Identifying Needs in Poultry Meat Quality Research

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Checked by:

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Introduction and scope

Academia

Industry

Retailers

Summary

Potential areas for new research on poultry meat quality.

Annex 1  Weblinks of interest (legislation, guidance, codes of practice etc)

Annex 2  Contacts

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Annex 4  References
Identifying Needs in Poultry Meat Quality Research

(Defra Reference FO0310)

Report 1.1

Review of available information of factors influencing consumer perception and purchasing and quality parameters important to consumers.

Introduction and scope

The poultry industry is one of continued growth in the UK. According to Mintel (2006) it showed 2% growth in terms of volume and 16% growth in terms of value, with high incidence of household penetration. Poultry is perceived as healthy and nutritious, is relatively low in fat, has a more desirable unsaturated fatty acid content than other meats, and is affordable to most consumers.

An important growth area for the industry in recent years has been that of further processed or added value products contributing to a 2005 poultry sales market value of £2.9 billion (£2.4 billion for chicken). This reflects changing socio-economic factors and trends in the UK including an increase in the number of one or two person households, more women in employment, an increase in eating out and the purchase of takeaways, an ageing population whose life expectancy is increasing and an increase in travel abroad, all of which conspire to develop the need for convenient high quality meals that are affordable to a consumer who is ever more discerning and has a greater awareness of environmental and animal welfare issues.

The definition of the term quality varies and very much depends on which part of the supply chain is addressing the issue. Quality traits important to the farmer may be different to those of the processor, the retailer and the consumer.

Becker (2002) reviews the definition of meat quality in some depth. He argues that both quality and price are the key factors of success, both being important for efficiency and competitiveness throughout the supply chain in meeting consumer demands and that the price premium of high quality products can be a measure (financial) of product quality.
Moreover, with interests at each stage of the supply chain in conflict with respect to price, there is an inherent potential effect on quality. Broadly speaking, retailers are interested in high margins, ease of handling, long shelf life, fast turnover and strong own label branding. Manufacturers look towards uniformity of raw material, quality parameters that fit within the tolerances of the manufacturing process and the creation of value-added products, preferably for their own brand, whilst farmers try to get the best price for their product. Thus throughout the supply chain, perceived quality can be at variance to that required by the consumer.

In this section of the report it is consumer quality perception and purchasing quality parameters important to consumers that will be addressed.

**Consumer quality perception**

Consumers look for both sensory quality and products that are safe to eat. They may also include other quality attributes such as nutritional quality with associated health benefits (such as low fat content). Additionally, consumers may extend their definition of quality according to their own personal beliefs or targets and include welfare standards, environmental issues, the way in which the product is processed or the absence of certain ingredients.

Quality can be assessed both objectively and subjectively. Objective assessment tends to predominate throughout the supply chain prior to consumption by the consumer where quality attributes can be measured scientifically. Consumer perceptions of quality, however, tend to be more subjective in nature. Becker (2002) describes Quality Cues (QC) as what the consumer observes at the point of sale as a predictor of likely quality (e.g. place of purchase, indications of quality assurance schemes, free from, organic) and Quality Attributes (QA) as what the consumer wants in terms of product quality (colour, appearance, texture, flavour).
Erdtsieck (1989) categorises quality attributes as shown in Figure 1.

<table>
<thead>
<tr>
<th>Eating Quality</th>
<th>Appearance</th>
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<tbody>
<tr>
<td></td>
<td>Texture</td>
</tr>
<tr>
<td></td>
<td>Flavour</td>
</tr>
<tr>
<td>Convenience</td>
<td>Availability</td>
</tr>
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<td></td>
<td>Ease of preparation</td>
</tr>
<tr>
<td>Stability</td>
<td>Shelf life</td>
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<tr>
<td></td>
<td>Quality retention</td>
</tr>
<tr>
<td>Wholesomeness</td>
<td>Safety</td>
</tr>
<tr>
<td></td>
<td>Purity</td>
</tr>
<tr>
<td>Nutritive value</td>
<td>Nutrient content</td>
</tr>
<tr>
<td></td>
<td>Nutrient availability</td>
</tr>
<tr>
<td></td>
<td>Calorific value</td>
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</tbody>
</table>

Figure 1. Quality attributes of a food product. (Adapted from Erdtsieck, 1989)

Therefore, from a consumer point of view, food should be attractive, safe, tasty, nutritious or good for health, produced in accordance with personal ethical beliefs and, ideally, convenient to use.

Poultry falls into two broad sectors namely primary poultry meat, which comprises all fresh or frozen meat in whole-bird or portion format, and further processed products such as coated portions (crumbs, glazes, marinades), burgers, cooked rolls, ready meal components (e.g. chicken tikka).

This report will concentrate on primary poultry meat although factors affecting quality in relation to further processing may be addressed as necessary.
Reviews and surveys of consumer attitudes to poultry quality

According to Fletcher (2002), the two most important quality attributes for poultry quality are appearance and texture. Appearance is important both at point of purchase, as it affects initial selection by the consumer, and at point of consumption as this influences eating enjoyment. Texture is the single most important sensory attribute affecting final quality assessment.

Quality attributes relating to appearance include skin colour, meat colour (cooked and uncooked) and defects such as bruises or haemorrhages. Skin colour is important for the marketing of whole birds and portions with flesh colour being important for raw skinless portions such as breast fillets. Texture can be affected by processing errors and although juiciness and flavor are important, they are often a function of preparation.

Mintel (2006) reviewed the poultry market in the UK in 2006, just after the H5N1 virus was found in Scotland. Not normally a high priority, it was felt that provenance became an issue for consumers at that time when domestic flocks were not infected. Along with other consumer issues such as regional sourcing and organics, higher standards of welfare (e.g. Freedom Foods) and breeding systems (e.g. Oakham chickens, reared from a cross between normal hens and slow growing, bigger breasted males which are fed on a special diet and slaughtered at a date later than normal, resulting in a bigger breasted bird with improved taste claims), this was seen as a route to affording consumer reassurance regarding quality (and as a route to a premium product).

Consumers perceived chicken as a healthy low fat alternative to red meat, with versatility and easiness to cook being considered important. Within the primary market, top tier ranges within retailer own brands offering specific breeds, free range reared birds, organic and schemes such as the RSPCA’s Freedom Food scheme was an area gaining momentum.

Nutrition or health concerns were addressed by the introduction of birds with a higher omega 3 content and for further processed chicken the “cleaning up” of labels.
Concerns about health such as obesity were important to consumers who also saw a perceived benefit in fresh rather than frozen chickens.

Convenience was important to consumers with portions preferred to whole birds and growth in further processed products. This is demonstrated in Figure 2.

<table>
<thead>
<tr>
<th></th>
<th>% market share 2005</th>
<th>% change 2001-2005</th>
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<tbody>
<tr>
<td>Whole birds</td>
<td>23.9</td>
<td>+9.9</td>
</tr>
<tr>
<td>Portions/cuts</td>
<td>49.9</td>
<td>+5.9</td>
</tr>
<tr>
<td>Further processed</td>
<td>26.2</td>
<td>+23.4</td>
</tr>
</tbody>
</table>

Figure 2. Retail sales of chicken by type, by value. Source Mintel (2006)

This also demonstrates the size of the whole bird and portions/cuts market where the greatest quality attribute, that of appearance, clearly is of great importance.

A major consumer attitude study was addressed at a joint workshop held in France in April 1996 bringing together an EU AIR project (AAIR3) “Consumer Attitudes” and a FAIR (0046) project “Quality Policy”. Coordination of the AIR-CAT project was managed by MATFORSK in Norway who published the proceedings (AIR-CAT Project).

Objectives of the AIR-CAT project included the development, comparison and validation of scales that would track the same food attitude in different European countries, establishing a base with state of the art measurements of consumer attitudes.

The FAIR project sought to reflect “the increased importance of quality products and the consequent introduction of rules adopted under the reform of the Common Agricultural Policy” and the “key issues affecting consumer behaviour, consumer attitudes and acceptability, implications of novel technologies on consumer confidence; improved understanding of food choice, environmental and ethical aspects, socio-economic factors, access and availability and finally communication and information flows to consumers, retailers, manufacturers, primary producers”.

Research efforts were concentrated on the meat and meat products area, recognized as being particularly sensitive areas for consumer attitudes.

The aim of the workshop was to bring together those with a keen interest in consumer attitudes and behaviour towards meat and included researchers and marketing people from nine European countries. CCFRA was a participant in the AIR-CAT project and a presentation was made by our Consumer and Sensory Science Department entitled “The changing demand for meat. The impact of the consumer on new product development in the UK”.

Although focused on meat and meat products in general, some factors influencing consumer perception and purchasing and quality parameters important to customers in relation to poultry emerged:

- Unlike other EU countries who saw growth in meat consumption from 1960 to 1980 before apparent stagnation around 1988, the UK appeared to reach consumption stagnation around 1970 for lamb and pork and around 1980 for beef. Poultry consumption continued to increase for all countries from 5-10kg (per capita p.a.) in 1960 with different growth rates placing the UK and Ireland at the top of consumption tables in the 1990’s (20-25kg/head). Income and price were thought to be factors influencing this change.

- The most important growth in the French meat market from 1978 to 1994 was for chicken cuts with whole chicken consumption improving too, at the expense of traditional meats such as veal, offal, horse meat etc. This was attributed to many factors including relative price decreasing (apart from chicken breast where price and market share increased), sociological trends (health, safety, convenience, the growth of supermarkets/pre-packed foods). They also identified more consumption of chicken amongst consumers under 35. Reasons for the popularity of a “modern” product such as chicken breast for the French consumer included fast cooking time, small portion size, suitability for children, health and festive uses.
• The Spanish market saw huge growth in chicken consumption between 1960 and the 1990’s with consumption of poultry meat increasing by a factor of 41. Price was a major factor in this. More recently it was felt that factors influencing consumer attitudes and purchase of poultry included media information, health issues, such as residues and wholesomeness with prompt reaction to media publications.

Measurement of consumer attitudes towards food (poultry) consumption brings together studies in economics and psychology/sociology with further research required (Meulenberg and Steenkamp, 1991) according to the Spanish presentation on “Analysis of meat and meat products consumption in Spain: a qualitative multidisciplinary approach”. Demand is affected at a microeconomic level (need of nutrients, income, prices, attitudes etc, and at a macro-economic level (average income, socioeconomic structures, supply, nutrition norms etc).

• Consumers in Spain are willing to pay more for premium products such as poultry belonging to recognized quality schemes (e.g. designation of origin, ecologically friendly) and for those associated with strong brands that guarantee meat quality (manufacturers, retailers, fast food chains). Nutritional and “free from” claims influence consumer choice. In questionnaires, chicken was the third most preferred meat for Spanish consumers and animal welfare featured highly as a reason affecting purchase.

• The UK presentation showed a shift from red meat to poultry, more convenience foods being eaten and consumer preference for freshness.

• A presentation was made on consumer attitudes and behaviour towards poultry in Belgium. Analysis of questionnaires showed increased consumption due to a relative price reduction compared to income, convenience, nutritional value (low fat level, necessary proteins, easy to digest, vitamin and mineral content, more unsaturated fatty acids, low in cholesterol). Portions were increasing due to increased barbecue use, improved packaging, improved TQM. Ease of use featured highly with hot and cold eating being a plus as was its versatility within meals.
• The German delegates looked at consumer attitudes in their country and found intensive livestock farming was an immediate negative spontaneous association and that broilers (along with meat and pork) had a the poorest quality image scores among 16 food items surveyed.

• A presentation was made by the University of Gottingen, Germany, referring to a consumer study carried out by Becker et al, (1995) where some 800 butchers’ customers were asked about the importance to them of several quality aspects. In order of importance the results were:
  - meat colour
  - low fat meat
  - animals from the region
  - animals from small farms
  - feeding with regional feed
  - meat preparation characteristics (frying/roasting)
  - humane animal keeping
  - responsible transport and slaughtering
  - non-use of antibiotics in feeding

This presentation spoke about consumers increase in fear of food being hazardous to health (an increase from 20 to 50% of respondents over the 20 years prior to 1995). This was backed up by other studies showing increased fear of spoilage or contamination.

A consumer survey by CWS in the UK was mentioned where 70% of 30,000 consumers questioned stated they worried about animal protection and animal welfare. Ethical values were important with some 60% sufficiently motivated to boycott products on welfare grounds. Origin was important too.

The importance of quality to the consumer was illustrated in a further study (Frohn, 1992) where the statement “when buying something one has to look at the price but finally the quality of the goods decides whether this is bought or not”. In 1970, 65% of respondents agreed, by 1990, it was 94% who agreed.
In order to understand perceived quality, 1000 housewives were asked which characteristics they considered essential for defining the degree of quality of a product (Frohn, 1992). The results were:

- fresh appetizing appearance (67%)
- date of perish (40%)
- ingredients, chemical additives (33%)
- scent, odour (27%)
- brand, name (23%)
- German product (18%)
- label of origin (16%)
- opinion of sales person (16%)

Trends were also discussed which showed that freshness, quality and variety had superceded price and special offers as reasons affecting purchase in the 1980s.

Quality schemes and origin were also of importance in Germany, with a general complaint about lack of information on labels.

A study investigating consumer attitudes towards food labels on meat products, including poultry, carried out by Arbindra (2005) in the USA showed 70% of respondents felt labels helped in the purchase of beef and other meat products. 50% thought present information was about right, 30% felt it was inadequate. High percentages of respondents (approx 80%) thought it was very important that labels contained information regarding nutrition, ingredients, health claims and production processes.

McCarthy et al (2004) investigated factors influencing the consumption of pork and poultry meat in Ireland. Using Fishbein and Aizen’s theory of reasoned action (TRA) they found consumers regarded pork as being safer but less tasty, healthier and more expensive than poultry meat. Attitudes towards poultry meat influenced consumption markedly. Important determinants of attitudes towards poultry meat were health, eating enjoyment, safety and price with environment and animal welfare being less important.
A study at the University of Ulster by Kennedy et al (2004) used qualitative factors to understand factors of importance to consumers. Focus group discussions were recorded. Results showed that appearance and convenience were the most important choice of determinants of choice of chicken meat and these factors appear to be associated with perceptions of freshness, healthiness, product versatility and concepts of value. It concluded that producers and retailers should concentrate on product appearance and convenience as market drivers.

An article by Pendrous (2003) looked at factors driving UK meat and poultry sectors included fluctuations in consumer demand due to health concerns, increasing popularity of low fat, convenience, high quality products and legislation.

Appearance and colour are of particular importance to the consumer.

In terms of appearance, consumers are affected by negative quality attributes such as broken bones, cuts, skin tears, bruises, blisters, lesions, reddening of wing tips, residual feathers, surface discolouration and excess fluid in the pack. According to Fletcher (2002), bruising and haemorrhaging are the two most important attributes.

The poultry meat sector in Germany is discussed by Koenig and Fink-Kessler (2001) with references to increased consumption in poultry meat, the market, consumer expectations, production methods and quality of poultry meat and inadequacies of labelling.

The acceptance of fresh chicken meat presented under three light sources was evaluated by Barbut (2001). The effect of using incandescent, fluorescent and metal halide light sources on consumer preference of three different cuts showed that for whole chicken and skinless thigh meat incandescent light was the preferred source. For skinless breast meat fluorescent was preferred over metal halide but not incandescent. Panellists also indicated they would buy thigh meat presented under incandescent and metal halide light but not under fluorescent. Light reflectance data indicated the reason was a lack of red light in the bulb output of fluorescent light which resulted in a lack of redness in the products.
Focus group studies were conducted by Elsner et al (1997) to assess marketing opportunities for fresh dark chicken meat. A sensory study assessed acceptability of ground dark chicken meat minced through different plate sizes with varying levels of sodium tripolyphosphate (STPP). Texture ratings improved with increasing grind size. Sensory properties were not significantly affected by STPP concentration. A simulated supermarket setting test showed highest consumer preference for breasts followed in order of decreasing preference by kebabs, stir fry, skinless boneless thighs, scallopini, bone in skin on thighs, and finally ground dark chicken meat.

Mulder (1995) carried out an overview of the poultry industry worldwide in terms of production levels, demand, consumption, quality, quality control systems, consumer perceptions with an emphasis on product safety (veterinary drugs, natural toxins, microbial hazards) and product image. Communication regarding risk management was seen as being significant to the development of consumer relations.

Holroyd (1991a) identified major production and processing factors influencing the overall eating quality of poultry and showed relationships between consumer requirements and particular production/processing factors (age, sex, weight, chilling, packaging).

A further paper by Holroyd (1991b) discussed how consumers evaluate eating quality being defined as that property which generates repeat business. Eating quality was defined as a combination of texture (tender to tough), succulence (dry to wet) and flavour (aroma and taste). The thought process during food evaluation generally follows this sequence. In order to satisfy the consumer, quality assurance programmes were seen as the route to avoid problems in eating quality.
Summary

In a market of continued growth, dominated by cut portions and whole birds but with real gains in processed products, many factors influence consumer perception and purchasing with appearance being the greatest quality attribute. Nutritional qualities, particularly with regard to fat content, were important as were issues of animal welfare, organics, safety and origin. Price, versatility and convenience were also factors influencing consumers’ attitudes to purchasing poultry.

Note

Product safety, social and ethical concerns featured regularly in reviewing consumer attitudes towards the purchase of poultry and much has changed, particularly in terms of legislative requirements, in recent years. As the next section of this report does not cover these areas, it was considered useful to list website links (see Annex 1) to various current poultry quality and welfare schemes and relevant legislation.
Campden & Chorleywood Food Research Association

Identifying Needs in Poultry Meat Quality Research

(Defra Reference FO0310)

Report 1.2

Review of recent UK research of poultry meat quality (Objective 1.2)

Introduction and scope

The purpose of this section of the report is to review recent UK research, including Defra funded research, on factors influencing poultry quality. The review will comprise a literature search over the last three years and will be complemented by any research identified at selected UK institutes and universities.

Major developments outside the UK may also be included and studies earlier than three years ago referred to as necessary in a contextual basis or in order to set the scene.

In section 1.1 it was found that many factors influenced consumer perception and purchasing of poultry such as appearance, nutritional quality, product safety, provenance and a range of social and ethical issues, many of which are perception issues. In this section, those quality attributes which result from changes to the physical or biochemical properties of the bird will be reviewed and for the consumer these attributes are appearance, eating quality and nutritive value.

The review will therefore focus on research aimed at improving appearance (colour, visual defects), eating quality (texture, flavour) and nutritional quality. Factors throughout the chain will be included.
FACTORS AFFECTING POULTRY MEAT QUALITY

Before reviewing recent UK research into factors affecting poultry meat quality, it was considered useful to set the scene by giving a historical perspective of poultry quality research, which spans the UK and USA in particular and is well documented in textbooks and review papers.

A. Historical research of factors affecting poultry meat quality

1. Appearance

It could be argued that appearance is the most important quality attribute of poultry. Consumers may accept or reject a product initially on appearance and once cooked it is an important part of sensory evaluation. Skin colour is important for whole birds and parts. Visual defects and meat colour are also important both in the raw and cooked state.

Skin colour

It is well known that skin colour influences consumer attitudes to fresh poultry and that preferences were, and still are, for traditionally available colours. Fletcher (2002) mentions regional preferences in USA for pale through to deep pigmentation, whilst consumers in the UK tend to prefer a white, non-pigmented skin. Historically, these colours are based mainly on the availability of lipid soluble pigments such as carotenoids in the feedstuff and the ability of some breeds to deposit carotenoid pigments in the skin.

Many factors affect skin pigmentation including feed sources (e.g. grain type), xanthophyll concentrates and exotic sources (e.g. broccoli, paprika extract and tomato), feed additives (e.g. fish oils, antioxidants, vitamins and trace minerals), xanthophyll stability and biological availability and management and processing parameters (e.g. breed and strain, disease and health, environment, housing type, scalding and sex. Factors affecting poultry pigmentation were reviewed by Fletcher (1989) and in symposium proceedings by Sunde (1992).

Many breeds lack the genetic ability to deposit pigments in the epidermis giving a white colour, irrespective of diet. Those birds that do have a genetic disposition to deposit
carotenoid pigments in the skin need those pigments supplied in their diet and this has been studied extensively.

Flock health is important as certain diseases affect pigment absorption and deposition. The epidermal layer containing the pigmentation is loosened at temperatures in excess of 54deg C and so care must be taken during the scalding operation.

**Meat colour**

The main issues with meat colour are muscle type (dark or light meat), colour variation and colour defects. Colour variation can be a problem in e.g. breast fillet packs and Fletcher (1995) found significant variations in breast meat colour across five commercial broiler plants with a strong negative correlation with muscle pH. Mottling, extreme paleness (PSE-like condition) and darkness are problems, as are appearance defects such as bruises, poor bleeding, haemorrhages, bone darkening and other blood related problems.

Mugler and Cunningham (1972) reviewed many of the factors affecting poultry meat colour that include sex, age, strain, processing procedures, chemical exposure, cooking temperature, irradiation, and freezing conditions. More recently Maga (1994) reviewed pink discolouration in cooked meat and a study was carried out between CCFRA and Reading University in recent years as part of a member funded study into unwelcome pink discolouration in cooked poultry.

Froning (1995) completed a comprehensive review of factors affecting poultry meat colour, the main factors being:

- the state of the haem pigments
- pre-slaughter factors (genetics, feed, handling, stress, heat and cold stress, gaseous environment)
- slaughter, chilling, processing conditions (stunning techniques, presence of nitrates, additives and pH, final cook temperature, reducing conditions, irradiation).

Stress immediately before and during slaughter affects meat colour. Ante-mortem temperature stress and excitement just prior to slaughter has been shown to affect turkey meat colour (Froning *et al.* 1978; Babji *et al.*, 1982; Ngoka and Froning, 1982). Also, Walker and Fletcher (1993) simulated severe ante-mortem stress by injecting with adrenaline just prior to
slaughter resulting in darker breast meat due to both a higher muscle pH and increased haemoglobin content.

Broiler skin and meat colour changes during storage were looked at by Petrachi and Fletcher (2002) who showed that colour values for both skin and meat changed dramatically during the first 6 hours post-mortem after which changes were less pronounced and that this 6 hour time period should be taken into consideration by manufacturers using on-line vision systems.

Although electrical stunning at high currents (greater than 100mA) was shown by Veerkamp (1987) to increase blood spots in broiler chicken breast meat and thus affect appearance, comparisons of high and low current stunning appears to have little effect on broiler breast meat colour (Pampinaho and Fletcher, 1995; Craig and Fletcher, 1997)

Gas stunning or killing has been shown to affect breast meat colour. Broiler breast muscles from birds killed by argon were less dark than those killed conventionally or by using carbon dioxide (Mohan Raj et al, 1990).

Various other studies have shown that stunning with carbon dioxide gave less red breast and thigh meat in turkeys compared to electrical stunning (Fleming et al 1991a), that electrical stimulation gave redder raw breast meat but lighter cooked breast meat than non-stimulated controls (Maki and Froning 1987), that post-mortem electrical stimulation gave darker broiler breast meat (Froning and Uijttenboogart, 1988) and that there were no effects of electrical stunning on turkey breast meat colour (Owens and Sams 1997).

The major factors affecting poultry meat colour are:
- myoglobin content (mainly related to species, muscle and age of animal)
- muscle pH (mainly related to biochemical state of muscle at time of slaughter and following rigor mortis)
- chemical state of the haem structure (of which the biochemistry is well documented).

Both the myoglobin content and the muscle pH contribute to meat colour and meat colour defects.
**PSE and DFD like conditions in poultry meat and the effects of pH**

Muscle pH and meat colour are highly correlated. Higher muscle pH is associated with darker meat and lower muscle pH is associated with lighter meat.

In the extremes, high pH meat may be classified as dark, firm and dry (DFD-like) with lighter meat classified as pale, soft and exudative (PSE-like). This relationship between raw meat colour and raw meat pH has been demonstrated by many researchers (Barbut, 1993; Boulianne and King, 1995 and 1998; Allen *et al*, 1997 and Fletcher, 1999b).

As well as many haem associated reactions being affected by pH, muscle pH also affects the water binding nature of the proteins, directly affecting the meat structure and its light reflecting properties (Briskey, 1964).

The pH also affects the enzymic activity of the mitochondrial system altering oxygen availability for haem reactions (Ashmore *et al*, 1972; Cornforth and Egbert, 1985).

Muscle pH has also been associated with other meat quality attributes such as tenderness, water-holding capacity, juiciness and shelf life. Variations in breast meat colour, mainly due to pH effects, were shown to affect shelf life, odour development, moisture pick up in marination, drip loss, water holding capacity and cooking loss (Allen *et al*, 1997 and 1998).

Although there is little disagreement PSE and DFD conditions do exist, and that these defects are related to factors affecting colour, from extreme lightness to darkness, there is uncertainty in the literature as to what extent colour variation can predict loss of meat functionality. Differences in lightness values have been correlated with differences in functional properties but cut-off values have yet to be established which can differentiate meat functionality.

Much research has been carried out to define factors likely to cause PSE or DFD like conditions. Qiao *et al* (2002) reported that broiler breast meat, which ranged from very pale to very dark in colour, had significant differences in chemical composition, concluding that although short-term stress may contribute to breast meat colour variation, compositional difference indicated...
that long term or genetic factors may create a disposition to light or dark carcases. Further studies (Wheeler et al, 1999; Owens et al, 2000a; Owens et al 2000b) showed that halothane is only a limited predictor of PSE in turkey meat.

**Visual Defects**

Visual defects can greatly affect the appearance of whole birds or cuts causing rejection by QC operatives, retailers and the consumer. The most important visual defects are those associated with bruising and haemorrhages.

Bruising is due to physical trauma (without laceration) causing capillary rupture and haemorrhaging (escape of blood from the circulatory system) of blood into the surrounding tissue. Bruises are initially red in colour but begin to change to a blue-black discolouration and finally to green/yellow as the haem compounds degrade.

Haemorrhaging refers directly to any capillary or blood vessel rupture causing blood pooling immediately below the skin. Thus, bruises are due to ageing of capillary haemorrhaging in the tissue due to trauma, whereas haemorrhages refer to any blood accumulation.

Factors affecting bruising include breed, strain, sex, housing density, feathering, bird size, bird age, season, light intensity, litter conditions, housing ventilation, disease, mycotoxins, vitamins, stress, holding conditions, unloading, hanging, stunning, killing and picking. Feed aflatoxins have been associated with capillary fragility and increased incidence of haemorrhages (Tung et al 1971) and electrical stunning has been implicated in increased haemorrhaging and blood spotting in meat with current stunning effects on bird welfare and carcase quality studies carried out by Wilkins et al (1999).

Other carcase defects leading to downgrading or trimming include:

a) Defects related to the animal and production factors
   - claw marks or skin injuries
   - regrowth of feathers
   - bone deformations (breast, legs)
   - blisters, abscesses, haematomas, pustules
b) Defects related to slaughter technology
- red wingtips, pygostyles and/or feather tracts
- engorged or haemorrhagic wing veins
- quality of plucking
- burned, grazed or torn skin
- dislocated or broken bones
(Adapted from Baeza, 2004)

2. Eating quality

Texture

Texture is probably the most important quality factor associated with consumer satisfaction in the eating quality of poultry.
The two major factors affecting tenderness are:
a) Maturity of the connective tissues.
   This involves the chemical cross bonding of the collagen in the muscle.
   Collagen cross-linking increases with age hence the tough meat found in older birds.
b) The contractile state of the myofibrillar proteins.
   This is mainly a function of the rate and severity of rigor mortis development.

Other factors affecting texture include the rate of rigor development, rate of chilling and filleting time.

Generally, age related toughness is not a problem in broiler meat quality due to the age of birds at slaughter except where there is a drive to slaughter younger birds. However, spent hens and older birds used for some poultry based products may give rise to tough meat.
Moreover, although it is unclear whether or not the total amount of muscle collagen is affected by age, its heat resistance increases and salt solubility decreases with age (Nakamura et al 1975; Touraille et al 1981a,b, Zanusso, 2002), probably as a result of cross-linkage formation between molecules, making this meat less suitable for further processing where salt solubility is important e.g. brining and marinading.
Early studies indicated that tenderness and juiciness decreased as the bird became older. In more recent studies, however, the effect of age on meat tenderness was less obvious. Sonayia *et al* (1990) reported no differences in the tenderness of breast and thigh meat between five and eight weeks of age in broilers with juiciness being greatest in the breast meat of older birds. Similar results were obtained by Mohan *et al* (1987) when comparing birds at six and eight weeks of age and Delpeche *et al* (1983) who found no differences in tenderness or juiciness between birds of seven, nine or eleven weeks of age. Differences here may reflect the use of broilers with different growth rates and hence the onset of maturity.

Koonz *et al* (1954) established long ago that poultry must be allowed a post-mortem ageing period prior to cutting, de-boning, cooking or freezing to avoid adverse toughening, especially in breast meat and further research suggests a minimum of 4 hours is needed to allow breast muscles sufficient time to complete rigor development, allowing subsequent removal from the carcase without excessive toughening.

The goal of much research over the years has been to develop slaughter methods that would allow acceleration of post-mortem rigor mortis so that carcases could be cut up and de-boned as soon as possible after slaughter.

This concept of accelerated processing is based on the rapid depletion of muscle glycogen and Adenosine Tri-Phosphate (ATP) stores as quickly as possible after death. Once the muscle loses the ability Studies with turkey have shown age related decrease in tenderness (Ngoka *et al* 1982). Other studies show a less organized distribution of muscle fibres and large round fibres clustered in groups (Grey et al 1986) Fibre diameter has been shown to increase with advancing age (Remingnon *et al* 1995). It is uncertain whether much research has been carried out to evaluate the effect of fibre size and distribution on chicken texture.

The effects of myofibrillar proteins on meat texture are mainly the function of the biochemical predisposition of the muscle at the time of slaughter, the rate and severity of rigor mortis development and the physical handling of the carcase and the muscle during rigor development.
If a carcase is cut into joints or breast meat is removed prior to the completion of rigor mortis, the muscle fibres will contract and the resulting meat will be less tender.

The rate of chilling can change muscle tension development and the time of relaxation in early post-mortem. Separation of breast muscle from carcases before rigor is completed removes the restraint that the skeleton of the bird has on the muscle causing irreversible rigor/cold shortening and tough meat. To generate ATP, rigor contractions stop and the muscle can be removed from its skeletal restraint with less adverse toughening.

The major factors affecting rigor development, and accelerated processing, are ante mortem handling, electrical stunning, gas stunning and electrical stimulation.

**Live bird handling and stress**

Muscle glycogen stores at the time of slaughter are affected by feed withdrawal, environment and struggle before slaughter. Birds with higher glycogen content in their muscle at slaughter have lower final muscle pH and lower shear values than birds with lower muscle glycogen. Kotula and Wang (1994) reported increasing feed withdrawal reduced initial breast muscle pH but had little effect on final muscle pH and resulted in higher breast meat shear values.

Ante-mortem stress, including heat stress, (Simpson and Goodwin, 1975; Lee *et al* 1976; Babji *et al* 1982) epinephrine injections, (Wood and Richards, 1975; Fletcher, 1991) and struggle (Ma and Addis, 1973; Lee *et al* 1979. Ngoka and Froning, 1982; Papinaho *et al* 1995) have been shown to accelerate glycogen depletion, increase the rate of pH decline and possibly result in tougher meat.

Although ante-mortem handling, feed withdrawal and stress affect muscle glycogen levels at slaughter and thus the rate and severity of rigor as well as the ultimate muscle pH, the effect on accelerated processing and final meat tenderness is still not defined.
Stunning and slaughter

Stunning methods can affect texture by altering the time of rigor development and the extent of muscle contraction and relaxation, which occurs shortly after slaughter.

Electrical stunning has been shown to result in more tender breast meat and altered post-mortem rigor development. Lee et al (1979) concluded that stunning inhibited metabolism and delayed the onset of rigor. Papinaho et al (1995) showed that the early delay in rigor attributed to electrical stunning was due more to suppression of ante-mortem struggle than any direct effects of electrical stunning on muscle metabolism.

Comparisons between high current stunning, as used in Europe and low voltage stunning, as commonly used in America, showed high current stunning had a more pronounced effect on early rigor delay (Papinaho and Fletcher 1995; Papinaho and Fletcher 1996; Craig and Fletcher 1997). Differences in muscle glycogen stores and breast muscle pH during early rigor development did not, however, affect ultimate muscle pH, tenderness or meat quality.

High current stunning to ensure humane slaughter is associated with increased carcase damage and much research has been carried out into argon and carbon dioxide gas killing systems with reported improvements in meat quality and reduced carcase damage. Killing birds in a gaseous environment resulted in accelerated rigor so that breast meat could be filleted earlier without adverse toughening (Mohan Raj et al 1990; Mohan Raj et al 1991).

Electrical stimulation

Poultry carcases are chilled after evisceration to lower the temperature to 4deg C within 4 hours post mortem, to minimize rigor shortening and toughness. Electric current can be used to hasten the onset of rigor in muscles (by depletion of ATP, rapid glycolysis and pH drop) and therefore shorten the post mortem ageing times prior to boning. A review of the electrical stimulation of poultry by Li et al (1993) showed variable and inconclusive results due to the high number of variations in the electrical stimulations studied.

Although it is generally accepted that electrical stimulation accelerates early rigor development, the extent of its effects and commercial application is still uncertain.

As mentioned, electrical stunning delays rigor development yet electrical stimulation accelerates it. A comparison of high and low current stunning followed by electrical stimulation (Craig *et al* 1999) shows electrical stimulation is most effective following high current stunning and had little effect on low voltage stunning.

More recent research has concentrated on combination treatments including electrical stimulation systems, extended chilling, high temperature conditioning and interactions with stunning and gas killing systems to enable accelerated processing and improve textural quality.

**Flavour**

The sensory quality of poultry meat is closely related to the age of the bird at slaughter although commercial selection for growth rate has led to birds being less mature with meat that is generally tender and juicy but of a less intense flavour.

Touraille *et al* (1981 a, b)) suggested that maximum flavour was found during the sexual maturation of broilers. Changes in the lipid fraction at this time in the phospholipid or fatty acid composition, was thought to play a part in this (Touraille *et al* 1981b, Zanusso 2002). Sonaiya *et al* (1990) found the flavour of breast and thigh meat from male and female Lohmann chickens was generally more intense at 54 than 34 days.

Apart from age, many other factors may affect flavour including sex, genotype, diet, stocking density, method of slaughter, post-slaughter factors of time and evisceration, time and temperature of chilling and storage and the actual cooking method used.

A comprehensive review of poultry meat flavour is given by Farmer (1999) who shows considerable disagreement between studies on many of the above factors. The summary indicates that production factors can affect flavour but often inconsistently, the one exception being males reaching maturity give meat with more flavour.
**Nutritional Quality**

The major components of raw poultry meat are proteins, lipids and minerals at proportions between 18.4 and 23.4%, 1.3 and 6.0%, 0.8 and 1.2% respectively (Culioli et al 2003). The nutritional composition of the meat will depend on the cut of the bird used and can be influenced by the feed of the bird.

The response of a bird to its feed is closely related to the changes in the growth of the skeleton, muscle and fat depot. In the first week post-hatch, the bird relies on using yolk-sac reserves until the gastrointestinal system develops adequately. The next “juvenile” growth phase involves the most rapid rate of body weight gain and is separate from subsequent pre-adolescent changes by the inflection point at about 36-44 days of age.

Transition at the inflection point is indicated by a change from an increasing to a decreasing rate of skeletal development, particularly for the long bones. The proportions of meat and fat continue to increase. The major and minor breast muscles are the greatest contributors to meat content and the most responsive to growth.

The percentage of body fat increases with age although its rate of accrual is not uniform in all areas. Early development tends to see fat deposited in the abdominal cavity followed by those in the main feather tracts of the skin which gain throughout “juvenile” development. Subdermal and intramuscular areas and accentuation of the abdominal fat depots predominate during adolescence.

For growth potential to be realized, the composition of the food should provide the nutrients needed for optimum performance in the total amount of feed consumed. Foods used in the production of broilers are usually formulated on the basis of minimum nutrient requirements. The National Research Council (1994) gives values for progressive intervals throughout life to accommodate growth alterations. This is regarded as only an estimate due to variations in growth rates and Hancock *et al* (1995) characterized growth and compositional alterations with six commercial genotypes sufficient to warrant separate nutritional requirements.

Often feeds are formulated on a least cost basis with expensive components not exceeding the total minimum. The expensive ingredients tend to provide energy protein and phosphorous.
Although inadequacies in these nutrients have little effect on live performance, they become more important in terms of eventual product quality with breast meat, which contributes nearly half the total edible protein, being particularly vulnerable in the skinless and boneless state.

As the dietary energy needed exceeds the optimum level of protein necessary to attain its delivery, body fatness increases and muscle mass decreases with the reverse occurring when protein is in excess of energy-again mainly affecting the yield of breast meat due to its extensive growth rate and predominance in the bird. Generally, also, studies show that the energy-protein relationship supporting the most favourable live bird performance corresponds to an optimization of the sensory value e.g. (Basker et al 1987).

Various other alterations to the feed not only have a direct effect on the nutritional composition of the meat but also affect its quality in other respects:

Sub-marginal levels of the essential amino acid lysine can lead to reductions in levels of muscle relative to all other tissues, especially breast, whilst energy normally expended on protein synthesis defers to fat deposition; substantial decreases in non-essential amino acids with oversupply of essential ones tend to give increased abdominal fat, reduced breast meat and increased bruising.

Phosphorous is the main mineral of concern in relation to poultry meat quality. Its high cost and pollution threat in excreta can lead to sub-marginal amounts in the feed and skeletal integrity can be affected with a lack of ready mobility and decreasing energy expenditure. However various carcase defects can occur-increased skeletal vulnerability may cause the bird to be affected by transportation and processing causing additional broken bones, blood splash and bone chips.

Added fat provides many different fatty acids and the nature of these can significantly influence meat quality. Although the fatty acid content of the feed can be diverse, the body can avoid extremes by absorption and hepatic modification: either increasing the number of carbon atoms when the acids are short to medium in length or an increase in unsaturation when they are saturated. Long chain polyunsaturated fatty acids generally remain unaltered. Thus fat such as animal tallow with its large quantity of stearic acid has little impact on the carcase (much is converted to oleic acid) whereas oils present in the feed have influence by virtue of their high amount of unsaturated fatty acids that are incorporated directly into the tissue. Carcase quality changes associated with unsaturated fatty acids may cause tearing of
skin covering during plucking, increased cooking loss (mainly due to additional fat in the drip from e.g. soybean oil in feed which has a high degree of unsaturation). There appears to be minimal effect on breast tenderness but the unsaturated state improves flavour whilst reducing perceived juiciness.

Membrane phospholipids have a large proportion of polyunsaturated fatty acids which are subject to oxidative peroxidation because of their exposure to water and oxygen at both surfaces. When chicken is cooked the membrane disrupts accentuating this exposure and may lead to a “warmed over” flavour in a short period of time and the speed of flavour deterioration generally increases with increasing unsaturation of dietary fat, its amount in the feed and duration of feeding. Use of fish oils in the feed may give rise to a “fishy” taste caused by large arrays and amounts of aldehydes and peroxides formed on cooking and a result of microbiological deterioration of fish prior to processing.

The use of antioxidants in feeds is particularly important in relation to meat quality. They are intended to minimize the oxidative rancidity of fat in the feed and for the protection of sensitive nutrients, mainly the fat-soluble vitamins. Butylated hydroxytoluene and other phenolic antioxidants are added to feed fat during storage to minimize peroxidation. Ethoxyquinn is a supplement which gives protection for double bonds associated with fat-soluble vitamins. Tocopherols (vitamin E) are usually associated with feedstuff of plant origin that are absorbed and used by the animal to protect its body lipids from peroxidation.

Increasing the concentration of n-3 polyunsaturated fatty acids (PUFA) by feeding linseed or fish oil to improve the value of the poultry for human nutrition puts great demand on the antioxidants and the change from n-6 to n-3 PUFA may result in stronger less acceptable flavour. The manipulation of dietary fatty acids to increase n-3 PUFA in poultry has been reviewed by Hargis and Van Elswyck (1993) and Leskanich and Noble (1997). From studies reported it would appear that poultry meat can be modified successfully to meet nutritional guidelines with regard to n-6: n-3 PUFA ratio and the concentration of EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). This would require supplementation with sources of a-linolenic acid and EPA and DHA due to the inefficient synthesis of the latter two from a-linolenic acid. Supranutritional levels of vitamin E would be required along with testing for stability of meat prone to oxidation such as frozen comminuted products and refrigerated cooked meat.
Genetics

Traits in birds affected by genotype include meat yield, the amount of fat present, sensory characteristics, age of inflection, live bird performance and technological properties of the meat.

Studies looking at improved meat yield have concentrated on the breast muscle due to its economic importance. Vereijken (1992) reviewed the genetics of body conformation and breast meat yield using subjective scoring. Increased size of breast muscle is also associated with improved protection of the skeleton, in particular the incidence of broken clavicles, and reduction in breast blisters.

Many studies have been carried out on the effect of genetics on inflection point, a key factor affecting quality and Gous et al (1992) confirmed previous similar studies of different breeds of commercial broilers finding inflection points between 45 and 50 days for cockerels and 45-53 days for females in a study of six breeds.

Farmer et al (1997) showed significant differences between two genotypes when evaluating texture and cooked appearance of roast breast meat and in the texture and cooked odour of thigh meat. Various studies (Ricard et al 1983, Chambers et al 1989) have shown that carcase fatness affects sensory traits in only a minor way.

Experimental selection for increased breast meat yield and reduced abdominal fat (Le Bihan-Duval et al 1999) showed breast meat which was lighter in colour and had a lower drip loss. The breast meat also showed a lower rate of decline in pH post mortem and a higher ultimate pH compared to unselected birds, this being consistent with the lower reserves of muscle glycogen. A genetic study on the same selected strain (Le Bihan-Duval et al 2001) demonstrated the importance of ultimate pH, and initial pH in determining water holding capacity, which increases with both these values. This study also confirmed the effect of light colour of the meat, which increases as ultimate pH decreases.
B. Recent UK research of factors affecting poultry meat quality

This review was carried out by searching literature published over the last three years and by contacting relevant UK research institutions.

Searching for studies of factors affecting the quality of poultry meat proved to be a less than straightforward task. As was seen in the historical review, many factors throughout the lifecycle, slaughter and post-mortem treatment of the bird impinge on meat quality, and in particular appearance, texture, flavour and nutritional quality. Some studies that might, for instance, address a welfare issue and intrinsically affect meat quality may not necessarily be highlighted in a search of factors affecting poultry quality. Moreover, literature searches rely on articles being available electronically and it is believed that not all work or journal articles are available in this format. As much poultry meat quality research is carried out outside the UK, studies of importance from elsewhere are included.

Notwithstanding these constraints, the following studies came to light in the review of available literature on poultry quality:

a) Review of available literature in the UK and beyond of research on poultry quality and of research whose outcome affects meat quality.

**Functionality of poultry meat.** Grashorn (2007)

This study from the University of Hohenheim in Stuttgart, Germany, looked at poultry meat as a potential functional food enriched with fatty acids and antioxidants. In particular it looked at poultry meat as an enriched food capable of providing Recommended Daily Intake (RDI) levels (based on European figures) of omega-3 (n-3) fatty acids, conjugated linoleic acid (CLA), a-tocopherol and selenium. Previous studies showed that poultry meat could be enriched with CLA, omega-3 fatty acids and selenium in a way that 100g of enriched tissue met 3-11,70-130 and 60% of the RDI for humans respectively. They reported that muscle tissues can effectively be enriched with n-3 fatty acids, a-tocopherol and selenium whereas enrichment with CLA was less effective. It was concluded that the occurrence of tough meat caused by the CLA and an increased liability to oxidation caused by the omega-3 fatty acids would impair the likelihood of poultry as a functional meat.
The study also felt functional poultry meat would be a niche market due to limited application caused by changes and the limited proportion of customers interested in purchasing it.

Future research needs included more information on proven RDI levels of these ingredients and inter reactions between the substances with regard to their effect on human health.


Blood components, especially haemoglobin, are powerful promoters of lipid oxidation and may decrease the shelf life of meat products. This study examined different slaughter techniques and their effects on pH, colour, lipid oxidation, residual haemoglobin concentration and sensory evaluation in broiler breast fillets. The slaughter techniques evaluated were CO$_2$ slaughter and not bled, no stunning and bled, electrical stunning (ES) and bled, CO$_2$ stunning and bled and ES and decapitation. No significant differences in pH values 24 hours post mortem in any of the slaughter techniques were found. Lighter fillets were obtained from the decapitated and ES stunned birds. The CO$_2$ slaughter and not bled birds had more red colour compared to the ES and bled and decapitated birds. There were no significant differences in residual haemoglobin contents in the breast muscle of all treatments except the CO$_2$ slaughter and not bled which was significantly greater. ES and bled birds had the lowest TBAR values compared to other treatments. Sensory panels detected increased aroma and flavour in not bled samples at 24 hours post mortem but this was not evident 72 hours PM. ES and decapitation had the most favourable result on sensory quality.

**Comparison of Allo-Kramer, Warner-Bratzler and razor blade shears for predicting sensory tenderness of broiler breast meat.** Xiong *et al* (2006)

In this study birds were processed and the breasts removed at a range of times from 0.25 to 24 hours postmortem (PM). A trained panel evaluated cooked descriptive sensory attributes and a larger consumer panel evaluated overall tenderness and texture. The samples were also analysed using three instrumental shear tests. Shear values and sensory scores were significantly affected by PM de-boning time. Shear values correlated well with descriptive sensory attributes and consumer studies. Although consumer tenderness was predicted well by all three shear tests, the razor blade shears was a better predictor of sensory tenderness.
(hardness) and this test, being simple and rapid, was recommended for evaluation by the poultry industry as a quality control method.

**Quality Assurance Models in the Food Supply Chain.** Manning et al (2006)

Although not strictly speaking a study on factors affecting poultry quality, this review by The Royal Agricultural College at Cirencester critically analysed Quality Assurance (QA) standards as a mechanism of delivering product quality in the supply chain using poultry as a model. It is argued private QA schemes verify through routine independent inspections that organisations are meeting certain prescribed standards set within the scheme addressing in general food safety, traceability, animal health and welfare and environmental protection and whilst this means poultry meat can be marketed on the basis that the birds have been produced to those standards, they are, however, extrinsic rather than intrinsic quality standards and do not form a business model that drives supply chain efficiency and business improvement nor do they ensure key consumer criteria such as product consistency or availability are met. The paper discusses different approaches to QA and the development of business models.

**Evaluation of slower-growing broiler genotypes grown with and without outdoor access: meat quality.** Fanatico et al (2005a)

With increasing consumer interest in natural and organic poultry products, this study looked at outdoor access and genotype on chicken meat quality. Slow (S), medium (M) and commercial fast (F) growing genotypes were raised. The principal effect of outdoor access on the S genotype was to make the meat more yellow but not the F genotype. Drip and cook loss were affected by genotype with the highest losses occurring with the S genotype. Tenderness was affected by gender as well as production system but only in the F birds. Pectoralis DM, fat and ash levels were unaffected by genotype or outdoor access. Outdoor access therefore had little effect on meat quality except to enrich the yellow colour of meat in slower growing chickens; however, genotype had a greater effect.

**Evaluation of slower-growing broiler genotypes grown with and without outdoor access: growth performance and carcase yield.** Fanatico et al (2005b)

In a further study looking at outdoor access and the impact of genotype this time on growth rate and carcase yield in chickens, data showed that substantial growth performance and yield differences exist among genotypes in alternative poultry systems. Weight gain was similar
among genotypes but males gained more weight than females. The F genotype had the greatest breast and lowest wing yield. The S genotype had the greatest leg quarter and lowest breast yield. Chickens given outdoor access had greatest bone strength in the tibia with the F genotype having the highest bone strength.


This study was a forerunner to that of Xiong et al (2006) and evaluated the ability of shear analysis to predict the sensory tenderness of chicken breast fillets. By comparing results with consumer sensory analysis, that for both descriptive and consumer sensory analysis, the instrumental shear tests performed similarly for predicting the tenderness of the cooked breast meat with the razor blade shear test having advantages in that no sample cutting or weighing was required to carry out the test, nor was it excessively destructive as only a small incision is made.

**Recent advances in breeding for quality chickens. Yang and Jiang (2005)**

This review looked at recent developments in chicken breeding programmes (world wide) aimed at improving chicken meat quality, recognizing that although white feathered chickens dominate world poultry production because of their rapid growth and high feed efficiency, consumer preference for colour-feathered slow growing chickens was increasing in certain countries. It looked at consumer preference in relation to meat quality, the French Label Rouge system and quality attributes that can be used by growers, such as appearance, flavour, tenderness, muscle composition) to diversify their range.

**Effect of dietary fat sources and zinc and selenium supplements on the composition and consumer acceptability of chicken meat. Bou et al 2005**

This was another study aimed at increasing the nutritional value of chicken, carried out by the University of Barcelona. It recognized that enriching poultry meat with n-3 polyunsaturated fatty acids (PUFA) was not without problems due to their tendency to produce off tastes and odours and also aimed to enrich the meat with some elements whose recommended daily intakes were not achieved by some communities. It examined the effect of supplementation with n-3PUFA, zinc and selenium and a-tocopheryl acetate on a-tocopherol, zinc, selenium, iron and copper contents and fatty acid composition in chicken meat as well as investigating oxidative stability and consumer acceptability of cooked dark meat. Fish oil and linseed oil
diets proved to be more successful in different respects at enriching the meat than animal feed diets and selenium content was increased with selenium and zinc supplements, with organically sourced selenium faring better. It also found the meat was acceptable to consumers with oxidative stability (including frozen storage) and useful provision of vitamin E from supplementation by a-tocopheryl acetate.

**Vitamin E supplementation, cereal feed type and consumer sensory perceptions of poultry meat quality.** Kennedy *et al* (2005).

This University of Ulster study looked at vitamin E supplementation of different poultry feeds and its effect on consumer acceptance. It found an interaction between vitamin E levels and storage time of the meat on perceived juiciness and tenderness and suggested optimal levels of vitamin E addition for corn fed and wheat fed birds.

**Skin pigmentation evaluation in broilers fed natural and synthetic pigments.** Castaneda *et al* (2005).

This study in the USA, where skin pigmentation has strong regional preferences, looked at the use of natural and synthetic pigments added to the feed and their effect on colour. Natural pigments produced consistently greater yellowness throughout growth than synthetic ones. By week 7 all pigment sources had reached plateau levels in the blood with synthetic ones giving higher blood levels of yellow and red pigments. It was suggested that although synthetic pigments may be absorbed from feed better than natural ones, natural pigments are more efficient at increasing skin yellowness.

**Chitin utilization by broilers and its effect on body composition and blood metabolites.** Hossain and Blair (2007).

This study by the Avian Research Centre at the University of British Columbia, Vancouver looked at the ability of farmed poultry to digest chitin and derive nutrients from the ingestion of insects. Triglyceride concentrations were significantly reduced in the liver and breast meat by chitin inclusion but no significant differences in carcase yield were found at age 21 days. It was concluded that the ingestion of insects was not an important source of nutrients.

Participants in this study were veterinary departments from the Universities of London and Glasgow, Rothamstead research at Harpenden and Stork Food Systems, the Netherlands. Using a variety of gas mixtures to stun the birds, few differences were found between gas mixes in terms of carcase and meat quality. Initial bleeding rate was slowest in bi-phasic (anaesthetic phase and euthanasia phase) stunned birds but total blood loss was not affected. Acceleration of post-mortem metabolism in anoxic stunned birds was not sufficient to allow boning within 5 hours without the risk of tough meat.

There were welfare benefits using consecutive phases of anaesthesia and euthanasia.


This was a follow-on study to that in the pilot scale one and claimed clear advantages to the processor in using CO₂ and O₂ rather than Ar and CO₂ to stun broiler chickens. In particular a much smaller number of fractures wings and fewer haemorrhages of the fillet were seen. Both studies concluded that controlled atmosphere stunning of broiler chickens based upon a biphasic hypercapnic hyperoxygenation approach has advantages, in terms of meat quality and welfare, over a single phase hypercapnic anoxic approach employing 60% Ar and 30%CO₂ in air with less than 2% O₂.


A study at the Sultan Qaboos University evaluated date fibre as a partial replacement of maize as an energy source and found no significant effect on carcase or meat quality characteristics.


This research at the Universitat Autonoma de Barcelona assessed the effects of different amounts of dietary polyunsaturated fatty acids (PUFA) on fatty acid composition of chickens and the contribution of de novo fatty acid synthesis to fatty acid profile was also estimated. It found that increasing dietary PUFA inclusion resulted in an increase in PUFA deposition with higher efficiency when dietary fat also provided saturated (SFA) and monounsaturated
(MUFA) fatty acids. Increasing dietary PUFA (keeping dietary fat constant and at increasing inclusion rates) resulted in a decrease in SFA and MUFA concentration in the whole body.

**Genetic relationships between feed conversion ratio, growth curve and body composition in slow growing chickens.** N'Dri *et al* (2006)

Relationships between feed conversion ratio, growth curve parameters and carcase composition were investigated in a slow-growing line of chickens in France and showed that indirect selection for feed conversion ratio is possible by using growth curve parameters and abdominal fatness.

**Effect of dietary conjugated linoleic acid (CLA) on broiler performance, serum lipoprotein content, muscle fatty acid composition and meat quality during storage.** Bolukba (2006)

This Turkish study showed that weight gain and feed conversion ratio were positively affected by dietary CLA level, that CLA isomer concentration increased in muscles in response to increasing dietary CLA and that addition of CLA to feeds significantly increased saturated fatty acid (SFA) and polyunsaturated fatty acid (PUFA) and decreased monounsaturated fatty acid (MUFA) in leg and breast tissues. Muscle pH decreased with duration of refrigerated storage and TBARS values were influenced by dietary CLA and storage time.

**Effect of dietary high-oleic acid sunflower seed, palm oil and vitamin E supplementation on broiler performance, fatty acid composition and oxidation susceptibility of meat.** Rebole *et al* (2006).

This Madrid based study looked at the effect of high-oleic acid sunflower seed (HOASS), palm oil (PO) and dietary supplementation of vitamin E in feed on performance, fatty acid composition and susceptibility to oxidation of white and dark chicken meat during refrigerated storage and found that, according to the fatty acid profile of the diets, SFA and PUFA contents were significantly reduced and MUFA content was significantly increased in white and dark chicken meat when the saturated oil, PO, was replaced progressively by HOASS in the diet. Also, the inclusion of vitamin E, increased PUFA content in both meats. After 4 and 7 days, of refrigerated storage, white and dark meat from birds fed on HOASS containing diets had significantly lower TBARS values than those derived from the PO diet.
Moreover, the addition of vitamin E significantly reduced the lipid oxidation in white and dark meat and helped improve chicken performance.

**Bone breaking strength and apparent metabolisability of calcium and phosphorous in selected and unselected broiler chicken genotypes.** McDevitt *et al* (2006)

This research carried out by the Avian Science research Centre at SAC, Edinburgh and the University of Aberdeen found stronger leg bones in selected broiler genotypes at the same age fed on a high or low quality diet. Bone breaking strength was lower for both bird genotypes fed on a low quality diet and both genotypes had similar calcium metabolisability.


This Portuguese study evaluated in vivo real time ultrasonic (RTU) to predict breast and carcase yields and weights in male broilers by comparing breast area, thickness and volume with breast and carcase weights and similar breast measurements post-slaughter. The best simple correlation between RTU and carcase measurements was obtained for breast volume. Breast and carcase weights were well predicted by live weight and breast volume, measured in carcase by or by RTU, was better at predicting breast weight and breast and carcase yields.

**Effect of chilling, polyphosphate and bicarbonate on quality characteristics of broiler breast meat.** Sen *et al* (2005)

This research study by the National Research Centre on meat in India assessed the effect of tetrassodium pyrophosphate and sodium bicarbonate on colour and sensory attributes of pre- and post-chilled breast meat and found that post-mortem injection of polyphosphate and sodium bicarbonate had beneficial effects pH, colour, water holding capacity, cooking loss and sensory attributes.

**Variations in chicken breast meat quality: implications of struggle and muscle glycogen content.** Berri *et al* (2005)

This French study investigated the consequences of variations in bird response to pre-slaughter stress on broiler breast meat quality. Three genotypes were used viz. a fast growing standard line (FGL), a slow growing French Label Rouge line (SGL) and a heavy line (HL). Each chicken line was subjected to one of three ante-mortem conditions viz. low stress,
shackling or shackling plus acute heat stress. Results showed that ante-mortem struggling and glycogen concentration in muscle at death were key factors associated with onset and extent of pH drop and ultimately breast meat quality. Factors which promoted bird struggling, particularly depressed the processing quality of breast meat of SGL birds (higher drip loss and redness, lower lightness and yellowness) while it hardly affected that of standard broilers, emphasizing the importance of adapting pre-slaughter conditions to broiler type. The study suggests it is necessary to determine for each genotype the impact of production and pre-slaughter conditions on muscle glycogen content at death order to control better the variability of muscle pH measured 24 hours after death, a major determining factor of breast meat processing quality.

**Rheological characteristics of fresh and frozen PSE, normal and DFD chicken breast meat.** Zhang and Barbut (2005)

This Canadian study evaluated textural and rheological differences among broiler breast meat ranging from pale soft and exudative (PSE) to dark firm and dry (DFD) in their fresh and frozen forms and found that PSE meat was significantly lighter in colour, had lower pH and water holding capacity values than normal and DFD meats. DFD meat was also significantly different from normal meat. During cooking, PSE meat lost more liquid than DFD meat and texture profile analysis parameters were lower for the PSE meat. Results also indicated that meat proteins were damaged during freezing and PSE meat was more severely affected.

**b) Research in academic and research institutions**

See Annex 2 for contacts.

**University of Bristol**

The University of Bristol has long been recognized as a centre of excellence for meat research and in particular is a world authority on stunning and killing methods for poultry, the physiological responses of the birds and effects on carcase and meat quality. Much leading research has been carried out on gas stunning. Publications highlighted over the last three years in the Division of Food Animal Science are welfare related yet ultimately will affect the quality of the chicken meat produced.

Warriss *et al* (2005) investigated the relationship between maximum daily temperature and mortality of broiler chickens during transport and lairage. Based on records of broiler
chickens slaughtered over three years at a processing plant, a pronounced seasonal effect on mortality was found during the hot summer months, increasing when the maximum daily temperature rose above 17 degrees C. Higher daily temperatures caused even higher mortality rates as the birds found it difficult to thermoregulate. There was no evidence of birds dying from hypothermia when the ambient temperature fell to minus1 degree C. It was suggested steps might need to be taken to lessen the damaging effects of transport on bird welfare.

Pagazaurtundua and Warriss (2006) looked at levels of foot pad dermatitis (FPD) in broiler chickens reared under five different systems; standard intensive, free range, organic, RSPCA Freedom Food compliant systems and corn-fed. From a large population study, they found that standard (intensive) systems had a mean FPD prevalence of 14.8%. Birds with access to the outside (free range and organic) had higher prevalence rates to those kept inside. Lowest prevalence of FPD (9.6%) and severity of lesions was in the birds reared under the Freedom Food systems and the highest prevalence (98.1%) and severity in organic systems. It was suggested that the variation in levels of FPD found should be taken into account when assessing the overall welfare of such schemes studied.

Haslam et al (2006) carried out a preliminary study examining the utility of using foot burn or hock burn to assess aspects of housing conditions for broiler chicken and the findings indicated that, where the incidence of contact dermatitis is used as a welfare assessment measure, foot burn may more closely reflect litter and air quality in the house.

A study by Brown et al (2008) on aspects meat and eating quality of broiler chickens reared under standard, corn fed, free range or organic systems has been carried out. No details were given and it has not yet been published.

Other studies include the link between pain, stress and the immune function in chicken and pigs, accurate and better measurement of animal welfare and cognitive abilities in animals.
University of Reading

Research being carried out here is concerned with nutritional aspects of poultry meat, in particular lipids in poultry meat. It is focused on enrichment of poultry meat with long chain n-3 fatty acids, as a potentially important source of this essential fatty acid, and is part of LipGene, an integrated project funded by the European Union Sixth Framework Programme.

A presentation at the 10th European Nutrition Conference in Paris by Givens (2007) addressed enhancement of poultry meat with very long chain n-3 PUFA and enhancement of other animal derived products such as milk in an effort to alleviate the generally sub-optimal dietary intake of these fatty acids that exist across much of the EU.

Gibbs et al (2007a) presented a paper at the Summer Meeting of the Nutrition Society on the effect of dietary source of very long chain (vlc) n-3 PUFA’s on the EPA and DHA concentrations of chicken meat.

Papers presented at the Proceedings of the British Society of Animal Science 2007 included:

-Gibbs et al (2007b) a study which looked at age and gender with regard to current and potential intakes of vlc n-3 PUFA’s from oil-rich fish and animal derived foods and concluded among other things that intakes among young people, particularly young men were substantially sub-optimal, however, with their relatively high intakes of animal derived foods, especially chicken, the potential to increase intake by enriching poultry was great.

-Gibbs et al (2007c) that compared different sources of vlc n-3 PUFA in the broiler diet in relation to their effects on EPA and DHA concentration of the white and dark meat of the chicken. Supplementation of the diet of growing birds with fish oil is potentially problematical in terms of oxidative stability and organoleptic properties of the poultry meat. Alternative sources supplementation investigated included marine algae (the primary producers of vlc n-3 PUFA) and encapsulated fish oil. Higher concentrations of EPA were found in the tissue of birds fed fish oil, including the encapsulated form, and DHA was equally available in tissue irrespective of dietary source.

-Rymer and Givens (2007) studied the effect of dietary source of the vlc PUFA’s in diets on the oxidative stability of the meat and found that dark meat was less stable than white meat.
due to it’s higher lipid content and the oxidative stability of the meat appeared to be reduced when birds were fed marine algae rather than fresh fish oil.

A study was carried out by Rymer et al (2006) investigating the effect of species and genotype on the efficiency of enrichment of poultry meat with n-3 PUFA’s.

Givens et al (2006) discussed the potential of animal derived foods such as chicken as a source of increasing PUFA’s in the diet highlighting the importance of examining trends of meat consumption. It was suggested that with sustainability of fish oil being questioned, alternative dietary sources need to be investigated.

**Agri-Food and Biosciences Institute**

Recent work at the Agri-Food and Biosciences Institute (AFBI) in Belfast includes research on the flavour of chicken.

In a study to determine some flavour precursors in chicken muscle, Aliani and Farmer (2005a) note that the natural components of raw meat have little aroma until they react together during cooking to give the characteristic aroma of cooked meat. These reactions include the Maillard reaction between an amino compound and a carbonyl compound, the thermal degradation of thiamine, the oxidation of lipids and the interactions between these pathways. The study looked at naturally occurring concentrations of selected precursors of Maillard and related flavour forming pathways. Using purchased product, it was shown that variation occurs both between commercial sources and between individual chickens from the same source.

In a subsequent study, Aliani and Farmer (2005b) tried to determine the importance of individual precursors for chicken odour and flavour. The cooking of meat generates hundreds of volatile compounds but relatively few make a key contribution to the odour and flavour of cooked meat. This study concentrated on those precursors believed to affect the Maillard and related flavour-forming reactions in meat. Elevated concentrations of ribose gave an increase in the selected aroma and flavour attributes of cooked chicken meat. Assessment of volatile odours by gas chromatography-odour assessment and gas chromatography-mass spectrometry showed that ribose increased odours described as “chicken” and “meaty” and likely compounds attributed to these odours are suggested.
Other publications of research in this area include those in books (Aliani and Farmer, 2006a) and other journals (Aliani and Farmer, 2006b).

Collaborative work with the animal feed industry has examined the effectiveness of modifying the fatty acid composition of chicken and turkey meat to increase n-3 PUFA by dietary means. Enriching poultry meat with folate through dietary supplementation has also been investigated in conjunction with a local university research group (Mc Cann et al 2004).

Earlier research (more than 3 years ago) on factors affecting post-slaughter pH declines showed that low voltage electrical stimulation enhances the rate of post-mortem glycolysis and rigor onset on the bone with no detrimental effect on poultry breast meat tenderness, facilitating early deboning.

**Roslin Institute**

Research at the Roslin Institute is structured through two divisions. Research in the Division of Genetics and Genomics is concerned with understanding the genetic control of complex traits in farmed animal species with strong emphasis on improving the health and welfare of farmed animals, the sustainability of animal production systems, the quality and safety of animal products and the knowledge base in animal biology. The Division of Gene Function and Development utilizes molecular and cell biology methodology to investigate gene function in animals.

Recent studies include that by Sandercock et al (2006) who compared thermoregulatory capacity and muscle membrane integrity in broilers and layers of the same weight. Programmes of genetic selection in poultry for economically important production traits such as high growth rate, food conversion efficiency and muscle yield have resulted in birds that grow up to 4 times faster than layer strains and exhibit 8 fold increases in breast muscle growth rate (Griffin and Goddard, 1994). However genetic selection for improvement in production traits may come at a cost to undesirable patho-physiological metabolic derangements that include respiratory and cardio-pulmonary disorders. During production poultry may be exposed to stressful environmental challenges such as chronic thermal stress (high or low environmental temperatures) that has a detrimental impact on production and
mortality and ultimately meat quality. The study reported that genetic selection for high muscle growth in broiler lines has compromised their capacity to respond to an acute thermal challenge, leading to detrimental consequences for muscle function. It suggested that this reduction in heat tolerance might have important implications for bird welfare and subsequent meat quality.

This study was a follow on from a Defra funded study by Sandercock et al (2001) which evaluated meat quality as a result of acute heat stress induced alteration to blood-acid base status and skeletal muscle membrane integrity. It concluded that acute heat stress induced blood acid/base status and muscle membrane integrity may be associated with changes in ante- and post-mortem breast muscle glycolytic metabolism, leading to alterations in meat characteristics such as increased drip loss and an increased incidence of haemorrhages. These changes have a detrimental effect on meat quality, which is exacerbated in older birds. Breast meat eating quality was not affected although overall reductions in taste attributes were observed with age.

The Defra funded research on the genetics of poultry meat quality was completed in 2001 and conclusions included that genetic selection for broiler traits has markedly altered cation regulation in muscle cells and may be associated with changes in muscle cell function and the development of pathology and meat quality problems (from “Changes in muscle cell cation regulation and meat quality traits are associated with genetic selection for high body weight and meat yield in broiler chickens”-paper from Dr. Paul Hocking). Some of this has been published and Roslin have recently submitted a paper with a second in preparation.

Other publications/studies at Roslin include:

Hocking (2005) published a review of quantitative trait loci for production, behaviour and disease resistance traits in chickens.

An assessment of environmental enrichment for broiler breeders to determine if welfare would be improved by decreasing aggression and feather damage (Hocking and Jones, 2006) found that provision of litter in the form of unopened wood shavings was a commercially acceptable form of environment enrichment, but there was no evidence that behavioural
changes associated with feed restriction, including the prevalence of aggression, were improved.

A collaborative exploration of the genetic architecture of blood oxygen saturation, body weight and breast conformation was carried out on 4 different meat type broilers (Navarro et al 2006) which suggested that, in principle, genetic selection to simultaneously increase blood oxygen saturation (and therefore decrease ascites susceptibility) and weight and flesh could be performed using traditional selection methods. A putative interaction between ascites and production traits is discussed in relation to potential jeopardisation of such methods.

BBSRC Grant D13983, PJ Sharp, “Chicken leptin-a candidate gene for chicken body composition and reproductive performance”
BBSRC Grant BBSE00000692 “Poultry genetics”
BBSRC Grant BBSE00000336 “Welfare assessment of gaseous stunning in poultry”

A previous BBSRC study (LS2004) from 1997 to 2001 aimed to determine the extent of genetic variation for putative meat quality traits in chickens by conducting a multi-strain experiment. Genetic correlations among production, carcase and meat quality traits to assess likely consequences of selection for these traits were calculated.

No information on results or applications for these studies was found.

ADAS
A study (OF0153) from 1998-2002 examined the effect of breed suitability, system design and management on welfare and performance in traditional and organic poultry meat. The main project conclusions were:
- Breeds should be chosen according to their growth profile when daytime access to feed is not restricted.
- A suitable basis for defining breed differences in growth potential may be mature live weight (fat free).
- Active and inquisitive breeds should be chosen for use in extensive production systems as they are likely to be better rangers and foragers than the less active broiler hybrids
- Breeds that show extreme escape responses and ground peck in a stereotypic manner should be avoided as they will be more difficult to manage and there may be a risk of aggressive feather pecking.

- Feather colour may affect the chicken’s ability to hide from predators; white feathering may increase the risk of predation.

- There are breed differences in breast meat yield, which is also affected by lysine and methionine intake.

- There is the potential to optimize and promote the eating quality of extensively produced chicken meat.

- Pasture use is encouraged by providing access to pasture in early life, but there are implications for the build-up of parasitic disease and methods of parasite control will be needed.

- Conifer wig-wams are attractive to chickens and encourage birds to range away from the house.

- Chickens will follow a mobile conifer wig-wam around the paddock, and this practice can help to distribute droppings within the paddock.

- “Slow growing” hybrid chicks may not be available locally. Transporting small numbers of chicks is expensive and conditions during transit will affect mortality rates.

- Investment in free-range facilities and equipment will affect labour cost, ease of management and levels of performance achieved.

**University of Strathclyde**

A study by Jahan *et al* (2006) investigated relationships between flavour, lipid composition and antioxidants in organic, free-range and conventional chicken breasts from modeling. Eating quality, especially flavour, is important in cooked chicken and is influenced by various factors including lipid composition, antioxidant status and breed and production systems. The study showed that in chicken breast meat, lipid n-6 and n-3 fatty acid contents had a positive influence on chicken flavour and the inverse with less desirable oily and off-odour flavours and lipid oxidation. Adverse impacts on flavour were observed with lipid oxidation products related to C16:0 and other fatty acids correlated with flavour data. Specific antioxidants were correlated with sweet, fruity and chicken and a-tocopherol...
inversely with lipid oxidation aromas. Clear relationships were observed between lipid and antioxidant compositions and flavour in chicken breast meat.

A sensory study by Jahan et al (2004) of organic, free-range and corn-fed chicken breast found that the primary differentiation was on the basis of appearance and texture, but a sub-group of assessors could also differentiate on the basis of aroma and flavour. Corn-fed were differentiated on appearance but not flavour, organic differentiated on texture and free-range was generally similar to conventional breast meat.

**University of Nottingham**

A considerable amount of research is carried out on the Sutton Bonnington Campus (The Schools of Biosciences – SBS, and Veterinary Medicine and Science - SVMS) encompass a number of areas including (i) food safety and the pathogenesis of food borne pathogens in poultry, (ii) mechanisms of intestinal colonisation of chickens by Salmonella and Campylobacter, (iii) the immune response in chickens following infection by Salmonella and Campylobacter, (iv) the pathogenesis of systemic interaction between chickens and Salmonella, (v) novel approaches to controlling infection in chickens by Salmonella. These include the use of bacteriophage and immunomodulation and colonisation inhibition (competitive exclusion) using live, attenuated vaccines.

Nottingham considers this work to be concerned with poultry meat quality, specifically food safety. However it is not directly concerned with eating quality, texture, appearance or nutritional quality and therefore strictly speaking outside the remit of this review.

SBS also conducts poultry research in a number of other areas that are also outside of the remit of this review, which is concerned with Poultry Meat Quality.

Projects that are ongoing include:

(i) identification of colonisation genes in S. Enteritidis using microarrays
(ii) characterisation of the proteome of S. Enteritidis during gut colonisation
(iii) characterisation of the immune response to different salmonella pathovars during colonisation of the caecal tonsil.
None of the above work has been published yet. Projects that are ongoing and involve published work include (i) the dynamics of bacteriophage in Campylobacter-infected poultry in the field and (ii) the application of bacteriophage therapy for controlling C. jejuni in poultry and at the level of carcass decontamination.


DEFRA

Apart from those studies previously mentioned, the following Defra-funded studies could have an effect on poultry meat quality.

Project AW0236
From 2005-2005
Cost £61,460
Contractor-Scottish Agricultural College
“Estimating non-market benefits of reduced stocking density and other welfare increasing measures for meat chickens”
Pending EU proposals to amend stocking density in line with minimum standards for chicken welfare, this study reviews animal welfare benefits, improved market benefits and implications for compliance cost to industry.

Project MH0114
From 1998-2005
Cost £558,621
Contractor-Silsoe Research Institute
“Alternative stun/kill techniques for poultry”.
The objective of this study was to develop and test novel techniques that would improve the welfare of birds during stunning and killing, whilst maintaining carcase and meat quality. The techniques were electrical head only stunning and concussion stunning, both followed by cardiac arrest using electric current through additional electrodes. Expected outcomes were
the improvement of bird welfare at slaughter by individual treatment of the birds and by elimination of inversion and live shackling.

Project LS331
From 2003-2006
Cost £592,213
Contractor Roslin Institute
“The molecular biology of sex determination and sexual development in birds”

The main objective of this research was to underpin the development of sexing assays that would allow the identification of chick sex during the embryonic stage of development. This would be of benefit to poultry meat producers who have to accept the relative inefficiency of raising an equal amount of male and slower growing female birds, with males outweighing females by as much as 35% at age of sale.

No research abstract documents were found for these studies.

Summary
In section 1.2, a review of research on poultry meat quality was carried out.
Poultry meat quality was defined as those attributes resulting from changes to the physical or biochemical properties of the bird and included appearance (colour, visual defects), eating quality (texture, flavour) and nutritional quality. Factors throughout the chain were included.

By way of background information, a contextual historical review of factors affecting these quality traits was given.

A literature search of poultry meat quality research over the last three years was carried out and included major developments outside the UK. A deeper search was carried out, confined mainly to UK research, by extending the scope of the search to include studies not directly focused on meat quality but which nevertheless affect it, such as welfare studies, and by contact with selected research institutions and universities.

The range of research identified was diverse in nature. Some key findings were selected for discussion with industry as outlined in sections 2, 3 and 4.
Campden & Chorleywood Food Research Association

Identifying Needs in Meat Quality Research

(Defra Reference FO0310)
Report 2,3 and 4

Level of exploitation of current knowledge by industry, barriers to uptake and research needs. (Objectives 2,3 and 4)

Introduction and scope

In the previous section, a search was carried out of poultry quality research in the UK over the last three years, which encompassed a literature search and contact with selected research institutions and universities. Research of interest outside the UK was included as was research that would indirectly impact on meat quality. Selected topics of research were used as a basis for discussion for this stage of the review. Contact was made with selected key people in industry, academia and some retailers to determine the level of exploitation of current knowledge by the industry. Research outcomes that have resulted in industry change were sought, as were reasons for lack of uptake. Generic issues that require further research were solicited along with likely expertise and level of investment where possible.

Interviews were held by a series of meetings, by phone and by email. Those contacted can be found in Annex 2. Questionnaires were developed for industry, academia and retailers as a basis for discussion. Sample questionnaires can be found in Annex 3. The following is a summary based on the interviews held. It should be noted that not everyone who was contacted responded.

The poultry industry in the UK is in competition with that in other countries where production costs are lower. To stay ahead of the competition, it is important that higher quality, safety and traceability is demonstrated and that consumer expectations are fulfilled. To enable this to take place, ideally, relevant research outcomes should be adopted wherever practical or necessary. However, it became evident when interviewing academia, industry and retailers that three different perspectives were involved, each with their own drivers.
Academia

Unlike the red meat industry, there is no levy-funded research available for the poultry industry. Sources of funding include the UK government, the EU, other funding bodies, research councils and charities, and industry (processors, feed, breeding and machinery companies). They appreciate that the industry is hard-pressed and often collaborate with industry for “payment in kind” e.g. use of factory, labour and raw materials.

Much research, particularly that related to quality measurement, is carried out by students, but there can be a time delay before it is published. Often it is confidential. Some researchers have good relationships with particular processors, often local, who fund research. Most of this work is confidential in nature or there is an agreed delay in publication.

Research outcomes that have resulted in industry change include introduction of a patented low voltage electrical stimulation system and installation of immediate post-evisceration deboning with major carcase throughput, space saving and early chilling benefits. Some confidential flavour research has been beneficial in negotiations with retailers. Much of the research into enhancing the nutritional status of poultry meat is at an early stage for industry change. Some researchers were unaware of recent outcomes resulting in industry change, others were aware of change some time in the past.

Research outcomes yet to be adopted by industry includes the production of long chain n-3 enriched meat for retail. Lack of uptake is probably because work is still on going but there is interest in the poultry industry. However, the subject of nutritional or health benefit claims is an issue for manufacturers. Under Regulation 1924/2006, any food product claiming to have a health or nutritional benefit must meet a list of European Commission approved wording, and be supported by science. The new regulation is explained at the following website:

http://ec.europa.eu/food/food/labellingnutrition/claims/index_en.htm
Successful uptake of research is usually a result of close collaboration between scientists and industry and involvement of all parties at all stages of the project. In other cases, however, the competitiveness of the market and low margins has created a risk-averse attitude with a reluctance to adopt new developments until they have been proven elsewhere. Such was the influence of low margins that it was suggested by one researcher that any new measure would not be taken up unless it cost less than one half penny per bird and that this restraint stifles innovation.

Economic benefit would be a reason for uptake or the solution of a problem in an economic manner.

Others suggested a perceived irrelevance of poultry meat quality, lack of coordination within industry, ignorance of research findings or relevance and inadequate mechanisms for technology transfer as reasons for lack of uptake and blame was also directed at a lack of focus in the world of poultry research citing many journals, many ways to publish and not all of it web-based. It was felt that industry did not fully appreciate the cost of research.

Benefits of adopting research outcomes are varied but quantifying them in terms of cost has been difficult. For enriched poultry meat, the obvious benefit would be to public health nutrition with reduced incidence and hence costs associated with chronic disease. Improved product quality, safety and traceability help to keep the industry ahead of the competition and have economic benefits.

Industry

Industry keeps itself abreast of research in a variety of ways. Many are members of research organisations such as CCFRA which has a strong and active Meat and Poultry Panel, whose members have the opportunity to keep abreast of legislative changes, receive regular research updates, hear talks from invited speakers and enjoy the opportunity to network. Research funds have recently been made available to CCFRA members to investigate various meat related issues, some of which will
benefit the poultry industry. CCFRA also runs seminars for the meat and poultry industry which are an important source of information of what’s new.

Similarly, membership of the British Poultry Council helps keep industry up to date. Many companies have strong links with universities and some commission research by funding PhD courses. By providing farms, processing facilities, materials and labour, industry can be party to collaborative research, such as Food Standards Agency projects, and receive regular updates from researchers.

Links also exist with feed and breeding companies who carry out research. Many receive journals and the Internet is becoming increasingly important as a source of information.

However, comment was made that there was no vehicle for research and that many providers of support favoured smaller companies.

Some companies feel they have a good overview of research being carried out, others do not and some are critical of research which they feel absorbs huge sums of money, rarely delivers conclusions and merely provides a need for further research. There was a perceived need by one company for the FSA to carry out more near-market work, using universities to check and challenge the work.

For many companies, internal research is carried out on an ad hoc basis to identify causes and solutions to problems, enlisting the help of organisations such as CCFRA as required. Some companies employ graduates to carry out internal research whilst others do not have the resources, including time and equipment, to do so.

Research outcomes that have resulted in changes to industry practice include work carried out by a machinery company and a university on gas mixtures for gas stunning/killing of poultry and welfare studies relating to on farm practices and stunning techniques. Many could think of no changes.

Reasons for lack of research uptake often came down to cost. It was felt that the industry was well developed and any changes to process would likely involve
investment in new equipment. Such investment would need to show significant benefit and payback before it would be considered. Small margins and adversity by retailers to pay for something with no cost benefit to themselves were cited. Tight margins have meant capital goes into areas required by retailers. Some felt that researchers /decision makers did not understand the commercial opportunities. Lack of in-house expertise was another reason for lack of research uptake.

Benefits to industry in adopting research outcomes include shelf life improvement or a reduction in production costs. One company suggested that quality improvement could not be supported unless it added value to the product or lowered production costs. They acknowledged that some retailers might contribute to additional cost if there was a benefit to their customers whilst they thought others would tighten margins should production costs decrease. Some companies welcomed research that improved quality but queried customer willingness to pay for it, whilst others were keen to improve food safety.

Research needs identified by industry are included in the list at the end of this section. Although strictly speaking not within the scope of this review, Campylobacter was a persistent issue for industry with a requirement for a major focus to understand routes of contamination and for processes to control, reduce and eradicate it. “With 300,000 cases of Campylobacter in 2006, (data from cabinet office), the levels of other human disease from the guillaume syndrome would suggest this issue needs urgent action.”

**Retailers**

For retailers, the most important quality attributes for their customers are taste, texture, succulence and visual appearance. Some have a considerable budget for consumer research which they carry-out in-house. They keep up to date with latest research by supplier discussions, Internet searches, networking and relationships with research institutions. Successful uptake of research is usually due to retailer buy-in who applies pressure to industry. Retailers feel industry will not implement anything themselves unless there is a cost benefit. As a goal, retailers want natural, healthy, tasty products with scope for their customers to trade up to premium ranges.
For at least one retailer, labelling of meat with modified nutritional properties would be an issue, as would any modifications to fresh meat.

By far the greatest area of importance to retailers is animal welfare, both at the farm and at slaughter, as they feel welfare and meat quality are inextricably linked. It was suggested that if welfare issues were addressed, “everything else would fall into place”. Some employ technical staff who have been trained in poultry welfare. One retailer said they would like to see defined minimum welfare standards adopted by industry and more uniformity in audit and Quality Management standards throughout the EU.

**Summary**

Relatively little published research directly relating to poultry meat quality over the last three years in the UK has been found. By broadening the horizons and scope of the search, more has been uncovered and given more time it is likely yet more would be found. Some fairly recent research outcomes, particularly in the area of animal welfare and its indirect effect on meat quality (stunning/killing), have been adopted by some parts of industry. There is a perceived need by academia for technology and information transfer of their findings and for research funding in the area of poultry meat quality research. Much research carried out for larger organisations tends to be confidential in nature. Industry does try to keep abreast of latest research developments by a variety of routes but tight margins means that any quality improvements should have a cost benefit. Extension of shelf-life and control of microorganisms, particularly pathogens, is important. Retailers consider themselves to be in tune with their customers' needs in terms of poultry quality and see animal welfare as an important research area as it is inextricably linked with quality.
Potential areas for new research on poultry meat quality.

The following list has been compiled from knowledge gaps identified and from suggestions given by academia, industry and retailers. It covers a broad spectrum of issues and includes “wish-lists” from researchers. It is felt that the expertise to carry out this work exists in the research community but costs of carrying out the work have been difficult to estimate and are only given where they have been provided.

- Understanding consumer preferences for consumer quality aspects of poultry. What is the relative importance of eating quality, safety, provenance/origin, traceability. Within eating quality, which traits are important for acceptability? Using consumer panels, quantitative descriptive analysis and instrumental measurements of quality. Costs depend on specific requirements, but one researcher has estimated this to be in the region of £250k.

- Because of its widespread and high consumption, poultry meat is a good vehicle for nutritional enrichment of diets. Unique to poultry, fatty acids can be absorbed directly into the portal blood system. Enrichment with other key nutrients such as folate and selenium would be worthwhile, as would the value of poultry protein to the young and the elderly. Needs feeding trials, nutrient analyses, sensory analyses. Costs depend on specific requirements, but one researcher has estimated this to be in the region of £250k.

- Concern about poultry meat produced using diets with nutritionally inferior lipids requires research.

- Factors affecting shelf life and flavour

- On-line monitoring of quality traits. Using NIR and Raman spectroscopy for monitoring of nutritional and quality traits. Costs depend on specific requirements/sensory work, but one researcher has estimated this to be in the region of £250k.

- Role of genetics in eating quality of poultry breeding has been conducted for yield and growth rate-has this affected eating quality?

- There is genetic variation for quality traits related to keeping quality and processing characteristics that could be changed by genetic selection, most likely by the use of genetic markers

- Genetic research into stress susceptibility as this affects muscle quality
• Good quantification and definition of quality traits throughout the chain
• Method of slaughter has a large effect on product quality. Well-designed studies are needed. Insensibility of birds needs to be better understood. Methods of stunning/killing, especially whilst birds are still in the crate need to be developed—this would have welfare benefits too.
• Use of industry records and quality assessment to provide information for quality improvement. To facilitate a study to determine appropriate methods for using relevant industry information to determine factors affecting quality. Cost depends on specific requirements e.g. £300k
• Research carried out on immune responses to salmonella in poultry needs to be applied. Facilitation is required for translation. This could enable the generic modulation of immune responses to bacterial and food-borne bacterial infections with value to industry.
• A better understanding of PSE-like conditions
• Shelf-life extension/reduction in microbial growth
• Specific action against pathogens, particularly a focus to reduce campylobacter.
• Multiple options for safe carcase decontamination is required
• On-line detection of Oregon disease which is deep in muscle tissue
• Breed identification —quick test to confirm authenticity
• Sex identification of bird—quick test.
• Cause of red-leg in cooked poultry (perceived under-cooking)
• Effects of pre-slaughter stress on feather release
• Effect of Electrical Stimulation on muscle tissue quality, texture and taste
• Generic research into breeding and welfare standards that would improve meat quality
• More information on proven RDI levels of nutrients and fatty acids for nutritionally enhanced poultry, and effect of interaction of these ingredients on human health
• Alternative sources to PUFA’s than fish oils (sustainability)
Themed areas for research include genetics (genetic markers for quality traits, stress susceptibility, rapid testing for breed and sex), animal welfare (particularly to minimise stress and stunning/killing regimes), enhanced nutrition, processing (electrical stimulation, red leg, on-line detection of Oregon’s disease), microbiological (shelf-life extension, reduction of salmonella and campylobacter), and flavour.
Web links to relevant legislation, guidance, codes of practice etc

POULTRY QUALITY:

Council Regulation (EEC) No. 1906/90 on certain marketing standards for poultry meat (as amended)

and


DEFRA’s DRAFT enforcement Guide to EC poultry Marketing Standards Regulations:

DEFRA’s Poultrymeat Quality Guide:

POULTRY WELFARE:

The Welfare of Farmed Animals (England) Regulations 2007, Statutory Instrument No. 2078:

These Regulations, which came into force in October 2007, implement the requirements of the following EC Directives:

- Council Directive 98/58/EC concerning the protection of animals kept for farming purposes;
- Council Directive 97/2/EC and Commission decision 97/182/EC; and
Defra’s Welfare Code for Meat Chickens and Breeding Chickens:


ETHICAL SCHEMES:
The following DEFRA website provides a round-up of the various schemes in operation:
http://www.defra.gov.uk/farm/trade/assurance/index.htm

The following may be of particular interest:

- The Red Tractor (Assured Food Standards) Scheme:
  http://www.redtractor.org.uk/site/rt_home.php

- Assured Chicken Production
  http://www.assuredchicken.org.uk/chickens/

- RSPCA Freedom Food Scheme

TRACEABILITY:
Article 18 of the following EC legislation lays down the general traceability requirement:

REGULATION (EC) No 178/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety:

European Commission Factsheet on Traceability:

ORIGIN:
The aforementioned EC Poultrymeat Marketing Standards include an origin labelling requirement for poultrymeat imported from outside the EEC (1906/90, Art 5(3)(e)).

In addition to this, Regulation 5(f) of the UK’s Food Labelling Regulations 1996, as amended lays down a general origin labelling requirement in the following manner:

“particulars of the place of origin or provenance of the food [must be given] if failure to give such particulars might mislead a purchaser to a material degree as to the true origin or provenance of the food”.
Food Standards Agency Guidelines on Origin Labelling are available at:

HYGIENE (INCLUDING HACCP):

The general rules on food hygiene are laid down in the following EC Regulations:

Corrigendum to Regulation (EC) No 852/2004 of the European Parliament and of the
Council of 29 April 2004 on the hygiene of foodstuffs:

It is Article 5 of this Regulation which lays down legal requirements relating to
hazard analysis and critical control points.

Council of 29 April 2004
laying down specific hygiene rules for food of animal origin:
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INDUSTRY QUESTIONNAIRE

Defra Project-Identifying Needs in Poultry Meat Quality Research

This project is being carried out by CCFRA for Defra to understand the uptake of research on poultry meat quality and future research needs in this area. For the purpose of this project poultry meat relates to chicken and meat quality includes all quality attributes and their measurement where appropriate, but with particular emphasis on those that impact consumer acceptability.

I would be most grateful if you would answer some or all of the following questions and return to me by email or fax.

Thanking you for your co-operation,

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mailto:e.mulvey@campden.co.uk

1. Does your organisation carry out research on poultry, do you outsource it or do you do both?

2. A literature review of poultry quality research over the last three years has found research on meat enhanced with polyunsaturated fatty acids and minerals in order to improve its nutritional value; comparisons of birds of different genotypes (growth rates), availability of outdoor access and effect on meat quality; comparison of shear tests to predict consumer acceptance and many other issues that impact on product quality, e.g. welfare studies.

   a) How do you keep up to date with latest research?
   b) Are you aware of research studies being carried out, particularly in the UK?

3. What poultry quality research are you aware of that has resulted in changes to industry practice in the last three years?

4. Please describe any research outcomes that have yet to be adopted by industry.

5. What do you think are the reasons for successful uptake/lack of uptake of poultry quality research?

6. Can you give any indications of the cost/benefit of adopting the outcomes of poultry quality research?

111x36 Doc Ref:FMT/REP/104174  ANNEX 3  Wp Ref:secs/2008/FMT/EMM/ SK01062
7. What future research (generic or specific) or knowledge transfer needs do you see in the area of poultry quality?

8. Can you indicate the likely expertise and likely cost to address the research needs you have identified?

Please add your contact details and any further comments you feel are relevant.
ACADEMIA QUESTIONNAIRE

Defra Project-Identifying Needs in Poultry Meat Quality Research

This project is being carried out by CCFRA for Defra to understand the uptake of research on poultry meat quality and future research needs in this area. For the purpose of this project poultry meat relates to chicken and meat quality includes all quality attributes and their measurement where appropriate, but with particular emphasis on those that impact consumer acceptability.

I would be most grateful if you would answer some or all of the following questions and return to me by email or fax.

Thanking you for your co-operation,

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1. Does your organisation carry out research on poultry?

2. Is this research directly or indirectly related to poultry meat quality and its measurement?

3. Please describe any poultry quality research in the last three years stating
   a) if it is on-going or completed
   b) if it has been published (please give references) or will/will not be published

4. Please describe any research outcomes that have resulted in industry change.

5. Please describe any research outcomes that have yet to be adopted by industry.

6. What do you think are the reasons for successful uptake/lack of uptake of poultry quality research?

7. Can you give any indications of the cost/benefit of adopting the outcomes of poultry quality research?

8. What future research (generic or specific) or knowledge transfer needs do you see in the area of poultry quality?

9. Is your organisation able to carry out the research needs you have identified and if so, can you indicate likely cost? Please add your contact details and any further comments you feel are relevant.
RETAILER QUESTIONNAIRE

Defra Project-Identifying Needs in Poultry Meat Quality Research

This project is being carried out by CCFRA for Defra to understand the uptake of research on poultry meat quality and future research needs in this area. For the purpose of this project poultry meat relates to chicken and meat quality includes all quality attributes and their measurement where appropriate, but with particular emphasis on those that impact consumer acceptability.

I would be most grateful if you would answer some or all of the following questions and return to me by email or fax.

Thanking you for your co-operation,

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1. Does your organisation carry out research on consumer attitudes to poultry meat quality?
2. What are the most important poultry quality attributes for your organisation and for your consumers?
3. A literature review of poultry quality research over the last three years has found research on meat enhanced with polyunsaturated fatty acids and minerals in order to improve its nutritional value; comparisons of birds of different genotypes (growth rates); availability of outdoor access and effect on meat quality; flavour studies; comparison of shear tests to predict consumer acceptance and many other issues which impact on product quality, e.g welfare studies.
   a) How do you keep up to date with latest research?
   b) Are you aware of research studies being carried out, particularly in the UK?

4. What poultry quality research are you aware of that has resulted in changes to industry practice in the last three years?

5. Please describe any research outcomes that have yet to be adopted by industry.

6. What do you think are the reasons for successful uptake/lack of uptake of poultry quality research?
7. Can you give any indications of the cost/benefit of adopting the outcomes of poultry quality research?

8. Could you describe any difficulties with labelling meat with modified nutritional properties.

8. What future research (generic or specific) or knowledge transfer needs do you see in the area of poultry quality?

9. Can you indicate the likely expertise and likely cost to address the research needs you have identified?

Please add your contact details and any further comments you feel are relevant.
ANNEX 4
References:


AIR-CAT project, “Measurement of consumer attitudes and their influence on food choice and acceptability (AIR-CAT), AAIR3 Concerted Action No.942481, supported by the commission of the European Communities, DGXII. Project period 1994-1998, publisher MATFORSK, 1430 As, Norway.


Holroyd PH (1991a) “Factors which influence product eating quality”, Poultry International, 30(14) 42,44,46,80,84,86,88


Fletcher DL (1989) “Factors influencing pigmentation in poultry” CRC Critical reviews in poultry biology, 2(2) 149-170


Fletcher DL (1995) “Relationship of breast meat colour variation to muscle pH and texture”, Poultry Science 74 (Suppl 1), 120

Mugler DJ and Cunningham FE (1972) “Factors affecting poultry meat colour-A review”, World’s Poultry Science Journal 28(4) 400-406


Ngoka DA and Froning GW (1982), “Effect of free struggle and pre-slaughter excitement on colour of turkey breast muscles”, Poultry Science (61) 2291-2293


Craig EW and Fletcher DL (1997), “A comparison of high current and low voltage electrical stunning systems on broiler breast rigor development and meat quality”, Poultry Science (76) 1178-1181


Owens CM and Sams AR (1997), “Muscle metabolism and meat quality of pectoralis from turkeys treated with post-mortem electrical stimulation”, Poultry Science (76) 1047-1051


Wheeler BR, McKee SR, Matthews NS, Miller RK and Sams AR (1999), “A halothane test to detect turkeys prone to developing pale, soft and exudative meat”, Poultry Science (78) 1634-1638


Sonayia EB, Ristic M and Klein WF (1990), “Effect of environmental temperature, dietary energy, age, sex on broiler carcase portions and palatability”, British Poultry Science (31) 121-128


Grey TC, Griffiths NM, Jones JM and Robinson D (1986), “A study of some factors influencing the tenderness of turkey breast meat”, Lebensmittel Wissenschaft und Technologie (19) 412-414


Koonz CH, Darrow MI and Essary EO (1954), “Factors influencing tenderness of principal muscles composing the poultry carcase”, Food Technology (8) 97-100

Simpson MD and Goodwin TL (1975), ”Tenderness of broilers as affected by processing plants and seasons of the year”, Poultry Science (54) 275-279


Ma RTI and Addis PB (1973), “The association of struggle during ex-sanguination to glycolysis, protein solubility and shear in turkey pectoralis muscle”, Journal of Food Science (38) 995-997


Zocchi, C.and Sams, A.R. (1996).”The use of electrical stimulation and extended aging times to reduce the aging needed to achieve maximum tenderness in broiler breast fillets”. Poultry Science, 75 (Suppl. 1) 21, (Abstr)


Hargis PS and van Elswyck ME (1993), “Manipulating the fatty acid composition of poultry meat and eggs for the health conscious consumer”, World’s Poultry Science Journal (49) 251-264


Manning L, Baines RN, Chad SA (2006), “Quality assurance models in the food supply chain”, British Food Journal 108 (2) 91-104


Yang N and Jiang RS (2005), “Recent advances in breeding for quality chickens”, World’s Poultry Science Journal 61(3) 373-381


Kennedy OB, Stewart-Knox BJ, Mitchell PC and Thurnam DI (2005), ”Vitamin E supplementation, cereal feed type and consumer sensory perceptions of poultry meat quality”, British Journal of Nutrition 93 (3) 333-338

Castaneda MP, Hirschler EM and Sams AR (2005), ”Skin pigmentation evaluation in broilers fed natural and synthetic pigments”, Poultry Science 48(1) 143-147


Zhang L and Barbut S (2005), “Rheological characteristics of fresh and frozen PSE, normal and DFD chicken breast meat”, British Poultry Science 46 (6) 687-693


Givens DI, Gibbs RA (2006), “Very long chain n-3 polyunsaturated fatty acids in the food chain in the UK and the potential of animal-derived foods to increase intake”, Nutrition Bulletin 31 (2) 104-110


Sandercock DA, Hunter RR, Mitchell MA, Hocking PM (2006), “Thermoregulatory capacity and muscle membrane integrity are compromised in broilers compared with layers at the same age or body weight”, British Poultry Science 47(3) 322-329


Hocking PM, Jones EKM (2006)”On-farm assessment of environmental enrichment for broiler breeders”, British Poultry Science 47 (4) 418-425


