# From meat to emulsion – a single operation

Separation systems for upgrading material properties of meat – Part 2

**Using appropriate cutting and separating machinery and equipment, it is possible to optimise the quality of meat as a raw material. Part 1 of this article described the fundamentals of processing and separating operations, as well as the ways in which they are measured. Part 2 below describes the mode of operation of the special perforated disc and knife systems as well as the application technologies of these methods. It presents concrete results of studies dealing with material optimising of meat as a resource. The article ends with a look at the future prospects of perforated disc-knife systems.**

**By Eberhard Haack and Wolfram Schnäckel**

It is the interaction between both perforated discs and knives that determines the operations in separation processes. The arrangement and frequency of these tools are determined by the targeted objectives. For example, there are simple cutting sets consisting of a knife and perforated disc as well as multiple perforated disc-knife arrangements.

The size of the hole in the final perforated disc is crucial for the actual separating process. The hole diameter determines the retention effect that is then shifted backwards right through to the (upstream) perforated discs arranged in series in the form of a delay in outflow at all cutting levels. The raw material is thus subjected to the same dwelling time as at the first perforated disc. This makes multiple separations possible, so that here too high-strength material components can be separated both centrally and radially with tangential discharge.

Fig. 2: Cutting set with central discharge with pneumatically controlled cutting setting without support cross (Power Tools, Germany)

A further effect is that the following raw materials exert a thrust or pushing pressure on the separated materials when they arrive at the final perforated disc. Under these conditions the material to be separated tends to scrape off at the edges of the hole. This results in the fine solid particles in the final product that can no longer be eliminated in the following processing. So separating the raw material components at several cutting levels reduces the share of separated material at the final perforated disc. This enhances the product quality.

## Function of the perforated discs

The perforated discs frequently take on the discharge functions through fitted grooves and flues that together with the knife rotation carry the solid raw material component to the point of discharge in order to channel it out there with various operating elements (Fig. 1).

In most cases, however, simple, smooth perforated discs that are then combined with a central discharge have proved successful (Fig. 2).

Examinations have shown that the high-strength material components disturb the product outflow on the perforated disc hole pattern. Above all extra-fine collagenous tissue tends to settle between the knife blades and the drilled surfaces and to clog them or coat them with a fine flow skin. This interrupts the function of the perforated discs/knives. The situation is caused by the high strengths of the type of raw material, which either does not infiltrate deeply enough into the holes or it is so elastic that the deformation is neutralised. The blocking of the holes increases the stress on the perforated discs and leads to the perforated disc vibrating under the thrust pressure. As a consequence the knives and perforated discs lift apart from each other. This can be prevented on the one hand by the separating grooves and diversion channels in the perforated disc hole pattern already described, or on the other hand by the arrangements of

Fig. 1: Perforated disc with discharge channels (Seydelmann, Germany)

cutting grooves with a slanting groove base to accept raw material components that move more sluggishly with continuous emptying and at the same time chopping by the knives and cutting edges. One goal of separating off lies in preventing the perforated discs from becoming clogged. First of all the heavy raw material is to be taken up, then it is to be reduced step by step and returned to the active perforated disc surface. This enhances the separating process for meat recovery and hard substances are removed from the function area of the perforated disc by separating knives (Fig. 3).

## Design of the knife systems

The function of the knives is generally to channel out the heavy material to be separated from the active perforated disc area via special blade arrangements or positions. Figure 4 shows examples of the product-guiding function of the knives to the point of discharge. Furthermore, augers are allocated to the knife bodies in order to avoid clogging effects via additional conveying support. Knives with spiral forms increase the dwelling time of the raw material in a specific direction over the entire perforated disc surface to increase the heat exchange and improve substance cohesion through friction.

In addition to these technical generalisations, detailed research has revealed a quite essential difference. The knives that guide the raw material over separate separation channels have major problems in leading off the raw materials when the blades become worn. This it due to the fact that with each grinding cycle (use plus re-grinding) the discharge or diversion channels lose a little depth for guiding away raw material. This means that the material to be separated is no longer discharged, but instead jammed against the perforated disc face. As a consequence the perforated disc is pushed away from the knife and so the cutting function is interrupted.

A much greater negative effect is exercised by strong clogging of the holes in the perforated disc with bones, cartilage and sinews that can then hardly be removed any more, even by a high-pressure cleaner. In practice the perforated discs are frequently drilled free hole for hole and cleaned. The service life of such channel knives is thus limited to 30 to 50% of the channel depth.

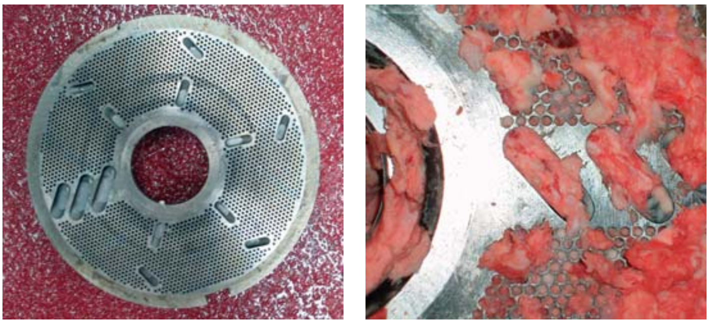


**Fig. 3:** Perforated disc W300 – hole diameter 2.4 mm with cutting grooves (left) and in operation (right) (Power Tools, Germany)

## Separating knives and ring knives with outlets

The separating channel is formed by the blade-knife body. Re-grinding reduces the distance between the knife and perforated disc and clogs the separating grooves in the knife. In the case of the stuffing-mincing machine under review here, the knife with drawing blades is designed in such a way that it conveys the raw material inwards to the separation point. As a result the separating knife remains operable over its full service life. The novel separating ring knife uses the complete knife chamber like a standard knife. The separating ring knife guides bones, cartilage and sinews inwards into the centre of the perforated disc with blades. The material to be processed is discharged through the holes of the perforated disc by means of a discharge auger on the knife body. The central separating knife works via a discharge tube in the middle at the final perforated disc. It can be used in the stuffing mincing machines produced by Vemag, Handtmann, Frey and Rex. The improved separating ring knives can be installed in all standard commercial separating sets. They are available in sizes B 98 to E 130, as well as for all mincing sizes up to 400 mm.

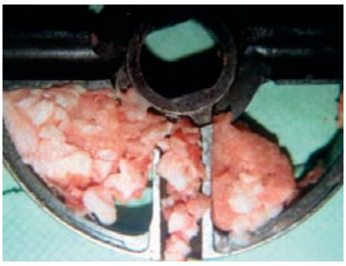


**Fig. 4:** Grading knife with side discharge above the knife ring

Despite the improved working width, the possibility of complete knife chambers becoming clogged has not so far been excluded. It happens when the bone and sinew components of the parent material are extremely high, or the amount of separated material discharged is too low. This clogging takes place both with controlled time intervals and at discharge in the case of mechanical gap control. A soft material share of at least 75% should be assumed for standard separating sets.

### Quality upgrading after the separation process

**Tab.:** Results of the wet chemical analysis of pork and beef as parent raw material and as minced-and-separated meat for processing

| Parameter in % | Parent raw material pork S III | S III, 3 mm minced; separated | Parent raw material beef R III | R III, 3 mm minced; separated |
|---|---|---|---|---|
| Water | 69 | 66.70 | 69 | 57.74 |
| Fat | 12 | 14.06 | 12 | 9.26 |
| Protein | 19 | 18.48 | 19 | 20.32 |
| Collagen | 3 | 3.41 | 3.4 | 1.35 |
| BEFFE[1] | 16 | 15.07 | 15.6 | 18.97 |
| BEFFE[1] in FE[2] | 84 | 81.53 | 82 | 93.35 |

[1] BEFFE = German acronym for content of meat protein free of connective tissue
[2] FE = Total meat protein

Source: Haack and Schnäckel — Fleischwirtschaft International 5/2008

Continuously controlled raw material removal with a motor-operated discharge auger is much more favourable. Here the quantity ratios can be recorded by sensors based on the pressure increase as a result of clogging in the knife chamber, or the increase in torque of the discharge auger can be averted by arranging for the speed to be increased.

Even removal of the raw material prevents stoppage in the movement of the material to be separated, which is generally the cause of malfunctions. This applies in particular for raw materials in the sub-zero temperature range of T = –3 to –5 °C, or when a product contains many solid materials. It is useful here to make a few fundamental and generally valid remarks about discharge systems.

## How discharge systems work

The task of discharge systems is to selectively channel materials to be separated that have gathered in the knife and cutting chamber out of the active cutting system. As the feed pressure develops in the cutting set through the auger or the feed organs with the reduction resistance of raw material and perforated disc, an overpressure prevails in the cutting set. The operating principle of material separation is based on the differences in firmness in the raw material and on reducing pressure via the apertures of discharge channels. By lowering the pressure it is possible to generate a local raw material outflow. Knife systems with cutters or blades mounted in a guiding function pass the sluggishly moving raw material to the discharge points. Perforated disc channels too support this operation.

**Fig. 5:** Mechanical Enterprise cutting set with solid discharge through an auger (Speco, USA – left) and motor-powered auger cutting set with central discharge (Power Tools, Germany – right)

The discharge systems have a pressure-regulating function that influences the dwelling time of the raw material types on the perforated disc pattern and hence the outflow quantities by means of gap or time control systems. A whole series of system variants exists for material discharge. These can work individually or be combined. Distinctions are made between mechanical separating sets, simple separating sets with electrical and pneumatic control, multiple separating sets with electrical/pneumatic control and lateral/central discharge or in combination with central mechanical diversion facilities and motor-operated auger separating sets to draw off the material to be separated. Figure 5 shows examples of separating set variants.

In principle these variants extend as far as five separation planes. With these separating sets it is possible to solve a wide variety of separating problems.

## Technologies in raw material separation and refining

The aim is to upgrade the quality of raw materials and to directly separate off foreign materials that are untypical for the final product. The interfering materials include bones, cartilage, bone gristle, residues of feather quills, possibly skin components etc. The raw materials are particularly interesting in the temperature range down to T = –5 °C, as they are available as merchandise for the meat industry in this frozen form. The temperature of –5 °C occurs on reduction of meat block products (T = –18 °C) using mincing machines at the final perforated disc with hole diameters of d = 3.0 to 8.0 mm due to the extreme compression of the cold raw material at the first reduction operation. This creates the prerequisite for the separating operation with a further mincer.

Separating systems have consistently developed further in line with the scope of tasks presented by the meat processing industry. Today this includes works such as:

- upgrading quality classes of raw material in order to enhance the economic exploitation,
- selective separating off of raw materials, e.g. of fat to produce low-fat granulated rind,
- improving the fineness in the end product without foreign particles,
- producing material compositions for specific end products,
- separating raw material in the low temperature range.

Fundamental examinations have revealed that separating off of fat, sinews and collagenous tissue distinctly reduces the temperature occurring as a consequence of size reduction and friction, for example at the final perforated disc with a hole diameter of 2.0 mm, resulting in clearer cutting patterns.

This phenomenon was examined specifically with a thermal image camera (Fig. 6). The outcome was that the temperature of the fat components and collagenous tissues rises much more strongly than that of lean meat in the passage through the cutting set. The raw material pork S III warmed by ΔT = 1 to 2 K within 48 hours on the light cooling face of the end perforated disc, hole diameter 4.0 mm. In a five-part cutting set there was no change in the temperature of lean meat. In the case of fat and collagenous tissue the temperature increased by ΔT = 8 to 10 K.

Although this increase in temperature has so far not been considered as a technological magnitude, it can be explained logically as follows:

- Lean meat with a water content of up to 80% has a high cooling performance.
- Fat with a water content of 3 to 5% has a low cooling performance.
- Collagenous tissues with a water content of 3 to 5% have a low cooling performance.
- Interior fats have higher water contents.

As a consequence only the lean meat cools itself through the meat juice with the high specific heat requirement for liquids, while lack of liquid and high mechanical substance strength in fat lead to a higher dwelling time, more introduction of friction work and less cooling from the exterior.

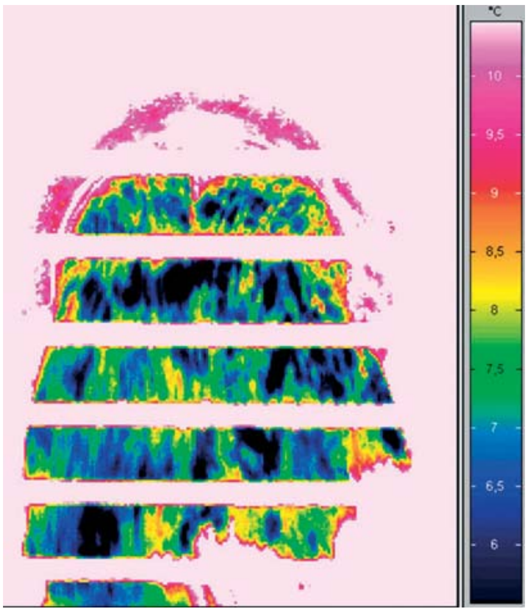


Fig. 6: Temperature differences in the product flow with material-typical composition

What is important, therefore, is to withdraw the sluggishly-moving raw material from the work area of the perforated disc as quickly as possible in order to be able to exploit the qualitative advantages. A further interesting aspect is the fact that raw material separation is possible with raw material in the temperature range of T = –3 to –5 °C.

Using a motor-powered auger separating set it is possible to draw off raw material uniformly at a wide variety of speeds without any dwelling time on the perforated disc. This leads to a situation in which as heat is generated and free meat juice or ice water results from the friction on the final perforated disc, no renewed freezing to form a solid body takes place. The raw material remains in movement and can thus be continuously discharged.

## Studies on optimising material properties

The BEFFE (water binding capacity and the content of meat protein free of connective tissue protein) value is ultimately the quality-determining parameter in meat grading after separation of fat components, collagenous connective tissue and bones. The result is termed refining. For this purpose specific examinations were conducted using Near Infrared Transmission Spectroscopy Infratec 1265 (NIR spectroscopy) in combination with TQC-Graphics in the range of 850 to 1050 nm. In addition the collagenous components were counted out under UV light. First of all an optical evaluation was conducted on pork S III and beef R III after central separation. The raw material heavily interspersed with bone particles and sinews is freed from all undesirable product constituents during separation in two separation planes. The result is a distinctly upgraded raw material.

The NIR spectroscopy following processing of pork S III and beef R III with a double separating set revealed that the potential application of the minced and separated material as high-grade material for production was perceptibly improved. A comparison between minced pork and minced-and-separated pork shows that fatty tissue can only be removed to the same extent by mincing alone with deliberately generous separating off of the lean meat component.

The values of the wet-chemical analysis of the processed pork and beef are compiled in the following table. It is evident from these values that after separation this meat was turned into top products in the raw sausage sector.

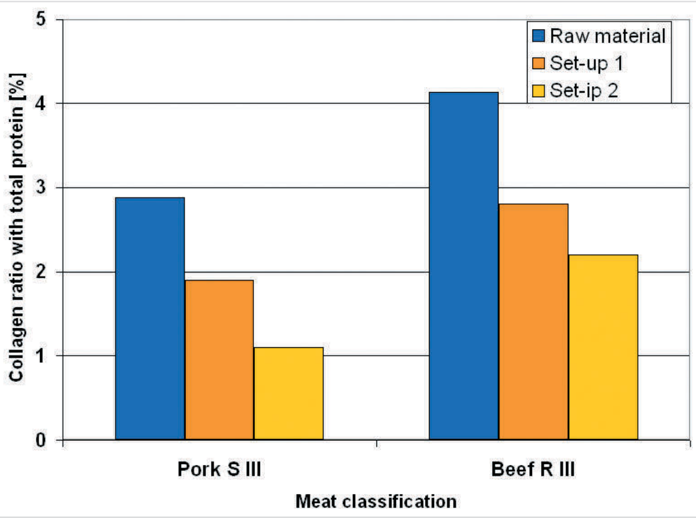
With the NIR analysis device measuring takes place very quickly, but calibration is necessary beforehand for each material. The advantage over wet-chemical analysis lies in the speed. Figure 7 shows how the percentage of the collagenous component in total protein in pork and beef of grade S III and R III respectively changes through the use of the separating method.

Sinew and cartilage components can be made clearly visible under UV light too. For this a wavelength of 336 nm is necessary. At this wave length collagenous particles appear as shining white points. It is possible to count out the parts and thus make a statement on the quality of the cutting set configuration.

## Appraising the use of separating systems

Systems for lateral and central separation right through to 4 separating planes were examined. The raw material quality can be influenced to a great extent. It has become apparent that raw material can be separated using perforated disc holes up to diameter d = 8 mm. If work is performed with several separating levels and fine end perforated discs, it is possible even to use hole diameters of d = 16 mm in the middle perforated disc segment.

However, the raw material must produce a higher thrust through the work auger at each




Source: Haack and Schnäckel Fleischwirtschaft International 5/2008

Fig. 7: Collagen contents of meat grades pork S III and beef R III determined with Near Infrared spectroscopy (NIR)

cutting plane, as the resistance of the tools increases altogether. This is due to the fact that the biochemical substance properties both have to secure the thrust force produced and at the same time overcome the material reduction in the cutting set with its resistances. The limit for force generation in the normal mincing machine is quite evidently reached with a 7-part cutting set. However, it is possible to carry out triple separation already with a 5-part cutting set. For this purpose a knife system that allows both discharge via the hub centre and tangential separation is used.

In 9-part cutting sets, although very good separating effects were evident, the cutting pattern achieved after the end perforated disc became unclear, representing a distinct loss in quality.

An alternative here is the stuffing-mincing machine, as the raw material remains virtually unstressed during the feed operation. Good quality studies on this are available.

The multiple separation makes it possible for slow-moving raw material components creating a jam at the end perforated disc to be separated off at all cutting levels. The hole size plays a subordinate role in the middle cutting levels here. The main function is the dwelling time on the surface of the perforated disc. This is generated from the end perforated disc with low off-flow performance. The separating quality at the individual planes is thus determined by the separating systems through the time-controlled or continuous parameters of the raw material diversion.

## Further application results

Within the framework of the investigations the following further applications were considered:

- fat removal from rinds,
- fat separation from beef,
- coarse disc separation, e.g. with perforated disc hole diameter of 8 mm.

### Fat removal from rinds

The processing of raw rinds generates enormous thrust potential against the cutting set. Here thrust pressures rise up to p = 60 bar. This is the reason why the fat is pressed out of the skin at the cutting levels during the reduction operation. Due to the high pressure increase during size reduction it then forms a separate, free outflowing soft mass, for example at the end perforated disc with a hole diameter of 3 mm in the knife chamber. When the knife chamber in the cutting part housing is opened, the soft fat that has been pressed out from the rind runs off very strongly. For this both the housing and the separating knife have to be adapted to the task. To this end the separating ring knife is equipped with a special outer ring that thus prevents the emergence of coarse solid particles.

### Fat separation from beef

The fat separation is readily used to generate high-grade lean beef components. Here the upgrading factor in the meat quality is particularly effective. For this task it is best to use multiple separating sets with vacuum support and steady raw material removal.

Since fat counts as one of the sluggishly-moving raw materials, this raw material component can be readily passed into the cutting set. Thus ultimately what is important is the parameter setting for the raw material discharge in order to obtain the maximum possible lean meat component.

### Coarse separation with perforated disc hole diameter of 8 mm

Coarse separation in preliminary cutter size is what all meat refiners want. During recent years separability has shifted from extra fine perforated discs with hole diameters of 2 to 4 mm to perforated discs with hole diameters of 5 to 8 mm. To this end sensitive isolation control is necessary, as the raw material acceptance capability at perforated discs with hole diameters d = 8 mm is very high. Consequently machines can only be run in the very low back-pressure control range in order to initiate the separating operation and continue with sustainable good quality. A particularly high requirement here is that the separated materials must be guided very quickly to the discharge point (e.g. central raw material discharge with motor-powered auger).

## Prospects

With new tool systems raw material processing in mincing machines of conventional design as well as in stuffing-and-mincing machines or extruder mincing machines will in future substantially shorten the processing chains from the initial raw material through to the preliminary meat product as ready-to-stuff filling. Qualitative tasks carried out by separating operations and raw material isolation are to be classified increasingly in the complete treatment process by controls and instrumentation. Already today it is possible using extruder-mincing machinery to mix coarse-sized meat pieces (200 x 200 x 200 mm) in hoppers with a capacity of 1000 to 2000 litres with all formulation ingredients, to reduce them, to conduct the mixing and separating processes in end product quality by means of tool geometries, and to safely isolate unwanted substances such as bones, cartilage and the like. Here the new motor-powered auger separating sets are helpful in keeping to filling weights and quantity-dependent characteristics, as well as in quality assurance.

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