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Description of the Processes used in the UK to Manufacture MSM and Former DSM Meat Products from Poultry and Pork and an Initial Assessment of Microbiological Risk

A final report for the UK Food Standards Agency

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1. Executive summary

The overall aim of this short project was to provide evidence to support the Food Standards Agency's (the Agency) assessment of whether current restrictions on the use of Mechanically Separated Meat (MSM) and Desinewed Meat (DSM) from poultry and pork are appropriate and proportionate for the protection of public health. To achieve this, the project sought to:

1. Describe the processes in use in the UK for the production of poultry and pork Type 1 and Type 2 MSM products, and meat preparations previously described as DSM and currently assessed as being outside the scope of the moratorium.
2. Gather and review any information that is available from literature, or from measurements made by food business operators, on the microbiological status at each stage of the production process.
3. Review and comment on the appropriateness of the required controls and restrictions for each process and suggest any changes, if required, to these controls and restrictions.
4. Identify any information gaps.

Following a short survey of industrial practice and literature regarding the manufacture of MSM and former DSM products it has been concluded that:

1. Current UK production process

This survey of 2 pork and 4 poultry UK processors has shown that processors are using similar processes to produce poultry and pork Type 1 and Type 2 MSM and meat preparations.

The pork processors used a pre-breaker followed by a Townsend press separator then a SEPAmatic drum & belt separator to produce their MSM. Relatively low pressures were used at both plants. One processor produced Type 1 MSM, one processor produced Type 2 MSM. The processors had described their products as DSM prior to the moratorium.

Three of the four poultry processors used Baader drum & belt separators to produce Type 1 MSM and meat preparations. One used an auger separator to produce Type 1 MSM. Two processors produced meat preparations that had previously been described as DSM before the moratorium. These products (derived from wishbone meat) were reclassified according to the advice of FSA guidance, 'Guidance on the moratorium on the production and use of desinewed meat from non ruminant bones or poultry carcases in the United Kingdom', published in May 2012.

At all the plants the legislative requirements for the production of MSM and meat preparations, i.e. the age of the raw materials used, treatment after production, chilling, freezing, storage, appear to be routinely adhered to.

2. Review of microbial status

There is very little published data on the microbial status of MSM. A number of publications indicate that the main factor influencing the microbial load on the MSM is the state and age of the raw material used to process the MSM. The few surveys that have been carried out generally report relatively high numbers of microorganisms with TVCs of as high as 6 – 7 $\log_{10}$ cfu g^{-1}. However, they also show a big range in counts, and it is not always clear what type (Type 1 or Type 2) of MSM is being sampled. It is likely that a number of the older publications report counts measured on MSM produced using older high pressure systems.

In these systems product temperatures are likely to be substantially higher than those produced in the current low pressure systems.

There are many statements in the general literature that MSM will preferentially support the growth of microorganisms, and that the degree of muscle fibre degradation may be an important factor influencing the microbial load on the MSM. However, no published scientific studies have been located that actually compare microbial growth on MSM meat with other forms of fresh, or even minced meat or meat preparations, under the same conditions. Nor are there any clear published studies that have compared the microbial growth on MSM meat with the degree of muscle fibre degradation (thus the degree of separation pressure).

Microbial data provided by current pork and poultry MSM producers show average TVCs that are similar to, or lower than, those found on mince meat. It therefore appears that the overall microbiological quality of MRM, particularly Type 1, is similar to that of minced meat and meat preparations.

3. Appropriateness of the controls and restrictions

There is evidence that the new Type 1 MSM produced under low pressure, previously labelled as Desinewed Meat (DSM), is similar to mince and is likely to represent a similar risk as mince. However, currently labelling it MSM means that it can no longer be counted towards the meat content of a product, making it less valuable to food manufacturers.

At present it may be considered that there is insufficient scientific evidence to establish the food safety risk of any type of MSM, and whether it is any different to mince or meat preparations.

4. Identify any information gaps

Many authors/researchers have remarked that MSM is "an excellent medium for bacterial growth" (Gill, 1988; ICMSF, 1998). However, provided the meat is rapidly reduced to chilled, or freezing, temperatures this need not be a problem. A similar argument has been made regarding mince. Howeve, a recent review of the literature on mince for the FSA (FSA M01054: *Quantification of the controls that should be placed on meat prior to mincing*) found no published scientific evidence to support the argument for mince. It is also clear that there is insufficient published data on MSM to substantiate such claims. Thus, there is a need to establish whether MSM is a better growth medium, under standard chilled storage conditions, in comparison with minced meat, or cuts of meat, and whether the degree of muscle fibre degradation, thus the separation pressure, has an effect on microbial growth.

There is also a clear need for survey work to establish what the prevalence of pathogens actually is in UK produced MSM in order to determine the risk this product poses, and how this compares with minced meat and meat preparations.

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2. Literature review

2.1 Introduction

Mechanical separators produce MSM by forcing bones with meat attached through sieves (Field, 1988). In the case of poultry and red meat, bones with meat attached are often pre-broken, or ground, through a 1.3 to 3 cm plate before being placed under pressure to remove the soft meat that flows through the sieve holes. Mechanical separation of meat from bones was first developed for the recovery of flesh from fish frames (left after filleting) in the late 1940s. The mechanical recovery of poultry meat from flesh-bearing bones started in the 1950s, while applications for red meat began in the 1970s (Field, 1988). One of the original aims of the development of MSM technology was to reduce the rate of repetitive strain injury (RSI) of workers caused by short cyclic boning work in cutting rooms of meat operations.

In appearance MSM can range from resembling a finely minced meat (Type 1 MSM produced under low pressure) to a paste or puree (Type 2 MSM produced under high pressure).

Following potential public health concerns regarding the BSE risk, the use of ruminant bones as raw material for the production of MSM has been banned in the EU since 2001.

Commission Directive 2001/101/EC agreed in July 2001 and published in November 20011 introduced a European generic definition of meat for the purposes of labelling. This directive restricted the generic term "meat" (as well as species names such as "beef", "pork", "chicken" etc.) to skeletal muscle with naturally included or adherent fat and connective tissue. This excluded mechanically separated meat (MSM) from counting towards the "meat" content of a product (QUID (Quantitative Ingredient Declarations) percentages of meat). This restriction reduced the commercial value of MSM markedly and led to the development of lower pressure processes with less yield but a more fresh meat type product. This product has been described as "mechanically desinewed meat" (DSM) or "Baader meat" (after the equipment commonly used to produce it) or "3 mm meat" according to different terminologies used in the meat sector (EFSA, 2013).

In March 2012 the European Commission ruled that DSM did not comply with European Union single market legislation and therefore requested that the UK discontinue producing DSM from the bones of cattle, sheep and goats and re-classify the DSM produced from pork and poultry bones as MSM.

2.2 Definition of MSM

The term "Mechanically Separated Meat" was adopted at the 10th Session of the Codex Committee on Processed Meat and Poultry products in Copenhagen in 1978 (Field, 1988). Nether-the-less, other terms remain in common usage for such products including "Mechanically Recovered Meat (MRM)", "Mechanically Deboned Meat (MDM)", and "Mechanically Deboned Poultry".

Within the EU "Mechanically Separated Meat" (MSM) was first defined in Regulation (EC) No. 853/2004 which came into force in 2004 and was applicable from 1st January 2006. It applies to all species. Previously, Article 2 of European Directive 64/433/EEC (on fresh meat) provided a definition of "Mechanically Recovered Meat" (MRM) as follows:

" 'Mechanically Recovered Meat' means meat obtained by mechanical means from flesh-bearing bones apart from the bones of the head, the extremities of the limbs below the carpal and tarsal joints and, in the case of swine, the coccygeal vertebrae, and intended for establishments approved in accordance with Article 6 of Directive 77/99/EEC".

European Directive 64/433/EEC was applicable only to ruminant animals (cattle, sheep and goats), pigs and horses. Council Directive 71/118/EEC on fresh poultry meat did not provide a definition of MRM although a requirement was added to that Directive by Council Directive 94/65/EC in December 1994, which stipulated that mechanically recovered poultry meat could be traded only if it had previously undergone heat treatment in accordance with European Directive 77/99/EEC on meat products in the establishment of origin or any other establishment designated by the competent authority.

Current EU legislation, Annex I to Regulation (EC) No. 853/2004 and Article 3 (1) (n) to Regulation (EC) No. 999/2001, define MSM as follows:

'Mechanically separated meat' or 'MSM' means the product obtained by removing meat from flesh-bearing bones after boning or from poultry carcases, using mechanical means resulting in the loss or modification of the muscle fibre structure.

Thus according to this definition, MSM is defined by three properties:

1. The product is produced from meat residues that adhere to bones after deboning, and not from deboned meat;
2. These meat residues are extracted mechanically;
3. The extraction results in loss or modification of muscle fibre structure.

This definition implies that product mechanical separated from flesh-bearing bones in a manner that does not result in a modification of the muscle fibre structure should not be considered MSM. Defra guidance[1] (formally FSA guidance until Defra took policy lead in Summer 2010) on the labelling and composition of meat products published in 2003 (FSA, 2003) following the new definition of MSM was that:

"Products obtained by mechanical deboning, which remove definitive pieces of meat from meaty bones or carcass, which may or may not have had the primal muscles previously removed, such that the muscle fibre structure of the meat is substantially intact are not considered to be MRM or MSM. This meat may then be de-sinewed and have the appearance of finely minced meat. These products may still be considered meat, and may be counted towards the QUID declaration."

In comparison, Regulation (EC) No. 853/2004 Annex I defines minced meat as:

"Minced meat' means boned meat that has been minced into fragments and contains less than 1 % salt."

And meat preparations:

"Meat preparations' means fresh meat, including meat that has been reduced to fragments, which has had foodstuffs, seasonings or additives added to it or which has undergone processes insufficient to modify the internal muscle fibre structure of the meat and thus to eliminate the characteristics of fresh meat."

[1] The authors have not found any more recent guidance from the FSA or Defra regarding MSM.

Current EU legislation (Regulation (EC) No. 853/2004) describes two types of MSM.

1. Type 1, the production of which must not alter the structure of the bones, or contain a calcium content that is not significantly higher than that of minced meat; and
2. Type 2, all other processes.

The calcium content of Type 1 should not exceed 1000 ppm of fresh product.

Three main types of mechanical separator can be used to produce MSM. One type typically uses a low pressure process, one type typically uses a high pressure process, while the third can operate at low or high pressures. Low pressure processing produces Type 1 MSM, while high pressure processing produces Type 2 MSM.

The use of MSM produced using techniques that

1. Do not alter the structure of the bones used in the production of MSM and
2. Have a calcium content which is not significantly higher than that of minced meat (Type 1)

is permitted in meat products if the FBO has carried out analyses demonstrating that the MSM complies with the microbiological criteria for minced meat as set out in Regulation (EC) 2073/2005. MSM that has not been shown to comply with the above criteria (Type 2) may be used only to manufacture heat-treated meat products in establishments approved in accordance with Regulation (EC) 853/2004. The use of MSM produced using techniques other than those mentioned above may only be used to manufacture heat-treated meat products in establishments approved in accordance with Regulation (EC) 853/2004.

The differentiation between the two types of MSM is that it is believed that high pressure produced MSM is of higher risk to public health than low pressure produced MSM.

2.3 Desinewed meat (DSM)

Restrictions in the use of MSM following legislation in 2001 reduced the commercial value of MSM markedly and led to the development of lower pressure processes with less yield but a more fresh meat type product, i.e. desinewed meat (DSM).

FSA guidance, 'The production of meat preparations obtained by desinewing meat', published in September 2010 defined DSM as:

1. "Desinewed meat is meat from which the sinews and tendons have been removed. It may be obtained from a number of sources including meat trim and the removal of residual meat from bones.
2. It is produced by passing trim or meaty bones through a low pressure machine where the material obtained appears to retain its muscle fibre structure. Some machines remove and desinew the meat as part of a continuous process; others do it in a two stage operation. The resulting product is variously known as Baader meat, 3mm meat or desinewed meat; for the purposes of this document it is called desinewed meat. Whether a "one stage" or a "two stage" method is used it is the end result of both stages that should be considered to be the desinewed meat. Such material would appear to fall within the definition of a meat preparation (paragraph 1.15, Annex I of Regulation (EC) No. 853/2004), which includes "fresh meat that has been reduced to fragments ..... or which has undergone processes insufficient to modify the internal muscle fibre structure of the meat and thus to eliminate the characteristics of fresh meat". As the muscle fibre structure is maintained, the material falls outside the

definition of MSM in Regulation (EC) No. 853/2004, (i.e. where the mechanical process results in the loss or modification of the muscle fibre structure). It cannot be considered to be minced meat because it is produced under pressure and not by cutting.

3. Whilst this desinewed meat is derived from fresh meat and still retains the characteristics of fresh meat it has, nevertheless, undergone a process (i.e. it has been removed from the bone and been desinewed, whether in one stage or two stages). However the process was insufficient to substantially alter the initial product and thereby turn it into a meat product. (The definition of a "meat product" in paragraph 7.1, Annex I of Regulation (EC) 853/2004 and of "processing" in Article 2.1(m) of Regulation (EC) 852/2004, refer.)"

In March 2012 the European Commission ruled that DSM did not comply with European Union single market legislation and therefore requested that the UK discontinue producing DSM from the bones of cattle, sheep and goats and re-classify the DSM produced from pork and poultry bones as MSM.

Following this an FSA guidance document, 'Guidance on the moratorium on the production and use of desinewed meat from non ruminant bones or poultry carcases in the United Kingdom', published in May 2012, advised that following processes were "outside the scope of the moratorium":

- "Residual non ruminant meat which has been removed from the bone, either with a knife or hand held powered equipment with a cutting or shearing action, and which does not involve removing the meat by means of applying low or high pressure techniques, is **not considered to be MSM**.
- If the product obtained from the process described in the bullet point above contains cartilage, sinew or bone fragments / chips, it may be passed through a meat separator to remove such cartilage, sinew or fragments, and is **not considered to be MSM**.
- DSM produced from portions of non ruminant meat (which is not on the bone, and that has not been obtained by mechanical separation) by passing it through a meat separator to remove sinew or fat is **not considered to be MSM**.
- Meat removed by mechanical means from non ruminant bone-in cuts of meat that have not been subject to any previous boning* is **not considered to be MSM**. Examples include wishbone meat, and recognised pork and poultry cuts. This process is regarded as mechanical deboning as it is the removal of bones from meat, rather than the removal of residual meat from bones.
- * 'previous boning' is the specific physical removal of meat directly from the bone(s) resulting in a bone with residual meat attached. The removal of the residual meat from the bone would be considered as MSM production."

2.4 Mechanical meat separation processes

Mechanical separators produce MSM by forcing bones with meat attached through sieves (Field, 1988). In the case of poultry and red meat, bones with meat attached are often pre-broken, or ground, through a 1.3 to 3 cm plate before being placed under pressure to remove the soft meat that flows through the sieve holes.

In appearance MSM can range from resembling a finely minced meat (Type 1 MSM produced under low pressure) to a paste or puree (Type 2 MSM produced under high pressure). As noted in the EFSA opinion (EFSA, 2013) and by our own observations in this survey, some technologies for low pressure recovery of meat are able to provide a final product with characteristics close or similar to those of minced meat and possibly indistinguishable from minced meat.

Like minced meat and meat preparations, MSM contains muscle, fat and connective tissue. Unlike minced meat it can also contains fine bone particles in greater abundance than are found in hand boned products (Field, 1988). In some MSM, for example 92-100% of the bone particles are less than 1 mm in length (Koolmees *et al*., 1986). However not all types of MSM contain bone particles (EFSA, 2013). MSM may also contain bone marrow (Field, 1988). Although Field (1999) notes that "the amount of marrow in current systems may be lower than the amount of marrow in meat from past recovery systems" indicating that bone marrow is more associated with MSM produced under high pressure (which was more common in the past) than MSM produced under low pressure. Analysing marrow content has proved to be difficult (Field, 1999; EFSA, 2013). The EFSA opinion (2013) concluded that bone marrow was one of the histological parameters related to tissue composition (the others being muscle, connective tissue, adipose tissue, cartilage, and central nervous tissue) that "do not provide clear differentiation between MSM and fresh meat, minced meat and meat preparations". Bone marrow content does not appear to a parameter than differentiate Type 1 MSM from Type 2 MSM.

Factors that may affect MSM composition (Church & Wood, 1992) include:

- Age of bones.
- Type of bones.
- Temperature of recovery.
- Whether bones have been frozen.
- Amount of meat on the bones.
- Type of machine used.
- Machine setting.
- Feed rate.
- Quantity of material in machine.
- Wear and maintenance of machine.

2.4.1 Types of machine

Three main types of mechanical separator have been designed (Field, 1988; Barbut, 2002):

1) Drum & belt separators
2) Auger separators
3) Press separators

The pressure used may vary with machine type and the specific settings used. Most machines can operate at low or high pressure, but some types of machine are more normally used at low pressure than other types:

1) Drum & belt separators - normally operate at low pressure.

2) Auger separators - can operate at low or high pressures.

3) Press separators - normally operate at high pressures but can be used at low pressures.

Therefore most of the machines used for the production of MSM may produce both Type 1 MSM (low pressure) and Type 2 MSM (high pressure) by adjusting the pressure settings. A low pressure process is normally considered to use pressures below 104 kPa (equal to 100 bar) while a high pressure MSM process operates with pressures from 104 kPa up to 4x104 kPa or more (EC, 2010; EFSA, 2013). These machines may also be used to produce meat preparations, if the raw material processed meets requirements.

As noted in the EFSA opinion (EFSA, 2013) and by our own observations in this survey, some technologies for low pressure recovery of meat are able to provide a final product with characteristics close or similar to those of minced meat and possibly indistinguishable from minced meat.

Drum & belt separators (Baader type)

This method was developed for fish frames and is also used for poultry and red meat (Field, 1988). Drum & belt separators squeeze flesh-bearing bones between a rubber belt and a perforated steel drum. The meat attached to the bone passes through the drum perforations while the bone on the outside is separated and ejected through a discharge chute. Holes in the stainless steel drum range from 1 to 10 mm in diameter. Pressure on the belts can be adjusted, and sometimes pressure rollers are used to ensure an even distribution of the tissue on the belt (Barbut, 2002). Following deboning, the derived MSM may be refined by passing it through a strainer that removes most particles and small pieces of belly lining. The mince can range from a coarse texture to a fine paste depending on source material, machine type and setting, and processing method.

Drum & belt separators can operate at low pressure to produce the low pressure MSM or what has been described as “Baader meat” (after the equipment commonly used to produce it) or “3 mm meat” or “desinewed meat” according to different terminologies used in the meat sector (EFSA, 2013). This meat has the appearance of traditional minced meat (EFSA, 2013; Personal observations).

Current suppliers of this type of separator include:

Baader (http://www.baader.com/en/products/separator_processing/index.html)

SEPAmatic (http://www.bfdcorp.com/index.php/soft-tissue-separators-1)

Auger separators (Beehive type)

Auger separators use a rotating auger inside a perforated cylinder to force the meat through holes in the perforated cylinder (Field, 1988; Barbut, 2002; EFSA, 2013), similar to the action of a standard meat mincer. The perforated cylinder acts like a sieve with the meat passing through the holes and the bone remaining in the cylinder and being pushed out at the end by the auger. The size of the holes can be adjusted and are usually around 0.5 mm in diameter (Barbut, 2002). Meat recovered by auger separators set at high pressure falls within the definition of mechanically separated meat (MSM) given in Section V, Annex III of Regulation (EC) No. 853/2004 because of the high pressure used which causes bone disruption and loss or extensive modification of the muscle fibre structure.

Current suppliers of this type of separator include:

Beehive (http://www.provisur.com/beehive)

AM2C (http://www.am2c.com/Site_AM2C.html)

GEA (http://www.gea-foodsolutions.com/Desinewing--Meat-recovery.1643/GEA-RecoScreen.11.aspx)

LIMA (http://www.lima-france.com/eng/machines-specs)

Marel/Townsend (http://www.marel.com/meat-processing/systems-and-equipment/meat-harvesting/mrs-meat-harvesting-system/336?prdct=1&pc=1)

Press separator (Protecon type)

Press separators use a hydraulic piston to force flesh-bearing bones under low or high pressure to the separation chamber while crushing them and squeezing the meat puree through thin slits between the concentric rings. Press separators are commonly used for red meat (Field, 1988). Meat recovered by hydraulically powered press separators typically fall within the definition of mechanically separated meat (MSM) given in Section V, Annex III of Regulation (EC) No. 853/2004 because of the high pressure often used which causes bone disruption and loss of or extensive modification of the muscle fibre structure. Recovered meat is transferred to a desinewing step where it passes between a belt and a drum with holes 1.0-1.3 mm in diameter (Barbut, 2002). Sinews, cartilage and bone particles are removed at this stage and the product is ready for use (Field, 2004).

Current suppliers of this type of separator include:

Marel/Townsend (incorporating what was Protecon) (http://www.marel.com/meat-processing/systems-and-equipment/meat-harvesting/mrs-meat-harvesting-system/336?prdct=1&pc=1)

2.5 Microbiological quality of MSM

The microbiological condition of MSM is considered to be largely determined by the manner in which the raw material has been handled during dressing, boning, collection and storage (Gill, 1988). To quote Gill (1988); "Since the (raw material) is extensively handled during its removal and separation from other edible or inedible parts of the carcass, there is ample opportunity for organisms to be transferred from the environment to meat surfaces. Consequently, initial microbial numbers on recovered meats tend to be higher than on carcasses, with numbers being at least equivalent to those found on prepared cuts."

While the microbial hazards in MSM are expected to be similar to non-MSM, a number of specific concerns have been raised on the microbiological quality/safety of MSM. The main points being:

- Many authors/researchers have remarked that MSM is "an excellent medium for bacterial growth" (Gill, 1988; ICMSF, 1998).
- Several aspects of the mechanical recovery process (release of intracellular fluids that are very rich in nutrients, incorporation of air and rise in temperature), the small particle size and so the large surface, and the high pH of MRPM theoretically favour microbial development (Field, 1988; Yuste *et al*., 2002).
- That "the risk of microbial growth increases with the degree of muscle fibre degradation, thus with the separation pressure" (EFSA, 2013).
- Both the kinetic action of separation and the equipment itself can lead to the product rising in temperature during operation. Temperatures as high as 35°C have been

reported with some equipment, from bones at 1.1°C (Swingler, 1982; Gill, 1988; ICMSF, 1998).

- In addition, "bacteria may grow on stagnant material retained within the equipment operating at warm temperatures and serve as a source for the continuous inoculation of the product with pathogenic organisms" (Gill, 1988).

Although the above concerns are widely quoted they do not appear to be based on, or supported by, any scientific investigations that have resulted in any peer reviewed publications that we have been able to locate. Given these concerns, it is surprising how little actual published data there is on the microbiological quality of MSM (as also noted in the recent EFSA opinion; EFSA, 2013).

A summary of published data on the microbiological quality of MSM is shown in Table 1. These surveys generally report relatively high numbers of microorganisms with TVCs of as high as 6 – 7 $\log_{10}$ cfu g^{-1}, although they also show a big range in counts, and it is not always clear what type (Type 1 or Type 2) of MSM is being sampled. There would appear to be no recent relevant published data on the microbiological status of either Type 1 or Type 2 MSM as categorised according to the current EC Regulation (EC) 853/2004.

Table 1. Summary of published data on the microbiological quality of MSM

Product	N	TVC (log cfu g^{-1})	Enterobacteriaceae (log cfu g^{-1})	*E. coli* (log cfu g^{-1})	Salmonella (%)	Campylobacter (%)	Yersinia (%)	Listeria (%)	*S. aureus* (log cfu g^{-1})	Country	Reference
Poultry					11					US	Ostovar *et al*., 1971
Pork		5.6 – 7.7	5 - 6						3.3 – 5.8	The Netherlands	Bijker *et al*., 1987
Poultry		5.6 – 7.7							3.1 – 4.7		Bijker *et al*., 1987
Pork	36	3.2 – 6.5	4.3 – 6.8		16.6	50.0	5.5	22.2		Germany	Atanassova & Ring, 1998
Poultry	36	5.6	7.4		32.3	38.5	-	11.6		Germany	Atanassova & Ring, 1998
Turkey	150							32		US	Ramos *et al*., 1998
Poultry	46	3.6 – 6.8			100					Poland	Pomykala & Michalski, 2008
Poultry	145	4.3 – 4.4 (medium)		2.4 – 2.6 (medium)		33 - 87				New Zealand	Lok Wong *et al*., 2011

In the most recent survey, a New Zealand study of poultry MSM, 145 samples collected at three different poultry MSM plants had Campylobacter contamination rates of 87%, 66% and 33% (Lok Wong *et al*., 2011). Median TVC and *E. coli* counts were around 4.3 and 2.5 $\log_{10}$ cfu g^{-1}, respectively, with highest counts being up to 7.26 $\log_{10}$ cfu g^{-1} and 3.72 $\log_{10}$ cfu g^{-1}, respectively.

As discussed in the recent EFSA opinion on MSM (EFSA, 2013), psychrotrophic and psychrophilic organisms have been shown to grow under chilled conditions in MSM.

Ostovar *et al*. (1971) showed an increase TVCs in poultry MSM from 5.5 $\log_{10}$ cfu g^{-1} to 7.0 $\log_{10}$ cfu g^{-1} after storage at 3°C for 12 days. Gomes *et al*. (2003), while investigating the effect of gamma radiation on refrigerated poultry MSM, reported an increase in psychrotrophic TVCs from approximately 3.8 $\log_{10}$ cfu g^{-1} to 4.9 $\log_{10}$ cfu g^{-1} after 4 days, to 6.6 $\log_{10}$ cfu g^{-1} after 6 days, and to 7.8 $\log_{10}$ cfu g^{-1} after 8 days storage at 2°C. Hecer & Sozen (2011), when investigating the effect of chemical treatments on poultry MSM, reported an increase in mesophillic TVCs from approximately 5.4 $\log_{10}$ cfu g^{-1} to 5.8 $\log_{10}$ cfu g^{-1} after just 3 days storage at 4°C. Psychrotrophic TVCs similarly increased from approximately 5.7 $\log_{10}$ cfu g^{-1} to 6.0 $\log_{10}$ cfu g^{-1}. However, no published scientific studies have been located that actually compare growth on MSM meat with other forms of fresh, or even minced meat, under the same conditions. So it difficult to establish whether the growth of psychrotrophic and psychrophilic organisms is any greater on MSM than other meats. In addition, it is unclear whether there is any difference according to the type of MSM, or species from which the MSM is derived.

Since the processes used to produce mince, meat preparations and MSM are known to distribute bacteria throughout the meat it stands to reason that theoretically such products have a higher risk than other meats. However there is some published evidence (Crowley *et al*., 2010) that mince may actually inhibit microbial growth through the action of free radicals released from muscle and bacterial cells.

Due to safety concerns, and legislative requirements, much MSM is frozen immediately after production. There would appear to be very little data on whether freezing has any effect on microbiological counts. Yuste (2002) noted that initial mesophile and psychrotroph counts of ca. 8 $\log_{10}$ cfu g^{-1} on MSM did not significantly decrease after freezing.

3. Survey of MSM and meat preparation production processes used in the UK

The project team worked with the contacts supplied via the Agency to gather information (using phone, email, post and visits) to assess what processes are in use in the UK for the production of poultry and pork Type 1 and Type 2 MSM and meat preparations previously described as DSM and currently assessed as being outside the scope of the moratorium. With the aid of the Agency a questionnaire was designed and sent to all contacts. This was followed up by e-mails, phone and direct visits.

In total data was obtained from 2 pork processors and 4 poultry processors. While all of these companies were happy to talk generally about their processes, some were wary in providing microbiological data due to concerns as to how this data would be interpreted and used.

Responses to the questionnaire were as follows.

3.1 Pork MSM and meat preparations

1. **What is the species of origin of your raw material?**

Data was supplied by 2 pork processors.

2. **Which type of MSM do you produce?**

One processor produced Type 1 MSM, one processor produced Type 2 MSM. The processors had described their products as DSM prior to the moratorium.

3. **Can you please supply us with a HACCP plan for your process?**

Both processors supplied some details of HACCP plans. Flow charts of their plans are shown in Figure 1 and Figure 2.

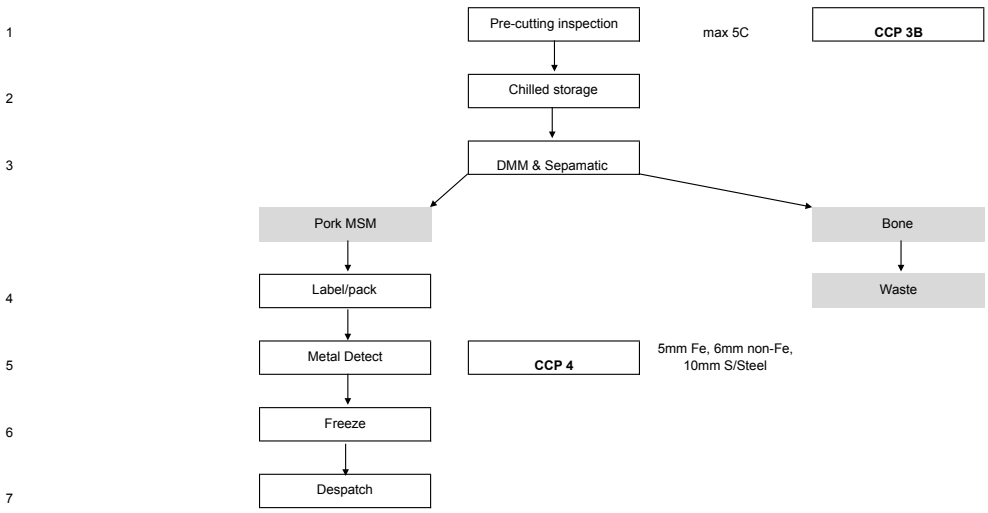

Figure 1. Flow diagram of pork MSM production process for pork Processor 2

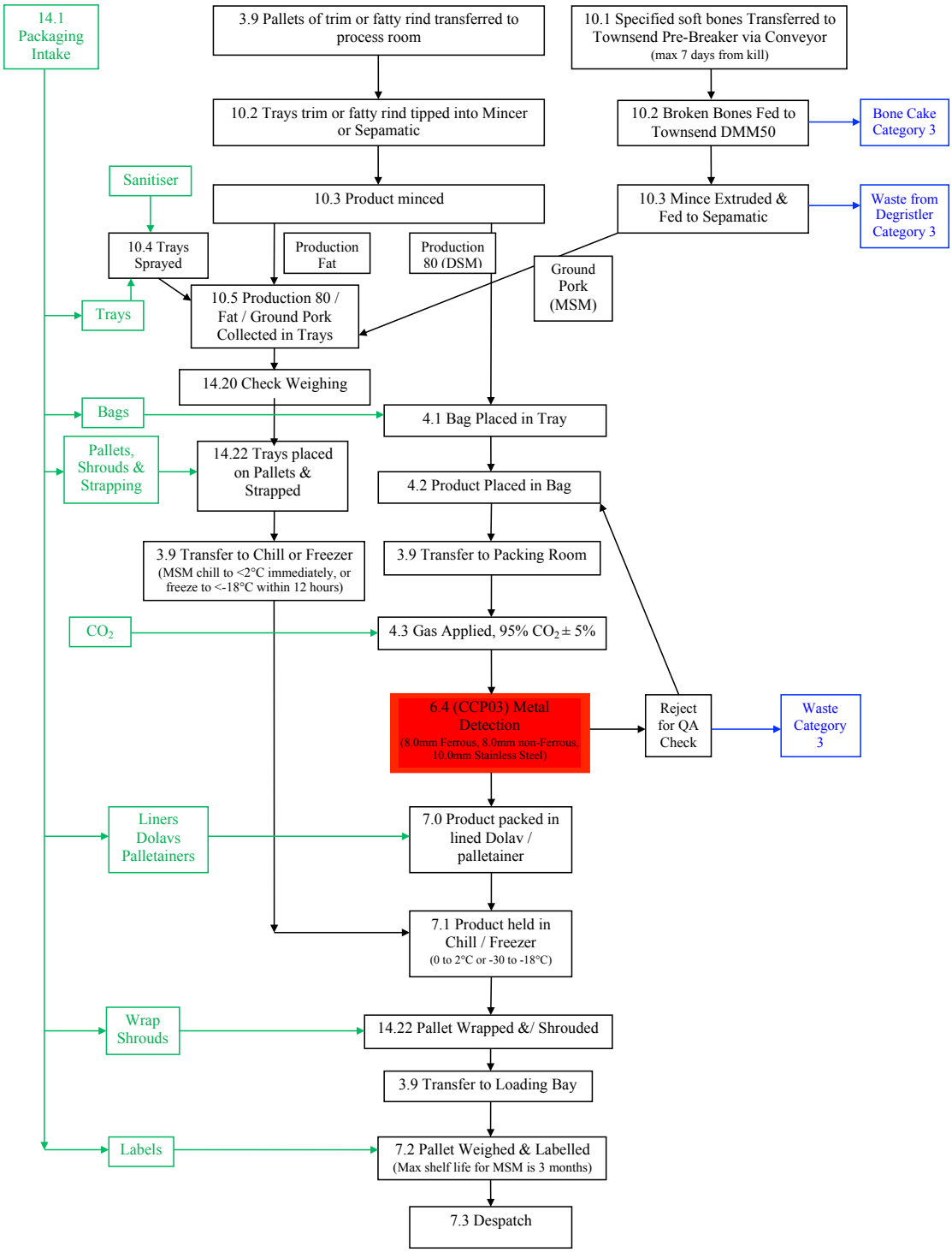

Figure 2. Flow diagram of pork MSM production process for pork Processor 1

4. **Do you undertake microbiological sampling and testing to verify compliance with the microbiological criteria for minced meat (Regulation 2073/2005)?**

Both processors undertake microbiological sampling and testing to verify compliance with the microbiological criteria for minced meat (Regulation 2073/2005).

5. **Do you maintain temperature records of any part of your MSM process?**

Both processors maintained temperature records and supplied some data.

6. What equipment do you use to produce your MSM?

Both processors were using a Townsend DMM 50 press separator followed by a SEPTAmatic drum separator.

The following data was supplied on the type of equipment used:

		Processor 1	Processor 2
Product		Type 1	Type 2
Pre		Pre-breaker	Pre-breaker
Stage 1	Type of machine:	Press separator	Press separator
	Make & model:	Townsend DMM 50 *	Townsend DMM 50 *
Stage 2	Type of machine:	Drum & belt separator	Drum & belt separator
	Make & model:	SEPAmatic SEPA 2000T **	SEPAmatic **
	Discharge plate hole diameter (if applicable):	75mm	
	Drum perforation diameter (if applicable):		2mm
	Typical pressure used:	Low	45 – 90 bar
	Typical size of meat cut fed in:	Soft Bones	up to 6”

* The Townsend DMM 50 is produced by Marel (http://www.marel.com/meat-processing/systems-and-equipment/beef/deboning--trimming/deboning/meat-harvesting/dmm-minced-meat-system/327?prdct=1&pc=1), the DMM stands for Desinewed Minced Meat and the manufacturer claims that it is a low pressure process (50 to 100 bar) and that the “product does not have to be labelled as MSM”.

** The SEPAmatic 2000T is produced by BFD (Better Food Development) Corporation (http://www.bfdcorp.com/index.php/food-processing-equipment/soft-tissue-separators). The manufacturer describes this model as a “soft tissue separator”.

7. What is the source of your raw material?

Both processors received raw material from an on-site slaughterhouse and from an off-site slaughterhouse.

8. How old, since slaughter, is the raw material when received?

Both processors reported that the typical age of the raw material was 5 - 7 days post-slaughter, and that the maximum age was 7 days post-slaughter.

9. What is the composition of your raw material?

The raw material processed by both processors was Trim and Mixed bones.

10. How long do you hold the raw material before processing?

	Processor 1	Processor 2
Typical time (days)	1	1
Maximum time (days)	3	3

11. At what temperature do you hold the raw material before processing?

	Processor 1	Processor 2
Target temperature (°C)	0	2
Maximum temperature (°C)	5	3

12. What is the temperature of the raw material prior to processing?

	Processor 1	Processor 2
Target temperature (°C)	3	2
Maximum temperature (°C)	5	3

13. What is the temperature of the MSM immediately after production?

	Processor 1 *	Processor 2
Target temperature (°C)	10	<5
Maximum temperature (°C)	13	7

* Temperature of 6.6°C measured on exit from SEPAmatic on visit to plant.

14. How often are the temperatures measured?

Processor 1	Processor 2
Every 1 - 2 hours	Raw materials – every intake. In process – twice per day.

15. How is the MSM packed immediately after production?

Processor 1	Processor 2
Plastic tray without liner	Plastic tray without liner
	Plastic tray with liner

16. What is the weight and dimensions of the filled MSM pack produced?

	Processor 1	Processor 2
Weight (kg)	15	~ 20
Length (mm)	1100	500
Width (mm)	620	400
Depth (mm)	100	100

17. Are the packs of MSM then?

	Processor 1	Processor 2
Chilled		
Frozen		✔
Chilled then frozen	✔	
Refrigerated off site		

18. What method do you use to chill your MSM after production?

Processors used air blast chilling systems to chill their MSM before freezing. Processor 2 froze their MSM directly after production.

19. How long does the chilling process take?

	Processor 1	Processor 2
Typically (h)	1	na
Minimum (h)	1	na
Maximum (h)	1	na

20. What is the temperature of the MSM at the end of the chilling process?

	Processor 1	Processor 2
Target temperature (°C)	2	na
Maximum temperature (°C)	2	na

21. If you do not subsequently freeze your MSM, what temperature do you hold your chilled MSM at prior to dispatch?

	Processor 1	Processor 2
Target temperature (°C)	2	na
Maximum temperature (°C)	2	na

22. If you do not subsequently freeze your MSM, how long do you hold your chilled MSM prior to dispatch?

	Processor 1	Processor 2
Target time (h)	24	na
Maximum time (h)	24	na

23. What method do you use to freeze your MSM after production?

Both processors used air blast freezing systems to freeze their pork MSM.

24. How long does the freezing process take?

	Processor 1	Processor 2
Typically (h)	8 - 10	48
Minimum (h)	8	48
Maximum (h)	12	48

25. At what is the temperature of your MSM at the end of the freezing process?

	Processor 1	Processor 2
Target temperature (°C)	-18	-18
Maximum temperature (°C)	-18	-18

26. At what temperature do you hold your frozen MSM at prior to dispatch?

	Processor 1	Processor 2
Target temperature (°C)	<-18	-20
Maximum temperature (°C)	-18	-18

27. How long do you hold your frozen MSM before dispatch?

	Processor 1	Processor 2
Target time (mths)	3	3
Maximum time (mths)	3	6

28. At what temperature is your MSM transported?

	Processor 1	Processor 2
Target temperature (°C)	-18	-18
Maximum temperature (°C)	-25	-18

29. **Can you please supply us with details of what microbial sampling and testing is carried out during the process and results obtained (data for 12 months if you have it)?**

No data was supplied by Processor 1. Processor 2 stated that no microbiological testing was carried out during process.

30. **Can you please supply us with details of any microbiological sampling and testing of the raw material prior to processing and results obtained either by yourself or by the raw material supplier (data for 12 months if you have it)?**

No data was supplied by Processor 1. Processor 2 stated that no microbiological testing was carried out on raw materials prior to processing.

31. **Can you please supply us with data on the microbial status of the finished MSM (data for 12 months if you have it)?**

Three months of data on microbial counts were supplied by Processor 1 (from 07/01/2013 to 02/04/2013). A summary of this data is shown in Table 2. This data shows that the mean TVCs were 3.5 $\log_{10}$ cfu g^{-1}, which is low in comparison with typical counts measured on UK pork mince (as reported in FSA M01054: Quantification of the controls that should be placed on meat prior to mincing and shown in Figure 3). Salmonella was measured on a weekly basis and was not detected in any of the 50 samples reported. The overall microbiological quality of the pork MSM produced by Processor 1 would appear to be similar to that expected for pork mince.

Table 2. Summary of microbial counts on pork MSM measured over a year (07/01/2013 to 02/04/2013) by Processor 1

	Aerobic Colony Count ($\log_{10}$ cfu g^{-1})	Salmonella spp in 25 g	E. coli ($\log_{10}$ cfu g^{-1})
N =	50	50	50
Mean	3.47		0.81
SD	0.65		0.27
Maximum	5.08		1.78
Minimum	<3		<1
N < LoD	15	50	41

Twelve months of data on microbial counts were supplied by Processor 2 (from 09/03/2012 to 18/04/2013). A summary of this data is shown in Table 3. This data shows that the mean TVCs were 2.5 $\log_{10}$ cfu g^{-1}, which, again, is low in comparison with typical counts measured on UK pork mince (as reported in FSA M01054: Quantification of the controls that should be placed on meat prior to mincing and shown in Figure 3). Salmonella was measured on a weekly basis and was not detected in any of the 57 samples reported. The overall microbiological quality of the pork MSM produced by Processor 2 would appear to be similar to that expected for pork mince.

Table 3. Summary of microbial counts on pork MSM measured over a year (09/03/2012 to 18/04/2013) by Processor 2

	Aerobic Colony Count (log_{10} cfu g^{-1})	Salmonella spp in 25 g	Enterobacteriaceae (log_{10} cfu g^{-1})	E. coli (log_{10} cfu g^{-1})	Cogaulase Positive Stafflococci (cfu g^{-1})
N =	283	57	283	283	283
Mean	2.48		1.18	0.74	6
SD	0.87		0.69	0.29	2
Maximum	5.28		3.72	3.20	10
Minimum	<2		<1	<1	<20
N < LoD	125	57	167	273	282

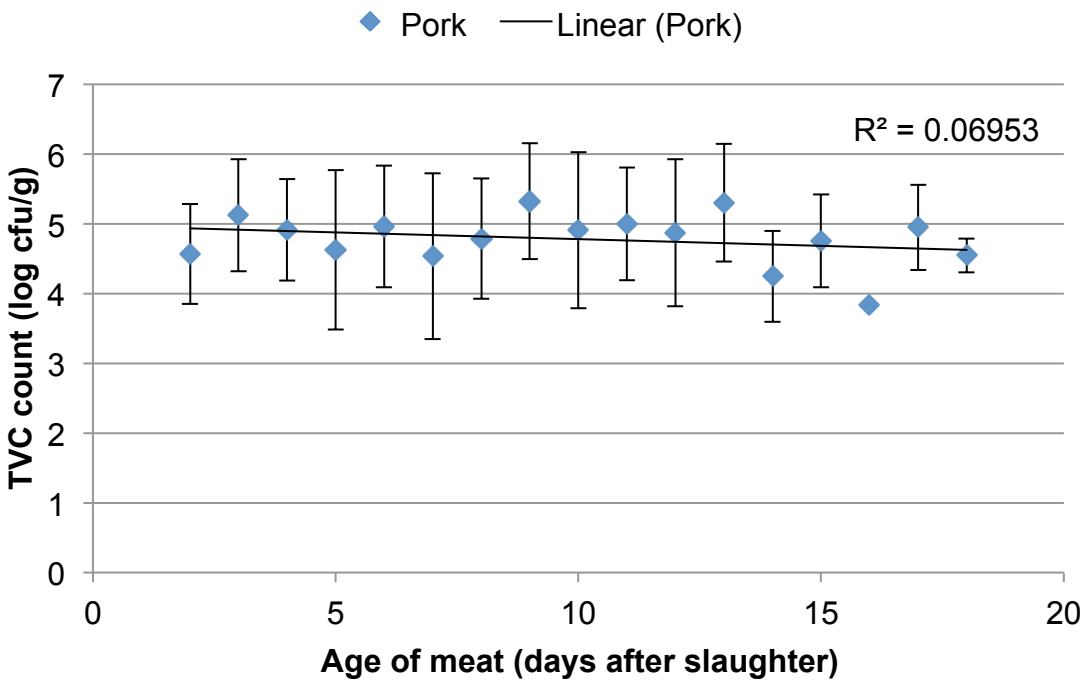

Figure 3. Overall comparison of pooled mean (SD) TVCs (n=545) on mince produced from pork related to age of meat prior to mincing (pooled total data supplied by UK processors); from FSA M01054: Quantification of the controls that should be placed on meat prior to mincing

3.2 Poultry MSM and meat preparations

Data was supplied by 4 processors producing poultry MSM and meat preparations (previously described as DSM). Three of these produced chicken, one produced turkey meat. Two processors produced meat preparations that had previously been described as DSM before the moratorium. These products (derived from wishbone meat) were reclassified according to the advice in the FSA guidance document - 'Guidance on the moratorium on the production and use of desinewed meat from non ruminant bones or poultry carcases in the United Kingdom', published in May 2012, that:

"Meat removed by mechanical means from non ruminant bone-in cuts of meat that have not been subject to any previous boning is not considered to be MSM. Examples include wishbone meat, and recognised pork and poultry cuts. This process is regarded as mechanical deboning as it is the removal of bones from meat, rather than the removal of residual meat from bones."

1. **What is the species of origin of your raw material?**

Data was supplied by 4 poultry processors. One of these produced chicken MSM (Processor 5), one produced chicken MSM and meat preparations (that had previously been described as DSM before the moratorium) (Processor 3), one produced a meat preparations (that had previously been described as DSM before the moratorium) (Processor 4) and one produced turkey MSM (Processor 6).

2. **Which type of MSM do you produce?**

	Processor 3	Processor 4	Processor 5	Processor 6
Type 1			✔	
Type 2	✔[1]			✔[3]
Meat preparation	✔ [2]	✔		

[1] "product is produced as a low pressure recovered MSM as in Type 1 BUT sold and specified as a Type 2 MSM as regards labelling and compliance with micro criteria"; [2] Described by processor as 3 mm meat; [3] Although produced with a low pressure separator.

3. **Can you please supply us with a HACCP plan for your process?**

Detailed HACCP plans were not supplied by any of the processors.

4. **Do you undertake microbiological sampling and testing to verify compliance with the microbiological criteria for minced meat (Regulation 2073/2005)?**

Processors undertake microbiological sampling and testing to verify compliance with the microbiological criteria for minced meat (Regulation 2073/2005).

	Processor 3	Processor 4	Processor 5	Processor 6
Yes	✔ [1]		-	✔[3]
No	✔[2]	✔	-	

[1] 3 mm meat; [2] "product is produced as a low pressure recovered MSM as in Type 1 BUT sold and spec as a Type 2 MSM as regards labelling and compliance with micro criteria"; [3] Although produced with a low pressure separator.

5. Do you maintain temperature records of any part of your MSM process?

All processors maintained temperature records and supplied some data.

6. What equipment do you use to produce your MSM?

The following data was supplied on the type of equipment used.

		Processor 3	Processor 4	Processor 5	Processor 6
	Product	Meat preparation; Type 2 MSM	Meat preparation	Type 1 MSM	Type 1 MSM
Stage 2	Type of machine:	Drum & belt separator	Drum & belt separator	Auger separator	Drum & belt separator
	Make & model:	Baader 605 * Baader 607 *	Baader 601 *		Baader
	Drum perforation diameter (if applicable):	3 mm	3 mm		3 mm
	Typical pressure used:	Low (15 – 18 bar)	Low (2 bar)		Low
	Typical size of meat cut fed in:	Chicken breast meat trim, wishbone and portions	Chicken trim, wishbone		Turkey necks

* The Baader 601, 605 and 607 are produced by Baader (http://www.baader.com/en/products/separator_processing/poultry/index.html#baader_605_en). The manufacturer describes these machines as "soft separators" and the process as "desinewing".

7. What is the source of your raw material?

	Processor 3	Processor 4	Processor 5	Processor 6
On-site slaughterhouse	✔			✔
Off-site slaughterhouse	✔	✔	✔	

8. How old, since slaughter, is the raw material when received?

	Processor 3	Processor 4	Processor 5	Processor 6
Typical time (days)	1	2		1
Maximum time (days)	3 *	4		3

* Max (DOK + 3 for cap then Deboning +1 for wishbone and trim)

9. What is the composition of your raw material?

	Processor 3	Processor 4	Processor 5	Processor 6
Type of raw material	Type 1: Chicken trim, wishbone and portions Type 2: Chicken cadge, frame and thigh bones	Chicken trim, wishbone	Chicken frames from which breasts, wings, wishbones and backends have been removed	"Can do whole frames, but mainly turkey neck deboning"

10. How long do you hold the raw material before processing?

	Processor 3	Processor 4	Processor 5	Processor 6
Typical time (days)	1	4 *		1
Maximum time (days)	3	5 *		3

* From date of kill.

11. At what temperature do you hold the raw material before processing?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)		0 - 3		2
Maximum temperature (°C)	≤4 (Type 1) ≤2 (Type 2)	4		3

12. What is the temperature of the raw material prior to processing?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)		0 - 2	0 - 2	2
Maximum temperature (°C)	≤4 (Type 1) ≤2 (Type 2)	4	<4	3

13. What is the temperature of the MSM immediately after production?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)	-	2 - 3	3 - 5	6
Maximum temperature (°C)	-	4		8

14. How often are the temperatures measured?

Processor 3	Processor 4	Processor 5	Processor 6
Exit secondary chiller – each day frozen every 15 mins	Half hourly		Every hour

15. How is the MSM packed immediately after production?

Processor 3	Processor 4	Processor 5	Processor 6
Packed in lined crates for fresh and for frozen in liners then frozen in slabs	Waxed lined cardboard boxes		In plastic casing as logs and deep frozen via brine tank

16. What is the weight and dimensions of the filled MSM pack produced?

	Processor 3	Processor 4	Processor 5	Processor 6
Weight (kg)	15	20	10 *	10
Length (mm)	550	590	400	2000
Width (mm)	350	390	300	
Depth (mm)	80	110	40	180

* Estimate.

17. Are the packs of MSM then?

	Processor 3	Processor 4	Processor 5	Processor 6
Chilled	✔			
Frozen	✔	✔	✔	✔
Chilled then frozen				
Refrigerated off site	✔ *			

* May be frozen off site.

18. What method do you use to chill your MSM after production?

	Processor 3	Processor 4	Processor 5	Processor 6
Air (blast)	✔	✔		na
Immersion				na
Plate				na

19. How long does the chilling process take?

	Processor 3	Processor 4	Processor 5	Processor 6
Typically (h)	3	24		na
Minimum (h)	4	2 - 4		na
Maximum (h)	5	48		na

20. What is the temperature of the MSM at the end of the chilling process?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)	-2 to 4	0 - 2		na
Maximum temperature (°C)		4		na

21. If you do not subsequently freeze your MSM, what temperature do you hold your chilled MSM at prior to dispatch?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)				na
Maximum temperature (°C)	-2 to 4			na

22. If you do not subsequently freeze your MSM, how long do you hold your chilled MSM prior to dispatch?

	Processor 3	Processor 4	Processor 5	Processor 6
Target time (h)				na
Maximum time (h)	12			na

23. What method do you use to freeze your MSM after production?

	Processor 3	Processor 4	Processor 5	Processor 6
Air (blast)	✔	✔		
Immersion				✔ (brine)
Plate			✔	

24. How long does the freezing process take?

	Processor 3	Processor 4	Processor 5	Processor 6
Typically (h)	20	24	2 - 3	-
Minimum (h)	18			-
Maximum (h)	24	36		-

25. At what is the temperature of your MSM at the end of the freezing process?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)		-18	<-16	-20
Maximum temperature (°C)	≤-18	-20		-20

26. At what temperature do you hold your frozen MSM at prior to dispatch?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)	≤-18	-18	-18	-20
Maximum temperature (°C)		-20		

27. How long do you hold your frozen MSM before dispatch?

	Processor 3	Processor 4	Processor 5	Processor 6
Target time (mths)	*	24 (h)	-	-
Maximum time (mths)		72 (h)		-

* Freeze and ship according to customer requirements.

28. At what temperature is your MSM transported?

	Processor 3	Processor 4	Processor 5	Processor 6
Target temperature (°C)	≤4; ≤-18	-18	-24	-20
Maximum temperature (°C)		-18		-20

29. Can you please supply us with details of what microbial sampling and testing is carried out during the process and results obtained (data for 12 months if you have it).

Processor 3; Composite samples tested weekly. Tested for TVC, Staphylococcus, Pseudomonads, Coli and *E. coli*.

30. Can you please supply us with details of any microbiological sampling and testing of the raw material prior to processing and results obtained either by yourself or by the raw material supplier (data for 12 months if you have it)?

None supplied.

31. Can you please supply us with data on the microbial status of the finished MSM (data for 12 months if you have it)?

Six months of data on microbial counts were supplied by Processor 4 (from 03/01/2012 to 30/06/2012). A summary of this data is shown in Table 3. This data shows that the mean TVCs were 4.5 $\log_{10}$ cfu g^{-1}, which is slightly higher in comparison with typical counts measured on UK turkey mince (as reported in FSA M01054: *Quantification of the controls that should be placed on meat prior to mincing* and shown in Figure 4). Salmonella was

detected in 1 of the 87 samples reported. The overall microbiological quality of the product produced by Processor 4 would appear to be similar to that expected for poultry mince.

Table 4. Summary of microbial counts on chicken meat preparation measured over 6 months (03/01/2012 to 30/06/2012) by Processor 4

	TVC at 30°C (log_{10} cfu g^{-1})	Presumptive coliforms (log_{10} cfu g^{-1})	Pseudomonas spp (log_{10} cfu g^{-1})	Coagulase Positive Staphylococci (cfu g^{-1})	E. coli (log_{10} cfu g^{-1})	Salmonella in 25g confirmed	Listeria, confirmed	Campylobacter in 25 g
N =	113	21	21	112	113	87	91	110
Mean	4.48	2.49	4.57	13	1.38			
SD	1.02	0.77	0.87	20	0.75			
Maximum	6.04	4.51	6.04	180	3.18			
Minimum	<2.3	<2.3	2	<20	<1			
N < LoD	8	13	1	109	48	86	91	76
% Positive						1.1	0	30.9
% Fails spec	7.1	4.8	76.2	0.0	23.0	1.1	0.0	30.9

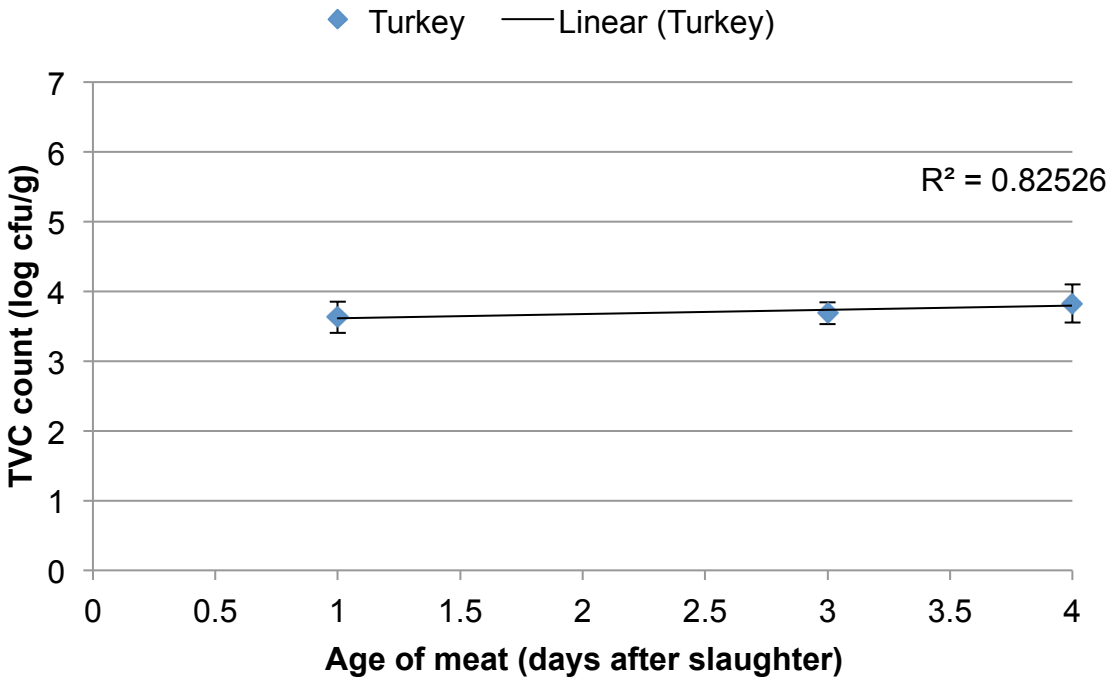

Figure 4. Overall comparison of pooled mean (SD) TVCs (n=111) on mince produced from turkey related to age of meat prior to mincing (pooled total data supplied by UK processors)

4. Conclusions and Recommendations

The overall aim of this short project was to provide evidence to support the Food Standards Agency's (the Agency) assessment of whether current restrictions on the use of Mechanically Separated Meat (MSM) and Desinewed Meat (DSM) from poultry and pork are appropriate and proportionate for the protection of public health. To achieve this, the project sought to:

1. Describe the processes in use in the UK for the production of poultry and pork Type 1 and Type 2 MSM products, and meat preparations previously described as DSM and currently assessed as being outside the scope of the moratorium.
2. Gather and review any information that is available from literature, or from measurements made by food business operators, on the microbiological status at each stage of the production process.
3. Review and comment on the appropriateness of the required controls and restrictions for each process and suggest any changes, if required, to these controls and restrictions.
4. Identify any information gaps.

Following a short survey of industrial practice and literature regarding the manufacture of MSM and former DSM products it has been concluded that:

1. Current UK production process

This survey of 2 pork and 4 poultry UK processors has shown that processors are using similar processes to produce poultry and pork Type 1 MSM, Type 2 MSM and meat preparations, and that they use similar raw materials. Details of the specific processes used at the plants have already been given in the previous text.

Both of the pork processors used a pre-breaker followed by a Townsend press separator then a SEPAmatic drum & belt separator to produce their MSM. Relatively low pressures were used at both plants. One processor produced Type 1 MSM, one processor produced Type 2 MSM. The processors had described their products as DSM prior to the moratorium.

Three of the four poultry processors used Baader drum & belt separators to produce meat preparations and Type 1 MSM. Two processors produced meat preparations that had previously been described as DSM before the moratorium. These products (derived from wishbone meat) were reclassified according to the advice of the FSA guidance document - 'Guidance on the moratorium on the production and use of desinewed meat from non ruminant bones or poultry carcases in the United Kingdom' published in May 2012. One used an auger separator to produce Type 1 MSM.

At all the plants the legislative requirements for the production of MSM and meat preparations, i.e. the age of the raw materials used, treatment after production, chilling, freezing, storage, appear to be routinely adhered to.

2. Review of microbial status

There is very little published data on the microbial status of MSM. A number of publications indicate that the main factor influencing the microbial load on the MSM is the state and age of the raw material used to process the MSM. The few surveys that have been carried out generally report relatively high numbers of microorganisms with TVCs of as high as 6 – 7 $\log_{10}$ cfu g^{-1}, although they also show a big range in counts, and it is not always clear what type (Type 1 or Type 2) of MSM is being sampled. It is likely that a number of the older

publications are counts measured on MSM produced using older high pressure systems. In these systems product temperatures are likely to be substantially higher than those produced in the current low pressure systems.

There are many statements in the general literature that MSM will preferentially support the growth of microorganisms and that the degree of muscle fibre degradation may be an important factor influencing the microbial load on the MSM. However, no published scientific studies have been located that actually compare growth on MSM meat with other forms of fresh, or even minced meat or meat preparations, under the same conditions. Nor are there any clear published studies that have compared the microbial growth on MSM meat with the degree of muscle fibre degradation (thus the degree of separation pressure). So it is difficult to establish whether the growth of psychrotrophic and psychrophilic organisms is any greater on MSM than other meats. In addition, it is unclear whether there is any difference according to the type of MSM, degree of muscle fibre degradation, or species from which the MSM is derived.

Microbial data from two current pork MSM producers shows that the mean TVCs were 2.5 and 3.5 $\log_{10}$ cfu g^{-1}, which is low in comparison with typical counts measured on UK pork mince (as reported in FSA M01054: *Quantification of the controls that should be placed on meat prior to mincing*). Salmonella was measured on a weekly basis and was not detected in any of the samples reported. The overall microbiological quality of the pork MSM produced by Processor 1 and 2 would appear to be similar to that expected for pork mince.

Microbial data from a current poultry producer producing a meat preparation previously described as DSM shows that the mean TVCs were 4.5 $\log_{10}$ cfu g^{-1}, which is slightly higher in comparison with typical counts measured on UK turkey mince (as reported in FSA M01054: *Quantification of the controls that should be placed on meat prior to mincing*). Salmonella was detected in 1 of the 87 samples reported. The overall microbiological quality of the product produced would appear to be similar to that expected for poultry mince.

Thus microbial data provided by current pork and poultry MSM producers show average TVCs that are similar to, or lower than, those found on mince meat. It therefore appears that the overall microbiological quality of MRM, particularly Type 1, is similar to that of minced meat and meat preparations.

3. Appropriateness of the controls and restrictions

The current legislation (Regulation (EC) No. 853/2004 Annex I) defines MSM in the following manner:

> 'Mechanically separated meat' or 'MSM' means the product obtained by removing meat from flesh-bearing bones after boning or from poultry carcases, using mechanical means **resulting in the loss or modification of the muscle fibre structure**.

Thus according to this definition, MSM is defined by three properties:

1. The product is produced from meat residues that adhere to bones after deboning, and not from deboned meat;
2. These meat residues are extracted mechanically;
3. The extraction results in loss or modification of muscle fibre structure.

This implies that product mechanical separated from flesh-bearing bones in a manner that doe not result in a modification of the muscle fibre structure should not be considered MSM.

Defra guidance[2] (formally FSA guidance until Defra took policy lead in Summer 2010) on the labelling and composition of meat products published in 2003 (FSA, 2003) following the new definition of MSM was that:

"Products obtained by mechanical deboning, which remove definitive pieces of meat from meaty bones or carcass, which may or may not have had the primal muscles previously removed, such that the muscle fibre structure of the meat is substantially intact are not considered to be MRM or MSM. This meat may then be de-sinewed and have the appearance of finely minced meat. These products may still be considered meat, and may be counted towards the QUID declaration."

There is evidence that the new Type 1 MSM produced using low pressure, previously labelled as Desinewed meat (DSM), is similar to mince and is likely to represent a similar risk as mince. However, currently labelling it MSM means that it can no longer be counted towards the meat content of a product, making it less valuable to food manufacturers.

At present it may be considered that there is insufficient scientific evidence to establish the food safety risk of any type of MSM, and whether it is any different to mince or meat preparations.

Applying a general HACCP approach to MSM production it is clear that:

- Since the microbiological condition of MSM is largely determined by the microbiological condition of the meat used, the time and temperature at which this meat is stored before processing should be controlled.
- Equipment coming in contact with the meat should be clean before use.
- The temperature history between separation and cooling to the storage temperature should be known and controlled.

4. Identify any information gaps

Many authors/researchers have remarked that MSM is "an excellent medium for bacterial growth" (Gill, 1988; ICMSF, 1998). However, provided the meat is rapidly reduced to chilled, or freezing, temperatures this is unlikely to be a problem. A similar argument has been made regarding mince. However, a review of the literature has found no scientific facts to support the argument for mince (FSA M01054: *Quantification of the controls that should be placed on meat prior to mincing*). It is also clear that there is insufficient published data on MSM to provide such claims.

The recent EFSA opinion (2013) states that "the risk of microbial growth increases with the degree of muscle fibre degradation and the associated release of nutrients". We have not been able to find any published study that clearly supports this statement. There is a need to establish whether MSM is a better growth medium, under standard chilled storage conditions, than meat preparations, minced meat or cuts of meat, and whether the degree of muscle fibre degradation is an important factor influencing the microbial growth on the MSM.

There is a clear need for survey work to establish what the prevalence of pathogens actually is in UK produced MSM in order to determine the risk this product poses, and how this compares with minced meat and meat preparations.

[2] The authors have not found any more recent guidance from the FSA or Defra regarding MSM.

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6. Appendix: Legislation regarding the production of MSM

Section V of Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for food of animal origin lists the requirements for the production of minced meat, meat preparations and Mechanically Separated Meat (MSM).

The legal requirements of raw materials used in the production of different meat products (minced meat, meat preparations, and MSM) are:

*CHAPTER I: **REQUIREMENTS FOR PRODUCTION ESTABLISHMENTS***

Food business operators operating establishments producing minced meat, meat preparations or MSM must ensure that they:

1. Are constructed so as to avoid contamination of meat and products, in particular by:

(a) Allowing constant progress of the operations;

or

(b) Ensuring separation between the different production batches;

2. Have rooms for the separate storage of packaged and exposed meat and products, unless they are stored at different times or in such a way that the packaging material and the manner of storage cannot be a source of contamination for the meat or products.

3. Have rooms equipped to ensure compliance with the temperature requirements laid down in Chapter III that require poultry meat to be kept below 4C, 3°C for offal and 7°C for other meat.

4. Have equipment for washing hands used by staff handling exposed meat and products with taps designed to prevent the spread of contamination.

5. Have facilities for disinfecting tools with hot water supplied at not less than 82°C, or an alternative system having an equivalent effect.

*CHAPTER II: **REQUIREMENTS FOR RAW MATERIAL***

Food business operators producing minced meat, meat preparations or MSM must ensure that the raw materials used satisfy the following requirements.

The legal requirements of raw materials used in the production of different meat products (minced meat, meat preparations, and MSM) are:

*1. The raw material used to prepare **minced meat** must meet the following requirements:*

(a) It must comply with the requirements for fresh meat;

(b) It must be derive from skeletal muscle, including adherent fatty tissues;

(c) It must not be derive from:

(i) scrap cuttings and scrap trimmings (other than whole muscle cuttings);

(ii) MSM;

(iii) meat containing bone fragments or skin;

(iv) meat of the head, with the exception of the masseters, the non- muscular part of the linea alba, the region of the carpus and the tarsus, bone scrapings and the muscles of the diaphragm (unless the serosa has been removed).

2. The following raw material may be used to prepare ***meat preparations****:*

(a) Fresh meat;

(b) Meat meeting the requirements of point 1;

(c) If the meat preparation is clearly not intended to be consumed without first undergoing heat treatment:

(i) meat derived from the mincing or fragmentation of meat meeting the requirements of point 1 other than point 1(c)(i);

(ii) MSM meeting the requirements of Chapter III, point 3(d).

3. ***The raw material used to produce MSM must meet the following requirements****.*

(a) It must comply with the requirements for fresh meat;

(b) The following material must not be used to produce MSM:

(i) for poultry, the feet, neckskin and head;

and

(ii) for other animals, the bones of the head, feet, tails, femur, tibia, fibula, humerus, radius and ulna.

CHAPTER III: ***HYGIENE DURING AND AFTER PRODUCTION***

Food business operators producing minced meat, meat preparations or MSM must ensure compliance with the following requirements.

1. The work on meat must be organised in such a way as to prevent or minimise contamination. To this end, food business operators must ensure in particular that the meat used is:

(a) at a temperature of not more than 4°C for poultry, 3°C for offal and 7°C for other meat;

and

(b) brought into the preparation room progressively as needed.

3. The following requirements apply to the production and use of MSM produced using techniques that do not alter the structure of the bones used in the production of MSM and the calcium content of which is not significantly higher than that of minced meat.

(a) Raw material for deboning from an on-site slaughterhouse must be no more than seven days old; otherwise, raw material for deboning must be no more than five days old. However, poultry carcases must be no more than three days old.

(b) Mechanical separation must take place immediately after deboning.

(c) If not used immediately after being obtained, MSM must be wrapped or packaged and then chilled to a temperature of not more than 2°C or frozen to an internal temperature of not more than –18°C. These temperature requirements must be maintained during storage and transport.

(d) If the food business operator has carried out analyses demonstrating that MSM complies with the microbiological criteria for minced meat adopted in accordance with Regulation (EC) No 852/2004 it may be used in meat preparations that are clearly not intended to be consumed without first undergoing heat treatment and in meat products.

(e) MSM not shown to comply with the criteria referred to in (d) may be used only to manufacture heat-treated meat products in establishments approved in accordance with this Regulation.

4. The following requirements apply to the production and use of MSM produced using techniques other than those mentioned in point 3.

(a) Raw material for deboning from an on-site slaughterhouse must be no more than seven days old; otherwise, raw material for deboning must be no more than five days old. However, poultry carcases must be no more than three days old.

(b) If mechanical separation does not take place immediately after deboning the flesh-bearing bones must be stored and transported at a temperature of not more than 2°C or, if frozen, at a temperature of not more than -18°C.

(c) Flesh-bearing bones obtained from frozen carcases must not be refrozen.

(d) If not used within one hour of being obtained, MSM must be chilled immediately to a temperature of not more than 2°C.

(e) If, after chilling, MSM is not processed within 24 hours, it must be frozen within 12 hours of production and reach an internal temperature of not more than –18°C within six hours.

(f) Frozen MSM must be wrapped or packaged before storage or transport, must not be stored for more than three months and must be maintained at a temperature of not more than –18°C during storage and transport.

(g) MSM may be used only to manufacture heat-treated meat products in establishments approved in accordance with this Regulation.

5. Minced meat, meat preparations and MSM must not be re-frozen after thawing.

The legal hygiene requirements of raw material and of derived MSM are shown in the tables below:

Table 5. Hygiene requirements of raw materials for MSM according to Regulations (EC) No 853/2004 and 2074/2005 (EC, 2010)

Raw material	Low pressure MSM	High pressure MSM
Poultry carcasses	Maximum 3 days old	Maximum 3 days old
Other raw material from on-site slaughterhouse	Maximum 7 days old	Maximum 7 days old
Other raw material from other site	Maximum 5 days old	Maximum 5 days old
Mechanical separation	Immediately after de-boning	If not immediately after deboning, storage and transport at < 2°C or freezing at < -18°C of the bones (no refreezing)

Table 6. Hygiene requirements of MSM after production (EC, 2010)

	Low pressure MSM	High pressure MSM
Storage if not used immediately used	Wrapped and packaged, chilling to a maximum of 2°C or frozen at an internal T of < -18°C	Wrapped and packaged, chilling at a maximum of 2°C if processed within 1 to 24h; if not, frozen within 12 h after production, reaching an internal temp of < -18°C within 6 h. Maximal storage of frozen MSM of 3 months at < -18°C.
Use	If the food business operator has carried out analyses demonstrating that MSM is complying with the microbiological criteria for minced meat: -in meat preparations which are clearly not intended to be consumed without first undergoing heat treatment -in meat products If the MSM is not complying with microbiological criteria: only in heat-treated meat products produced in approved establishments	Only for heat-treated meat products produced in approved establishments
Calcium content	Max. 0.1% (= 100 mg/100 g or 1000 ppm) of fresh product	Not defined

Commission Regulation (EC) No 2073/2005of 15 November 2005 on microbiological criteria for foodstuffs imposes the following process hygiene criteria on MSM:

	TVC	*Escherichia coli*	Salmonella
n	5	5	5
c	2	2	0
m	$5x10^5$ cfu/g	50 cfu/g	Absence in 10 g
M	$5x10^6$ cfu/g	500 cfu/g	
Analytical reference method	ISO 4833	ISO 16649-1 or 2	EN/ISO 6579
Stage where the criterion applies	End of the manufacturing process	End of the manufacturing process	Products placed on the market during their shelf-life
Action in case of unsatisfactory results	Improvements in production hygiene and improvements in selection and/or origin of raw materials	Improvements in production hygiene and improvements in selection and/or origin of raw materials	

7. Appendix: Glossary

The following definitions come from the relevant EC regulations:

Fresh meat: meat that has not undergone any preserving process other than chilling, freezing or quick-freezing, including meat that is vacuum-wrapped or wrapped in a controlled atmosphere.

Minced meat: means boned meat that has been minced into fragments and contains less than 1% salt.

Meat preparations: means fresh meat, including meat that has been reduced to fragments, which has had foodstuffs, seasonings or additives added to it or which has undergone processes insufficient to modify the internal muscle fibre structure of the meat and thus to eliminate the characteristics of fresh meat.

Mechanically separated meat or 'MSM': means the product obtained by removing meat from flesh-bearing bones after boning or from poultry carcases, using mechanical means resulting in the loss or modification of the muscle fibre structure.

Low pressure MSM: MSM produced using techniques that do not alter the structure of the bones used in the production of MSM and the calcium content of which is not significantly higher than that of minced meat. (Type 1 MSM)

High pressure MSM: MSM produced using techniques other than those mentioned for low pressure MSM. (Type 2 MSM)

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