Verwertung von Blut in vermahlenen Fleischprodukten

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Traditionell ist Blut in Blutwürsten mit den vom Blutgehalt dominierten sensorischen Eigenschaften angewendet worden. Dieses macht sich besonders für die Farbe der Produkte geltend. Die Anwendung des Blutes in anderen Fleischprodukten fordert ein Verfahren zur Verminderung des Farbengrades, um das traditionelle Aussehen der Produkte zu bewahren. Dieses kann nach Entfernung der roten Fraktion bei separater Verwendung von Blutplasma und Globin erreicht werden. Die Auswirkung der Entfernung des Hämoglobins auf die funktionellen Eigenschaften des Globins wird besprochen. Blut kann als eine Blut-Fett-Protein-Emulsion den Fleischprodukten beigegeben werden, aber eine spezielle Behandlung der Emulsion ist erforderlich, um die gewünschte Farbe zu erzielen. Die Technik der Emulsionsproduktion wird beschrieben. Die sensorischen Eigenschaften und der Ernährungswert der Würste mit Emulsionen werden besprochen.

Utilization of blood in comminuted meat products.

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Blood has traditionally been used in blood sausages with sensoric properties dominated by the blood content. This applies especially to the color of the product. Use of blood in other meat products require a procedure to decrease its color intensity to preserve the traditional appearance of the products. This can be achieved by separate use of blood plasma and globin after removal of the heme group. Heme removal by acetone treatment reduce the functional properties of globin with regard to use in a food system, especially at pH values normally found in meat products. Blood may be added to meat products as a blood-fat-protein emulsions. A Special treatment of the emulsion is required to mask the color of the erythrocytes. It may consist in application of ultrasonics or homogenization under high pressure. By use of homogenization emulsions containing 27% blood, 15% fat and 6,3% Na-caseinate may be produced which can replace meat in Wiener sausages to an extent that the sausages may contain 5% blood without affecting the normal color of the product. The production costs of the emulsion is about half of the marked price of the meat it replace, and the nutritional value considerably higher. The chemical score of the combined emulsion proteins is 94 with isoleucine as the limiting amino acid compared to a chemical score of 57 for pork head muscle with tryptophane as limiting aminoacid. The iron content is about three times that of the meat.

L'Utilisation de Sang dans des Produits consistant en Viande hachée

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Par tradition le sang a été utilisé pour des boudins noirs les propriétés sensorielles desquels sont dominés par le contenu en sang. Cela s'applique particulièrement à la couleur des produits. L'utilisation de sang dans d'autres produits de viande demande un procédé pour la réduction de l'intensité en couleur à l'égard de la préservation de l'apparence traditionnelle des produits. Cela peut être assurée par l'utilisation séparée du plasma sanguin et de la globine après l'enlèvement du groupe hémo. L'effet de l'enlèvement de l'hémo sur les propriétés fonctionnelles de la globine sera discuté. Le sang peut être ajouté aux produits de viande en tant qu'émulsion de sang-graisse-protéine; cependant, une opération spéciale de l'émulsion sera requérie pour l'obtention de la couleur désirée. La technique de production d'émulsions sera décrite. Les propriétés sensorielles et la valeur nutritive des saucisses à émulsions seront discutées.

Использование крови в колбасных изделиях.

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До сих пор кровь находила себе применение, главным образом, в производстве кровяных колбас, в сенсорных свойствах которых преобладало содержание крови. Это относится, в первую очередь, к окраске изделий.

Для использования крови в других мясных изделиях необходим технологический процесс осветления крови с целью сохранения их традиционного внешнего вида. Решением проблемы может быть отдельное использование кровяной плазмы и глобина, лишенного гемовой группы. Докладчик оговорит эффект отделения гемовой группы на функциональные качества глобина.

Кровь можно добавить к мясным изделиям в виде эмульсии, состоящей из крови, жира и протеина, однако для получения желаемой окраски необходима особая обработка эмульсии. Докладчик опишет технологию производства эмульсий и обсудит как сенсорные свойства, так и питательную ценность колбасных изделий с эмульсией.

Utilization of blood in comminuted meat products.

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During slaughter of animals considerable amounts of blood become available amounting to about 3,5% of the weight of the live carcasses. The nutritional value of the blood has long been recognized, and blood has been fully utilized in rural households in various European contries. Blood has been used as an ingredient in various types of blood sausages and puddings, blood soups and bread or bisquits. In urban populations have consumer interests in these types of products however been rather limited. At present give seasonal demands for blood sausages only utilization of a minute fraction of the available blood supply. Efforts to utilize blood in the meat industry have thus mainly been directed towards formulations which prevent blood from changing the normal sensoric properties of the products. This entails use of blood in small quantities to strengthen the pigmentation within the the natural color range of the products, or to use blood in emulsion systems. Special treatments of such emulsions may partly disguise the hemoglobin containing cells, the erythrocytes, so higher than usual amounts of blood may be incorporated in the products. Blood may however also be fractionated by centrifugation into the cell free fraction, the blood plasma, which can be added to meat products without color problems, and the erythrocyte fraction. Attempts have been made to utilize the hemoglobin of this fraction after decoloration.

Descoloration of hemoglobin.

The interest in utilization of the hemoglobin after decoloration stems from the fact that it is the major protein component in blood. When blood is collected after use of citrate as anticoagulant, centrifugation will then give appox. 66 kg plasma with ca. 8% protein or 5,3 kg protein and 33 kg erythrocyte concentrate with ca. 38% protein or 12,5 kg protein. (Düpjohan 1976). More than 90% of the content of dry matter of erythrocytes consists of hemoglobin. By removal of the prosthetic heme group the globin may be rendered colorless. This may be achieved in pilot plant scale (Tybor, Dill & Landmann, 1973, 1975) by use of a modification of the original method of Anson & Mirsky (1930). Lysis of the red corpuscles is done by diluting the erythrocyte concentrate with water. The released hemoglobin is separated from stroma by treatment with chloroform. The hemoglobin is oxidised to choleglobin by reaction with ascorbic acid and air, then acidified acetone is added to precipitate the globin. The globin is washed with acetone, redissolved and spray dried. The process require large expenditures of acetone to be regenerated, as about 50 l acetone is used to produce 1 kg globin. Palmin and Petrova (1973) has consequently suggested a methode to minimize acetone expenditure by concentrating the hemoglobin solution by precipitation with salt solutions prior to application of acetone. Globin has a very good capacity to absorb water in swelling, (Hermansson & Tornberg, 1976) to emulsify oils and to produce foams (Tybor et al. 1975). It does not produce gels on heating as do the plasma proteins but becomes creamy (Hermansson & Tornberg 1976). Removal of heme impaires the stability of the globin molecule so it becomes much less resistant to denaturing agents than is hemoglobin (Antonini & Brunort, 1971). This is reflected in a drastic reduction in solubility at pH values between 6 and 9 as illustrated on figure 1 (Buchbjerg 1977). The functional properties are thus mainly of interest in food systemes with pH values below 6. Globin isolated by the acetone method may unfortunately suffer from off-flavors due to undesirable side reactions in the process.

Hemoglobin may also be decolorizes by treatments with strong oxidants wich however partially destroy the protein quality (Gorbatov 1976). The high content of essential amino acids of hemoglobin may be utilizes by separation after enzymatic hydrolysis. Special techniques are however required to obtain a bland taste of the products (SIK 1977).

Disguise of hemoglobin color.

The methods to decolorize hemoglobin are predominantly based on removal of the heme moity. From a nutritional point of view the iron content of heme must be regarded as very desirable. Iron deficiency anemia have been identified by several nutritional surveys as a problem warranting attention (Leveille 1977). It is recognized that iron in the form of heme has a much higher availability than does non-heme iron. A high heme iron content of food products, especially those primarily consumed by low income groups with low consumption of lean meats, will consequently be desirable. There is therefore sound nutritional reason for including hemoglobin or whole blood in emulsion type sausages. In order to disguise the color of hemoglobin attempts have made to mix blood with skimmilk and precipitate the proteins. Smirnitskaya et al. (1973) held a mixture of 15% whole blood and 85% non-fat milk at 95°C for 5minutes in the presence of $CaCl_2$. The protein precipitate was pressed to a moisture content of 70-75% and used as a sausage extender. In another report Smirnitskaya et al. (1973 b) use a 1:1 mixture of blood and non-fat milk calculated on the protein contents. The results showed that the resulting protein mixture could replace up to 15% of beef in the production of sausage products. Another approach to disguise the hemoglobin color is to emulsify blood with fats. Zayas, Zyrina and Sokolov (1975) prepared an emulsion of 45% fat, 6-7% sodium caseinat, 20% blood and 28% water which was given an ultrasonic treatment for 7 minutes in a hydrodynamic vibrator. The resulting emulsions had an optical density corresponding to beef breakfast sausages and a good stability on storage and head treatment. Sodium sojaproteinate might replace the sodium caseinate although the latter is preferred. The emulsions may replace up to 15% of semi-lean pork in emulsion type sausages without significant changes in the sensoric properties of the products.

Homogenization of blood emulsions.

The essential feature of the ultrasonic treatment appears to be preparation of the most stabile emulsions with the fat droplets as finely dispersed as possible. Zayas et al. (1975) report an average diameter of the fat droplets of 1,95 μm. This is about the size of droplets produced by homogenizing ice cream emulsions in a pressure homogenizer at pressures of 140 to 210 kg/cm^2 (Berger 1976). In our experiments we have found that use of a pressure homogenizer brings about extensive decolorization.

In a pressure homogenizer dispersion of fat droplets arise from the physical impact created by forcing the emulsion through a narrow orifice or channel in the homogenizer valve by means of a powerful pump. In the most simple valve design the emulsion is passed through a narrow slit, 50-100 μm wide, between two plane surfaces as illustrated on figure 2a. The pressure difference across the slit gives the emulsion stream an acceleration up to a velocity from 50 to over 200 m/sec.. The acceleration elongates the fat droplets into long treads. As a result of surface tension and viscous drag effects, a series of varicose deformations appear and grow until the treads disintegrate (Taylor 1934), as illustrated on figure 2b. Drops of approximately 1/100 the size of the original drop may be formed. To prevent coalescence the fat droplets must be covered with a layer of protein. Observations on homogenization of cream have shown that in presence of casein the fat droplets will already at the exit of the homogenizing valve be covered with a layer of casein micelles as illustrated on figure 3. In decolorization of blood-fat-caseinate emulsions it is required that the process takes place at a temperature above the melting temperature but yet so low that damage on the functional properties of the blood proteins are minimized. When pork fat is used we prefer a temperature in the range of 30-50°C. Furthermore the emulsion should contain casein, or another protein capable to form micelles, in such a quantity that the droplets can be well covered with protein. Working with caseinate we prefer at least 7% protein calculated on the fat content.

Color effects of homogenization of blood emulsions.

On figure 4 is shown the relationship between homogenization pressure and color of the resulting emulsion measured as reflectance at 525 nm, the isobestic point of the three forms of hemoglobin. The test emulsion contained 42% pork fat, 27% blood, 6% Na:caseinate and 25% added water. The figure shows that increasing pressure increase reflectance especially up to 150 kg/cm^2. It is thus advantageously to apply pressures above 150 kg/cm^2, but increased decolorization is obtained at higher pressures up to at least 350 kg/cm^2. Observations of the emulsion in light microscope show that a homogenization pressure of 150 kg/cm^2 give droplets diameters of 1 and 2 μm with a few drops of 3 to 6 μm. Higher pressures tend to decrease the average droplet size. With a pressure of 350 kg/cm^2 the globules are generally uncountable ($<$ 0,5 m) with a few around 1 and 2 μm. The erythrocytes appears disintegrated in the process. For a poly-disperse system such as ice cream mix it has been shown that the mean volume surface diameter $d=a{\times}p^{-n}$, where a and n are experimental constants and p is the total pressure drop established during homogenization (Stistrup & Andreasen 1966). The effect of droplet size on the appearance of an emulsion has been studied by Griffin (1950). His observations are summarized in tabel 1. An average droplet size of about 1 μm appears preferable for decolorization purpose. Further reduction than that achieved with a pressure of 350 kg/cm^2 can thus hardly be expected to improve the decolorization of the emulsions.

When ice cream mix is homogenized it is often found that the individual fat droplets cohere in clusters, resulting in a very viscous mix which has poor processing properties in subsequent stages. The formation of clusters is enhanced by higher concentration of fat globules, higher homogenizing pressure and/or lower homogenizing temperature (Graf & Bauer 1976). Cluster formation need not necessarily occur in homogenized ice cream mix (Stistrup & Andreasen 1966) and viscosity measurement on blood emulsions has not shown increase in viscosity with increasing homogenization pressure.

On figure 5 is shown the relationship between fat content of emulsions homogenized at 300 kg/cm^2 and color of emulsions. As expected gives increased fat content increased decolorization of the emulsions. When whole blood is used in the emulsions fat contents between 20 and 30% make the emulsions attain color corresponding to normal lean meat. When the centrifuged erythrocyte fraction is used higher fat contents of the emulsions are required to produce normal meat color. With a content of 26% hemoglobin a fat content of 43% gave a reflectance of 21% which is within the normal meat color range. The emulsion color is stable on heating. Heating of emulsions to 80°C have thus only insignificantly change the reflectance measurements.

Homogenization of the emulsions bring about oxidation of the hemoglobin. Measurements of emulsion reflectance at 525 and 572 nm has shown a conversion of approx 60% of the hemoglobin to methemoglobin. We have avoided the resulting discoloration by conversion of hemoglobin to the stable nitrosylhemoglobin. This was done by addition of 100 ppm $NaNO_2$ and 5% sodium ascorbate to the blood during preparation of the emulsion.

Nutritive value of the blood emulsions.

In production of Frankfurter sausages the blood emulsions may partly replace pork jowls or beef head meat with a protein content of about 17% and a fat content of about 20%. These cuts have a connective content of about 29%. By utilization of the relationships between hydroxyproline and essential amino-acids published by Dvorak & Vognarova (1969) calculations gave the proteins of the meat a chemical score of 57 with tryptophane as the limiting amino acid. The content of essential amino acids in a typical emulsion containing 27% blood and 6,3% Na:caseinate is shown in table 2. The chemical score of the emulsion proteins is 94 with isoleucine as the limiting amino acid. The biological value of the proteins of the sausage may thus be improved by use of the blood emulsion in place of meat with a considerable content of connective tissue, which normally is used in these types of products.

The heme iron content of an emulsion containing 27% blood is 8 mg compared to 3 mg in pork and beef jawls. This fortification of heme iron is of nutritional importance as iron in this form is available for absoption in a mixed diet far better than when given as iron salts (Reizenstein et al. 1975). As pork fat may be substituted with other fats and oils, as soy bean oil, the blood emulsions may be used as a vehicle to introduce poly-unsaturated oils in the sausages and thus make to sausages more attractive for cholesterol consious consumers.

Use of blood emulsions in sausage production.

The question may be raised if the homogenization process impaire the functional properties of the blood proteins with regard to sausage production. Production of Wiener sausages with 5,34% blood either added as a blood emulsion homogenized at 50°C or added directly in the cutter gave final processing yields of 91,47 respectively 92,00%. The functional properties are thus only slightly impaired even at this rather high homogenizing temperature. In table 3 is shown examples of formulations of sausage products with blood and erythrocyte emulsions. The figures on the content of emulsions represent levels which may be use without any appreciable change in the normal sensoric properties of the products. When the collection costs of whole blood is calculated to 1 kg/liter the use of emulsions in the quantities listed in the table brings about a reduction in emulsion price of about 10 percent.

Conclusion.

Use of blood as an ingredient of sausage products increase their nutritional value due to fortification with iron and increase in biological value of the proteins. It is advantageoustly to use whole blood or isolated erythrocytes in finely dispersed casein-fat emulsions, which decolorize the hemoglobin. Products containing hemoglobin corresponding up to about 10 percent blood have been produced. They showed no appreciable change in their usual sensoric properties.

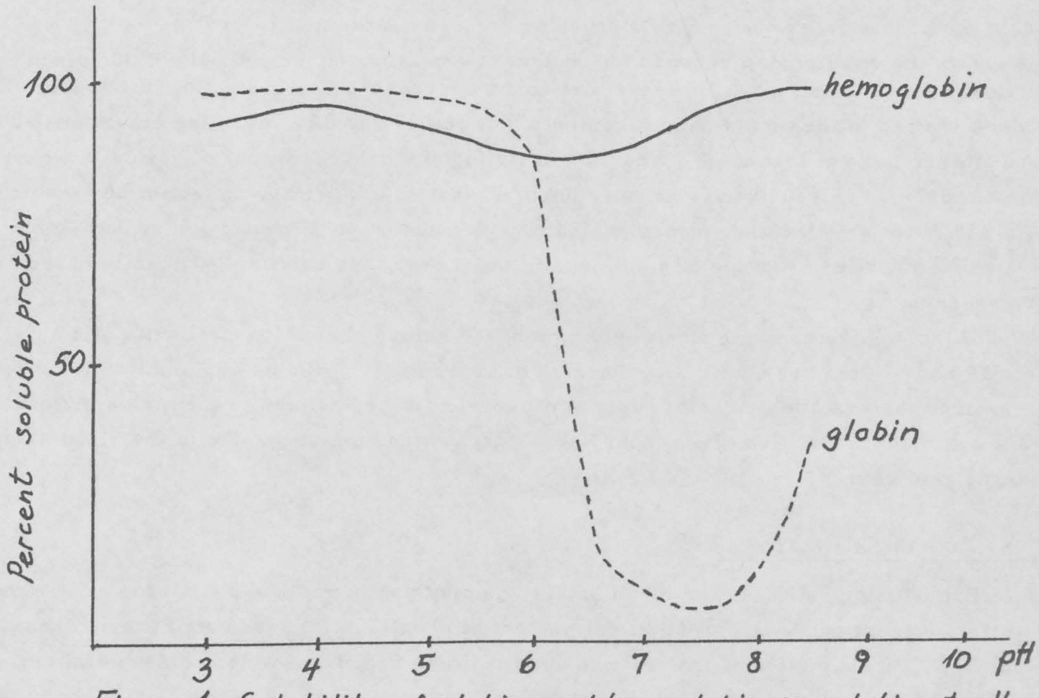


Figure 1. Solubility of globin and hemoglobin in relation to pH.

Table 1.

Effect of droplet size on emulsion apperance.

Droplet size.	Appearance.
Macro globules	Two phases may be distinguished
Greater than 1 μm	Milky white emulsions
1 to approx 0,1 μm	Blue-white emulsions
0,1 to 0,05	Gray semitransparent
0,05 μ to smaller	Transparent.

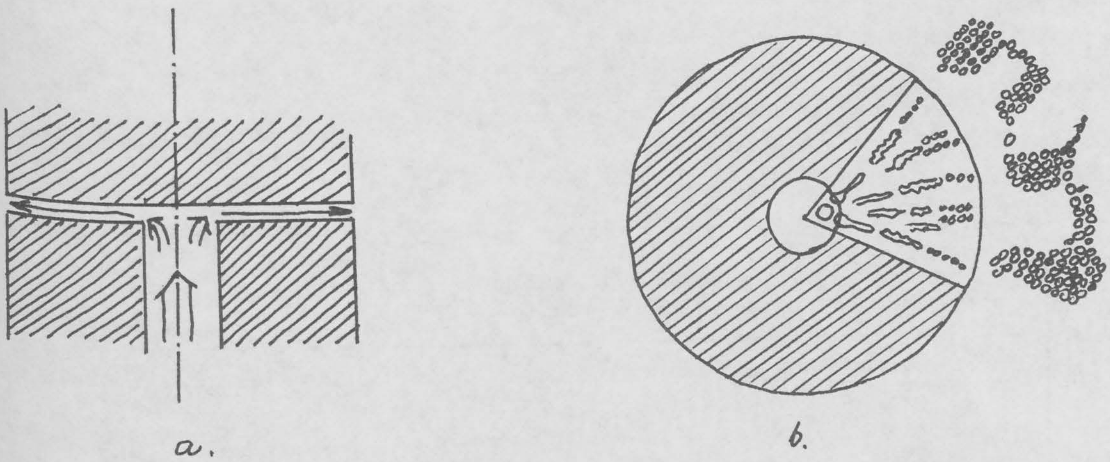


Figure 2. a Vertical and b horizontal sketch of homogenizing valve with illustration of the behavior of fat drops.

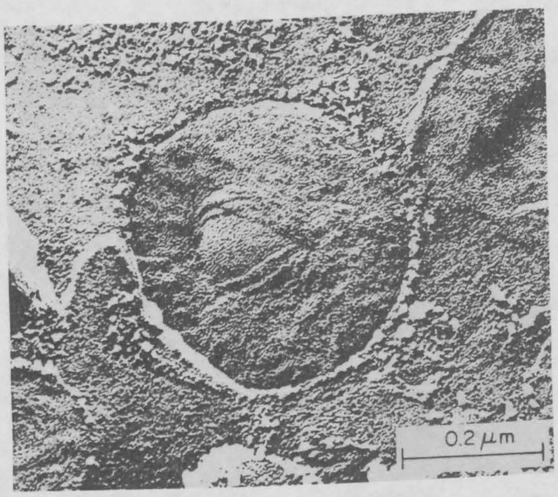


Figure 3. The surface layers of homogenized fat globules are composed of casein micelles (freeze etching, magnification × 130,000 (Eggmann 1969).

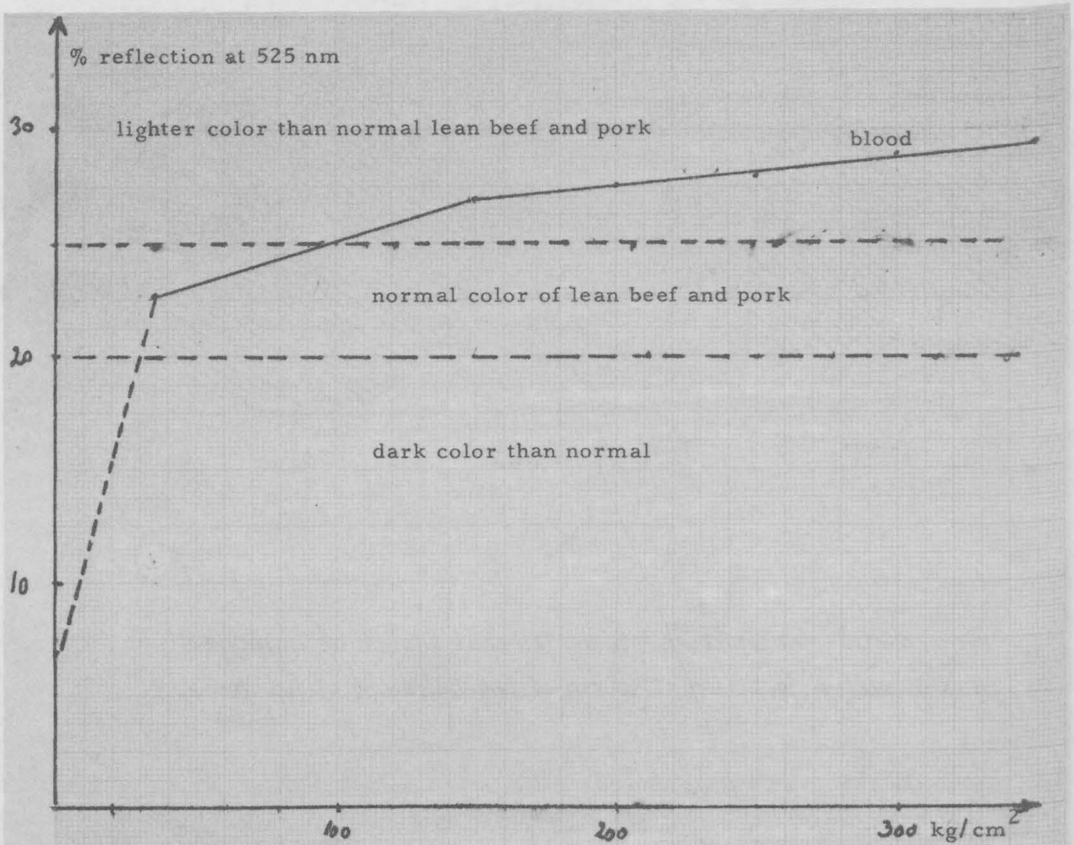
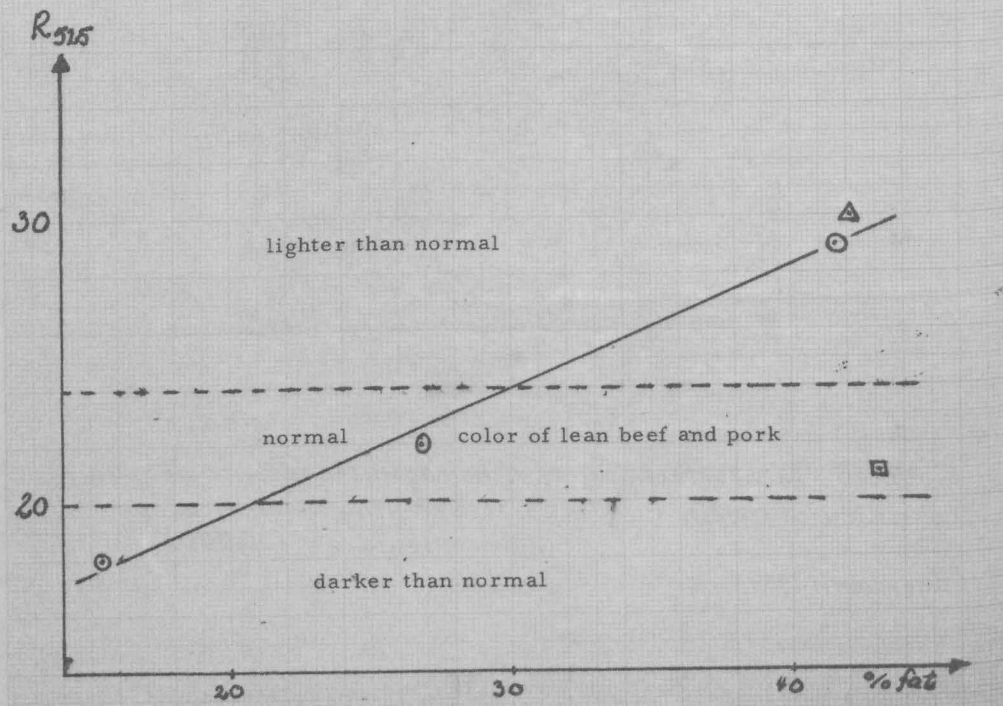


Figure 4. Relationship between emulsion color, measured as % reflection at 525 nm, and homogenization pressure.



Firure 5. Relationship between fat content and color, measured as % reflectance at 525 nm. ⊙ 3,5% hemoglobin △ 2,6% hemoglobin □ 26% hemoglobin in emulsion.

Table 2.

Content of essential amino acids and chemical score of a blood emulsion containing 27% blood and 6,3% Na:caseinate.

Essential amino acide	Blood	Caseinate	Combined emulsion proteins*	FAO reference pattern	Chemical score
Isoleucine	0,9	6,6	4,0	4,2	94
Leucine	12,4	10,6	11,2	4,8	100
Lysine	9,2	8,2	8,7	4,2	100
Methionine	1,3	3,3	2,4	2,2	100
Phenylalanine	7,0	5,8	6,4	2,8	100
Treonine	5,2	4,5	4,8	2,8	100
Tryptophane	1,4	1,5	1,5	1,4	100
Valine	9,1	7,4	8,2	4,2	100

The amino acid contents are given as g. pr. 16g N. *46,7% blood proteins + 53,3% caseinate

Table 3. Examples of formulations of sausage products with blood emulsions.

	% ingredients.							%
	Head meat.	Pork fat trimmings	Greaves	Liver	Blood emulsion	Erythrocyte emulsion	Water and miscellaneous ingredients	Blood in product calculated on hemoglobin
Wienersausage 1	30	18	3		18		31	5
Wienersausage 2	32	19	3			13	31	10,5
Cervelat sausage	24	21				15	39	12
Liver paste.		24		25	10		40	2,6

Lausen (1978).

Anson, M.L. & A.E. Mirsky (1930).
J. Gen. Physiol. 13, 469.

Antonini, E. & M. Brunort (1971).
Hemoglobin and Myoglobin in their Reactions with Ligands. North Holland Publishing Co. Amsterdam. p.125.

Berger, K.G. (1976).
Ice Cream in "Food Emulsions" (S. Friberg ed) Marcel Dekker Inc. p.175.

Buchbjerg, K.O. (1977).
Isolering af globin samt funktionelle egenskaber af globin og hæmoglobin. Hovedopgave. Afd. f. kødteknologi. KVL. København

Dvorak, Z. & I. Vognarova (1969).
Nutritive value of the proteins of veal, beef and pork determined on the basis of available essential amino acids or hydroxyproline analysis. J. Sci. Food Agr. 20, 146.

Düpjohann, J. (1976).
Ein Verfahren zur Verwertung von Schlachttierblut unter besonderer Berücksichtigung der Plasmagewinnung. Fleischwirtschaft Nr.1/1976, p. 54-59.

Eggmann, H. (1969).
Milchwissenschaft 24, 479.

Gorbatov, V.M. (1976).
The utilization of Blood and other Slaughter byproducts. 22. European Meeting of Meat Research Workers. Congress Documentation. Vol.II. paper 1.0.

Griffin, W.C. (1950).
in "Encyclopedia of Chemical Technology" (Kirk-Othmer ed) Interscience Encyclopedia, Inc. New Tork, vol.5, p.695.

Graf, E. & H. Bauer (1976).
Milk and Milk Products, in "Food Emulsions" (S. Friberg ed) Marcel Dekker Inc. p.295.

Hermansson, A.-M. & E. Tornberg (1976).
Functional Properties of some Protein Preparations from Blood. 22. European Meeting of Meat Research Workers. Congress Documentation, Vol. II, paper I.1.

Lausen, T. (1978).
Production experiments at the Meat Trade School in Roskilde, Denmark.

Leveille, G.A. (1977).
Select committee dietary goals fail to recognize all effects. National Provisioner Dec. 24 p. 11.

Reizenstein, P. et al. (1975).
Resorptionen af häm-järn och av järnsupplement. Näringsforskning 19, 39.

SIK (1977).
Svenska Livsmedelinstitutet Göteborg, Årsberättelse 76/77 SIK-Rapport 420, p. 5.

Smirnitskaya, N.E. et al. (1973a).
Manufacture of a protein concentrate and its use during production of sausages and chops. Vses. Nauchno-Issled Inst. Myasn. Prom-sti. 27, 71.

Smirnitskaya, N.E. et al. (1973b).
Die Anwendung des Blutes von Schlachttieren als Eiweisszugabe bei der Herstellung von Fleischwaren. 19. European Meeting of Meat Research Workers. Paper J/4.

Sommer, H.H. (1944).
Theory and Practice of Ice Cream Making. Sommer. Madison. Wisconsin.

Stistrup, K. & J. Andreasen (1966).
Homogenization of Ice Cream Mix. 17. Int. Dairy Congress F:2, p. 375.

Taylor, G. L. (1934).
Proc. Roy. Soc. A. 146, 501.

Tybor, P.T., C.W. Dill, W.A. Landmann (1973).
Effect of Decolorization and Lactose Incorporation on the Emulsification Capacity of Spray-Dried Blood Protein Concentrates. J. Food Sci. 38, 4.

Tybor, P.T., C.W. Dill, W.A: Landmann (1975).
Functional Properties of Proteins from Bovine Blood by a Continuous Pilot Process. J. Food Sci. 40, 155.

Zayas, Y., L. Zyrina & A. Sokolov (1975).
A Physical Metod of Imparting Lighter Colour to Blood. Myasnaya Industriya SSSR No. 1. p. 20.