Improving efficiency and reducing waste in the beef supply chain

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Summary

• Waste
• Definitions
• Critical control points
• Nutrition
• Packaging
• Decision support tools
• Conclusion
Overview of waste in beef supply chain

- 570K tonnes of meat & fish wasted in the home
- retailer ‘back of store’ waste ~ 1.6 M tonnes of food per annum
- beef products discarded in UK prior to retail sale ~ 1600 animals equivalents/week
Definition and scale of waste - UK

**EU waste framework definition**
Any substance or object the holder discards, intends to discard or is required to discard

**Meat industry definition**
Any meat that is discarded or discounted

- 25% of waste from food and drink industry arises from fresh meat
- 72,000 tonnes of fresh meat disposed by retailers
- 2.67 M cattle slaughter in 2008
Farm to retail sale

283 days

insemination + birth

1-12 weeks

rearing

3-36 months

finishing

9-42 days

processing

6-12 days

depot & store

80-85% COG’s

20-15%

‘Identification and rectification of factors that reduce quality and increase waste’
Causes of waste

Meat Colour

Off odours

Meat colour is a key determinant in consumer purchase decisions
Meat colour

Determined by:-

• Muscle micro-structure
• Concentration and oxidative state of haem pigments

Myoglobin (Mb)  Haemoglobin (Hb)

Image adapted from Williams 2015
Oxygenation and oxidation of myoglobin

- **Myoglobin (Fe²⁺)**
  - Oxygenation
  - Deoxygenation
  - Reduction
  - Oxidation

- **Oxymyoglobin (Fe²⁺)**
  - Oxidation

- **Metmyoglobin (Fe³⁺)**
  - Oxidation
Colour shelf life

- Meat colour can be measured using CIELAB system:
  - L*, a*, b* and saturation (chroma)
- Oxidation of 20% of surface pigment can be detected by a consumer
- This equates to a chroma measurement of 18 using the CIELAB system

(Warriss 2001, McDougall 1982)
Critical control points – shelf life

• Storage temperature
• Packaging
  – Overwrap
  – Modified atmosphere pack (MAP)
  – Vacuum skin pack

• Chemical composition of meat
  – ANIMAL DIET
  – Fatty acids
  – Antioxidants
Colour shelf life, physical and sensory attributes

PUFA
Lipid stability
Colour shelf life
physical and sensory
Antioxidants

Concentrate
Forage
**Antioxidants**

- Antioxidants persist after slaughter
  - Tocopherol, carotenoids and flavonoids
  - Prevent oxidation of muscle lipids and oxymyoglobin

- 8 isoforms of vitamin E:
  - α-, β-, γ-, δ- tocopherols
  - α-, β-, γ-, δ- tocotrienols

- α- tocopherol most effective when fed to the animal (basal diet; 300-1500 IU/d; time)

- Target a muscle concentration of 3.3 – 3.5 mg/kg
Innovative packaging to extend shelf life and reduce waste

- modified atmosphere (MA) packs
- vacuum skin packaging (VSP)
**Modified Atmosphere Packaging**

75-80% O₂ + 25-20% CO₂

**Gas barrier**

drip pad

**Advantage:** High oxygen gives increased colour shelf life, and carbon dioxide increased microbial shelf life

**Disadvantage:** Can increase lipid and protein oxidation
Vacuum packing retail portions

**Vacuum Skin** Packing seals meat portions between base film and of a heat-softened top film which is vacuum drawn onto the meat surface to give a skin-tight pack. No oxygen.

**Gas impermeable**
- no bloomed colour but 3-4 weeks life
Innovative packaging to extend shelf life and reduce waste

• ageing meat to improve tenderness shortens retail shelf life in modified atmosphere (MA) packs

• not known if the same applies to vacuum skin packaging (VSP) ~ a particular problem of spasmodic premature browning with rump muscle

• effect of muscle type, ageing period, length and frequency of prior blooming on the colour stability of MA and VS packed meat
Points against high $O_2$

- Whilst high $O_2$ will retain the colour longer it does increase lipid oxidation when vitamin E is low and could contribute to WOF when cooked

- High $O_2$-packed meat is less tender than vacuum packed, there is more protein oxidation

- Does this protein oxidation reduce tenderisation or cause toughening?

- Can you age meat first to make tender and then retain tenderness in high $O_2$?

- What effect does Vitamin E concentration have?
Days aged and subsequent shelf-life in MAP

Days displayed

Chroma

- 3 day aged
- 10 day aged
- 21 day aged
- 35 day aged
Rump steaks after display in modified atmosphere for the same time period. Why has the one on the right discoloured?
Sirloin and rump steaks, 21 days in Darfresh™, opened and bloomed 1 hr
Vitamin E and colour stability of sirloin and rump steaks in MAP
Raison d’etre

• Part of the colour variation which occurs in retail packs is due to metabolic changes which affect the oxidation of pigments and compounds some of which can develop as a consequence of cutting and holding practices at the packing plant.

• Red meat often aged for 21 to 35 days.

• This has the consequence of reducing retail shelf life in MAP most noticeable in red muscles which oxidise faster, e.g. rump.
Overview of waste in beef supply chain

• Steaks, joints, diced, burgers, mince

• Identifying waste and root causes

(WRAP, 2008)
Decision Support System (DSS)

• Map the entire beef supply chain and model the waste generated throughout the supply chain

• Identify hotspots of waste in whole beef supply chain, quantify the waste and prioritise the mitigation of waste hotspots

• Assist in improving the coordination within the whole beef supply chain

• Provide the real time solution for waste minimisation for all the stakeholders of beef supply chain
Prototype of Decision Support System

Waste in Mince process flow

Waste Categories:
- FW (Floor Waste)
- MD (Metal Detection)
- PL (Products left in De gristle Machine)

Animal By-products:
- Category 3

Rework:
- (Machine issue)
Reasons of waste in beef supply chain

• Expiry of shelf life of beef products prior to sale to consumers

• Premature discoloration and unusual odours are major reasons for rejection of beef products by consumers

• Error in forecasting the demand of consumers and lack of coordination in beef supply chain

• Beef products being damaged due to mishandling within the supply chain

• Lack of Decision Support System (DSS) to prioritise the mitigation of waste, linked with the root causes and assist in improving the coordination within the whole beef supply chain
Conclusions

• Identifying and addressing waste is a major issue

• Shelf life and odours

• Whole chain approach

• Interdisciplinary

• Underpinning and improve competitiveness of the UK beef supply chain