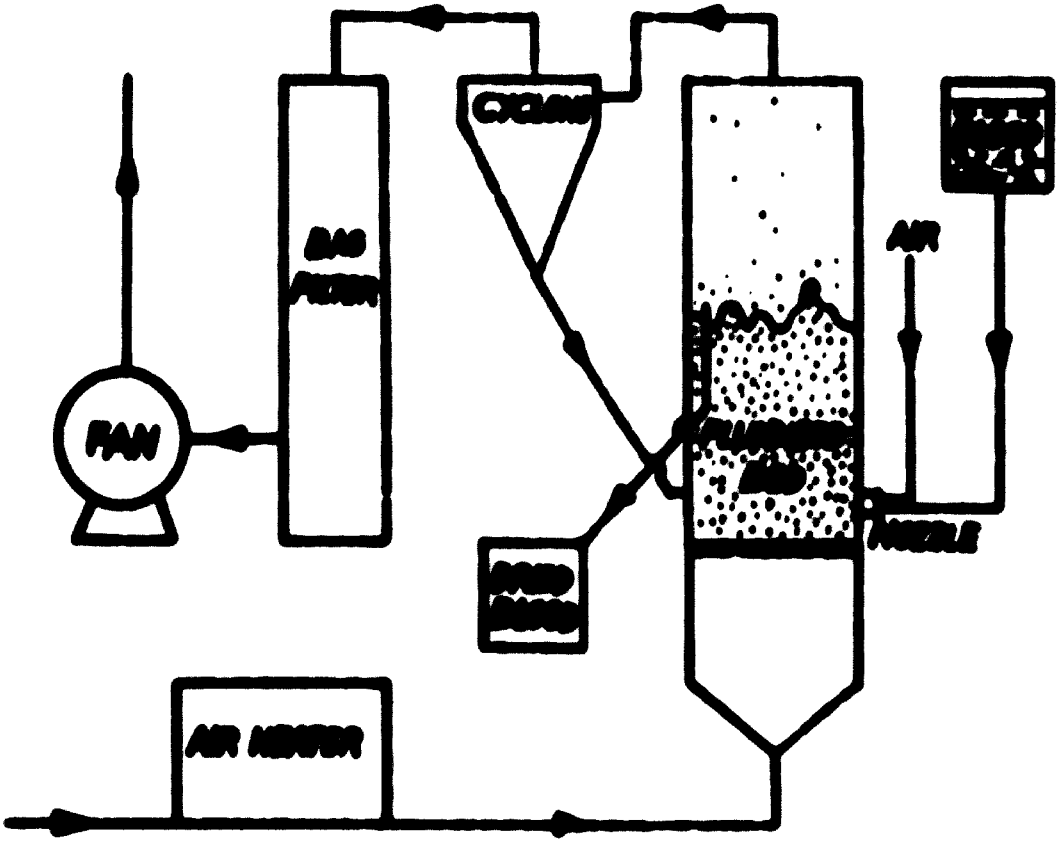


Figure IV. Schematic view of the ball drying system

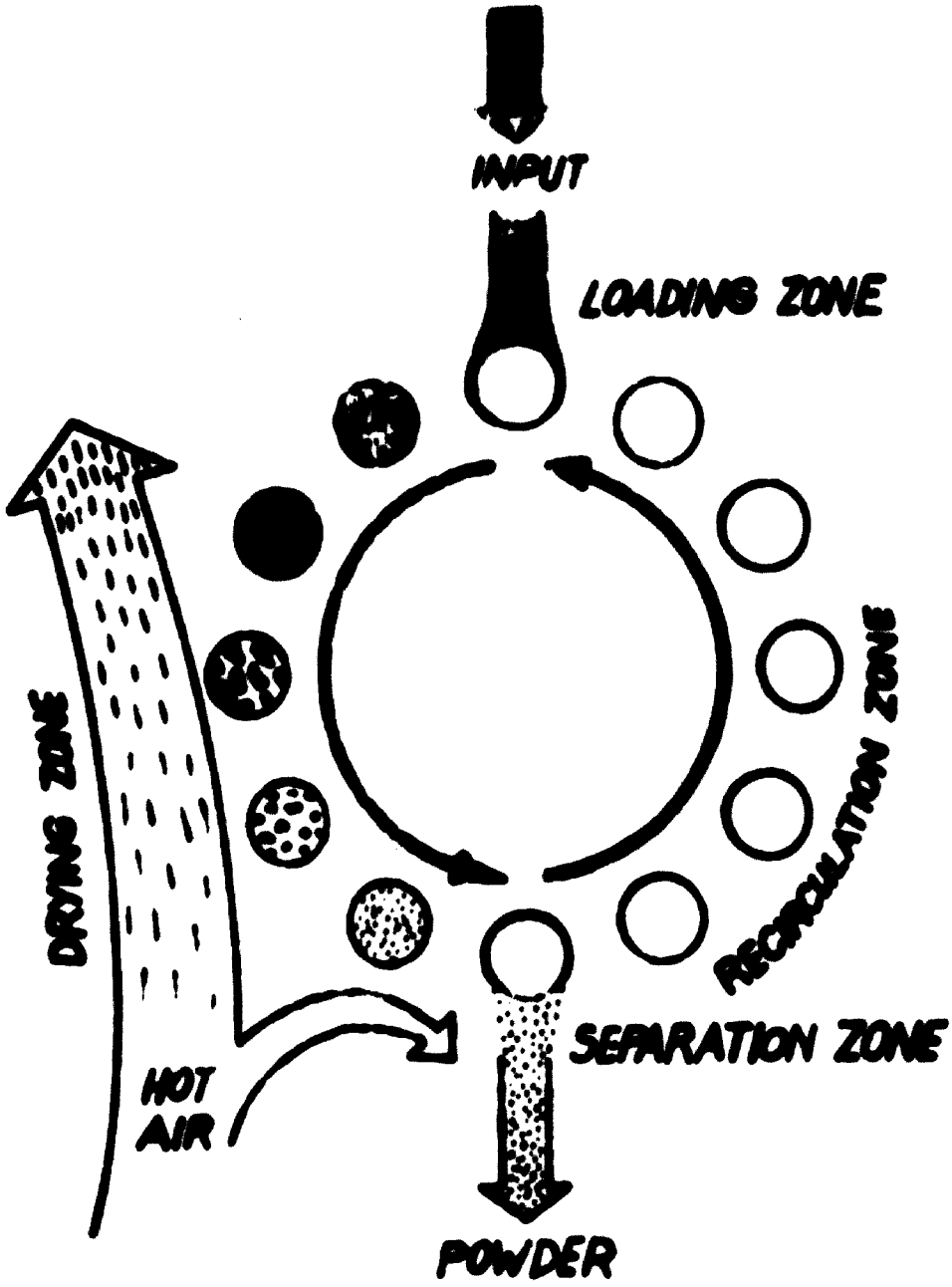
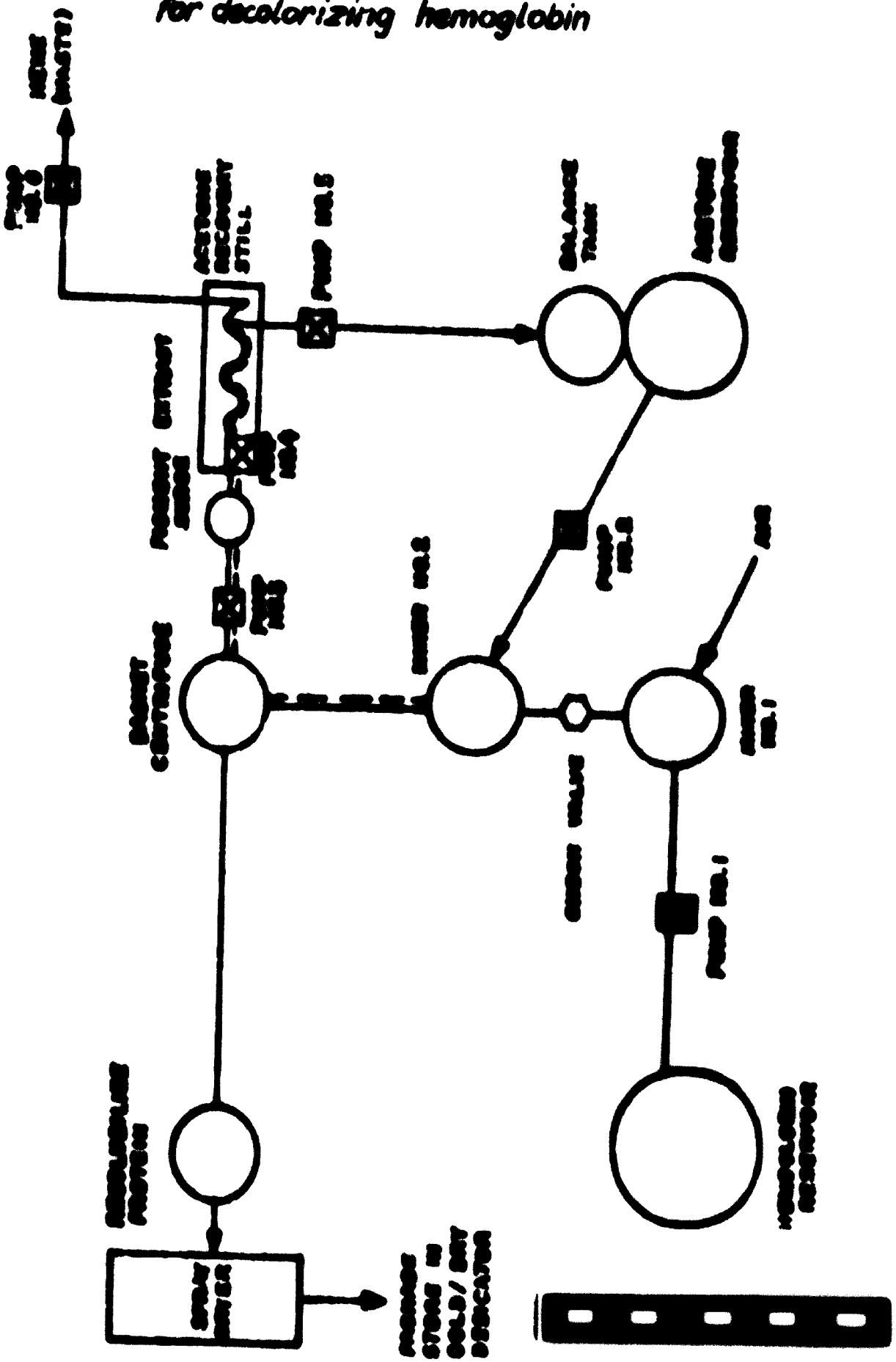
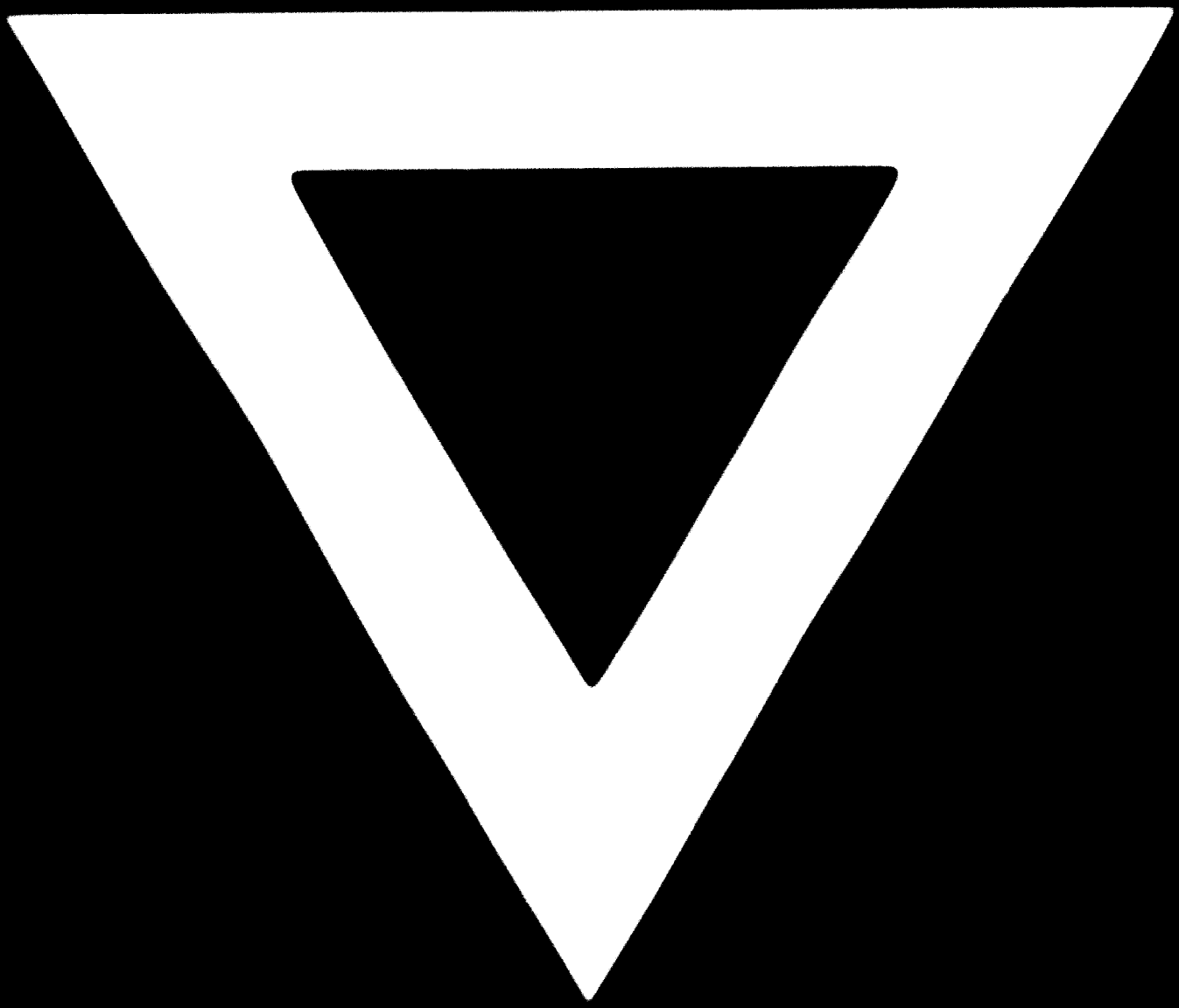


Figure V. Schematic layout of the continous system for decolorizing hemoglobin





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