ALL-UNION RESEARCH INSTITUTE

OF THE MEAT INDUSTRY

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V.M. Gorbatov

# INVESTIGATION OF THE PROCESS OF BLOOD EVAPORATION

Moscow, 1961

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# INVESTIGATION OF THE PROCESS OF BLOOD EVAPORATION

V.M.Gorbatov

## S U M M A R Y

There has been investigated a process of blood evaporation of slaughter animals. The experiments resulted in obtaining the data which served as the initial parameters in designing a new vacuum-evaporator to concentrate blood prior to drying in atomizing dryers.

Tests of this model of vacuum-evaporator confirmed its effectiveness when a small area and a simplicity of making, as compared with vacuum-evaporators of other types, were required.

A working design of semi-industrial apparatus with 400 kg of evaporated moisture per hour capacity, was made.

DAS ALLUNIONS-FORSCHUNGSINSTITUT DER FLEISCHWIRTSCHAFT

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# DIE UNTERSUCHUNG VON BLUTVERDAMPFUNGSVORGANG

W.M.Gorbatow

## Z U S A M M E N F A S S U N G

Die Untersuchungen des Verdampfungsvorgangs von Schlachttier-Blut wurden vorgenommen. Auf Grund der erhaltenen Werte wurde ein neuer Vakuumverdampfer zur Blutverdichtung vor dem Trocknen im Zerstäubungstrockner entwickelt.

Die Prüfung des Modellapparats bestätigte dessen Effektiwität bei wenigem Raumbedarf und Einfachheit im Vergleich mit anderen Typen der Vakuumverdampfer.

Ein Arbeitsprojekt von Halbbetriebs-Verdampfer mit der Leistung 400 kg Flüssigkeit pro Stunde ist aufgestellt worden.

L'INSTITUT D'ETAT DE RECHERCHES SCIENTIFIQUES DE LA VIANDE

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# LES RECHERCHES DU PROCÉDÉ D'ÉVAPORATION DU SANG

V.M.Gorbatov

## R É S U M É

On a réalisé des recherches du procédé d'évaporation du sang des bétails d'abattoir. Les données obtenues permettent d'effectuer la construction d'un vacuum-évaporateur neuf pour concentrer le sang avant le séchage dans le sécheur à pulverisation.

Les épreuves de cet appareil ont avéré son effectivité quand il y a lieu une petite nécessité de place et une simplicité de construction en comparaison d'autres vacuum-évaporateurs.

On a préparé le projet définitif d'un appareil semi-industriel avec la capacité de 400 kg/h de l'humeur évaporée.

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# INVESTIGATION OF THE PROCESS OF BLOOD EVAPORATION

V.M.Gorbatov

At present, a most widely spread method of technological processing of blood of slaughter animals is that of drying blood in atomized state. The advantage of dehydratation by atomization lies in the fact that this method excludes denaturation of protein matters and oxidation of the product, and also in the rate of drying process which does not result in the development of microorganisms causing blood protein decomposition. The drying process in atomizing dryers is entirely mechanized and it is possible to design apparatus with a wide range of capacity.

But the equipment of this type has a number of disadvantages: it is characterized by high cost and considerable size which increase with the increase of the capacity of the apparatus; besides, drying by atomization requires large expenses of steam, and it results in a sharp rise of cost price of a finished product.

One of the ways to improve technical and economic indices of the work of atomizing dryers is to preevaporate blood. This dicreases expenses of steam per a unit of evaporated moisture and increases the capacity of dryers avoiding the necessity of using large additional areas.

Only vacuum-evaporators can be used to evaporate blood as the whole process should be carried out without exceeding the protein coagulation temperature; otherwise, it can cause irreversible change of protein properties. To get a sufficient intensity of moisture evaporation under these conditions it is necessary to significantly lower the tempera-

ture of blood boiling by achieving high vacuum in the evaporator. Residual pressure must not exceed 60 mm. Hg.; it provides boiling at 40-50°.

The experimentally obtained diagram of relation of blood boiling heat to rarefaction degree (fig. I) indicates that blood boiling heat with residual pressure less than 55 mm.Hg. coincides with water boiling heat; with higher residual pressure, blood boiling heat increases.

It has been also established that with the changes of physical properties of blood during condensation, intensity of moisture evaporation is considerably slowed down (fig. 2). Viscosity increases within the following range:

| | | | |
|---|---|---|---|
| % blood moisture ..... | 83 | 59 | 58 |
| viscosity in ° at 20° ..... | 5 | II.6 | I6.3 |

The increase of blood viscosity during evaporation results in slowing down its movement under convection current and in the formation of a film (crust) of dried up blood on the surface at a certain degree of evaporation. This, in its turn, deteriorates the conditions of heat exchange on the line between heating surface and blood and disturbs hydrodynamic conditions for fluid movement through the apparatus. Blood evaporation is, therefore, effective up to a definite degree of dehydratation only, i.e., up to 33-35% dry matters content.

In a number of countries (Hungary, G.F.R., Denmark) they use tube vacuum-evaporators to pre-evaporate blood prior to drying; blood boils in the tubes which are warmed up by steam.

Experiments with an analogous apparatus at the Leningrad meat packing plant showed its unfitness when applying to blood which is very sensitive to temperature rate changes; the use of this apparatus does not exclude the possibility of overheating blood during evaporation which results in blood coagulation. On the other hand, the formation of a film on the heating surface of tubes results in relatively rapid decrease of their internal diameter and in deterioration of heat exchange.

Effectiveness of pre-evaporation was manifested in the increase of the dryer output by 25-35%; since steam expenses in vacuum-evaporators were 0.52 kg per a kg of evaporated moisture, total steam expenses for drying up of blood lowered from 2.5 kg to I.9 kg per a kg of evaporated moisture. At the same time, rapid overgrowing of vacuum-evaporator tubes and periodical temperature rises of blood which result in blood protein coagulation, led to frequent stoppages to clean the tubes, but this lowered the effectiveness of the apparatus.

Firm "Niro Atomizer, Ltd" (Denmark) marks in its prospects that it produces vacuum-evaporators where tubes are heated with warm water (not with steam). It should be noted that a vacuum-evaporator for blood, that the firm supplied to us in 1959, has steam heating and, therefore, it does not exclude the possibility of overheating blood in tubes and blood coagulation, which we observed in analogous units.

On the basis of the given above material, in 1959 we started our investigations with the aim of designing a reliable vacuum-evaporator for blood. In this work we used, as the base, Professor Levin's apparatus employed to concentrate different solutions in chemical industry.

Laboratory vacuum-evaporator model, made at the Institute, is characterized by the fact that boiling zone is out of heating zone (as there is hydrostatic pressure of blood column over heating zone); owing to this, there was excluded the possibility of overheating blood. Evaporated blood circulates through a closed system with the rate of 0.8 m/sec., gets warm while washing the heating element at the bottom of the lift pipe. Inside the heating element there circulates water, which is warmed up to 60-70° in electrical heater. Warmed blood rises through the lift pipe and begins to boil, while moving. Water vapour and foam from boiling are brought to the separator; secondary vapour gets free of foam and blood in a trap, from where blood returns through the drain-pipe, while condensate flows from the condenser to the collector.

Experiments on blood evaporation in the laboratory vacuum-evaporator were carried out to measure temperatures of blood and of heating water on its entering and leaving; residual pressure in the apparatus and the content of dry residue in blood before and after evaporation.

The following results were obtained:

| Heating water temperature | | Blood temperature | | Residual pressure (mm.Hg.) | Evaporation period (hrs) | Dry residue content | |
|---|---|---|---|---|---|---|---|
| entering | leaving | entering | leaving | | | before evaporation | after evaporation |
| 64.5 | 61.8 | 44.1 | 46.0 | 53.4 | 5 | 15.0 | 28.2 |
| 58.5 | 54.7 | 40.7 | 42.5 | 38.4 | 2 | 17.7 | 22.7 |
| 60.7 | 58.0 | 42.6 | 44.2 | 44.2 | 5 | 13.5 | 29.9 |

If blood temperature was on a similar level but the temperature of heating water reached 70-75°, blood coagulated.

Study of the evaporated blood by spectrophotometric method showed the presence of unchanged hemoglobin with typical absorbtion spectrum. During drying evaporated blood in an atomizing dryer ("Niro Atomizer, Ltd", "Minor" type), there was obtained albumen containing 95-96% of soluble protein matters; it points to the absence of denaturation of blood protein matters during evaporation process.

After testing the laboratory model of the apparatus, industrial vacuum-evaporator based on the same principle was designed.

While designing the unit, the following was taken into consideration: blood temperature must be maintained on the lowest level possible throughout the whole process. Test work confirmed the possibility of evaporation at 40° blood temperature.

With the preset capacity of the industrial apparatus (400 kg of evaporated moisture per hour), heating surface 15 $m^2$, heat transfer coefficient 1,140 $kcal/m^2 \cdot hr \cdot deg.$ and

blood circulation rate 1.37 m/sec., temperature difference between blood and heating medium (water) will be 15°, according to the calculations. Allowing some error for contaminated pipes (due to sticking of dry particles), it was accepted that water temperature for warming blood can be maintained at 60°. The temperature of pipe-wall from the blood side will be 50° (maximum), i.e., blood coagulation is excluded completely.

The apparatus should work as follows: blood, under atmospheric pressure, enters the receiver (4), where upper and lower levels are controlled by electron level-indicators. From the accumulator, blood is supplied to the separator housing through a float level-regulator. Warming is performed by water circulating through the boiler under the action of centrifugal pump: in the boiler the water reaches 70°. Warm water enters inter-pipe space of the heat exchanger and then the water tank. Blood circulates through heating pipes. It begins to boil as it moves up due to the drop in the pressure of fluid column. Vapour and blood mixture is then thrown into the separator housing, from where secondary vapour with a certain quantity of foamy blood enters the trap and, releasing from blood, passes to the condenser. Condensate from the condenser flows down through the drain-pipe, while blood flows down through the reverse circulating pipe to the collector, and further, again to heating pipes of the heat exchanger. Fresh blood is fed automatically through the level-regulator. Evaporated blood is continiously picked out by the blade pump. Vacuum-pump creates rarefaction of 95.5% order of magnitude.

At present, manufacture of the first industrial apparatus comes to an end. After its test, there will be organized serial production.

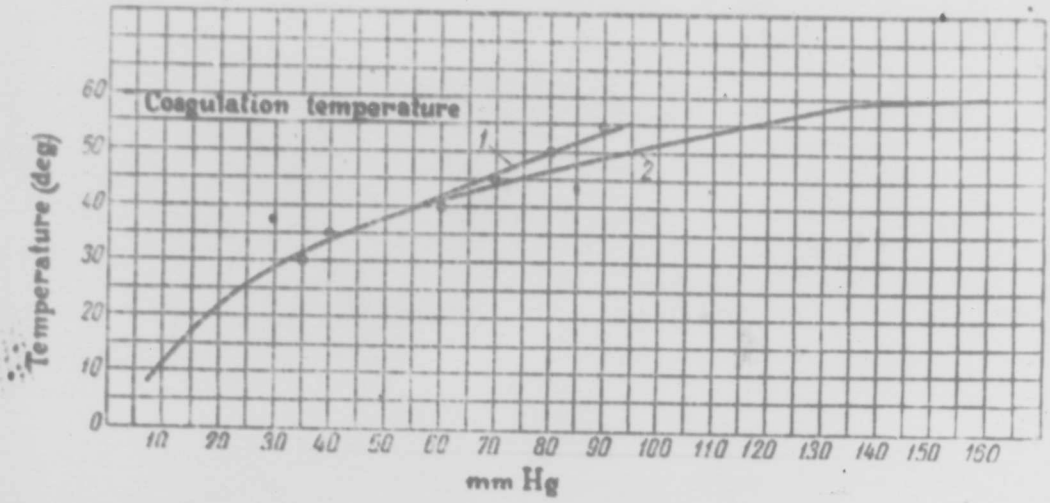


Fig.1 Relation of water boiling heat to vacuum:
1 - blood; 2 - water.

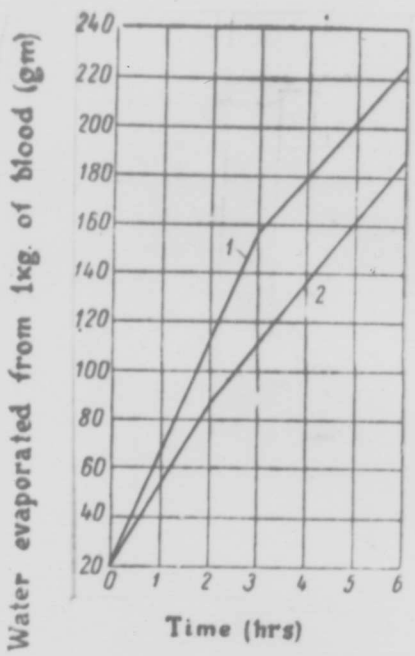


Fig.2 Relation of protein concentrates in blood to the intensity of moisture evaporation:
1-at 35°, 168mm Hg, 86% blood humidity. 2-at 45°, 35 mm Hg, 82% blood humidity