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Value added processed meat seminars DAQ.078

Prepared by:
International Food Institute of QLD

Published: June 1992
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MEAT & LIVESTOCK
AUSTRALIA

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ISBN 0 646 10235 4

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Published by McBenny Pty Ltd
89 Billan St Carina Qld
Ph (07) 398 9272

Printed by Merino Lithographics
18 Baldock St Moorooka

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Foreword

The Australian meat industry has played a significant role in the nation's economy since before Federation. Livestock production and processing activities were established in very early years to maintain an expanding community a long way from European food supplies. A little over one hundred years ago, with the advent of refrigerated shipment facilities, Australia became a meat exporter, and our meat continues to represent a significant proportion of the world export market.

The complexion of the market has changed in recent years from a basic commodity trade towards higher value, more clearly defined meat products. This trend is continuing with opportunities emerging both in Australia and overseas for new and innovative meat products. There has been an upsurge in options for adding value to meat. New processing technology and new packaging technology together with continuing research on microbiological and aesthetic aspects of product quality have combined to yield new challenges for the market place.

The Meat Research Corporation has recognised the need for coordinated research and development activities in the value-added meat product areas. In order to further stimulate development, the Corporation has undertaken a number of initiatives to encourage and assist processors with their efforts to establish themselves in the market. The decision to arrange this seminar, 'Value-added Meat Products' arose from the need to bring together the people involved with these developments, including processors, Government agencies responsible for supporting and/or regulating the industry and the research organisations that have been commissioned to undertake the associated research and development.

The seminar provided a unique opportunity to learn of the activities of the organisations involved with value-added meat product research, and the assembled papers, published in this proceedings will provide an ongoing reference for all interested parties.

The organisers of 'Value-added Meat Products' wish to thank the organisations responsible for the research presented here and those responsible for supporting that research:

Meat Research Corporation
Pig Research and Development Corporation
Food Research Institute (Victoria)
International Food Institute of Queensland
CSIRO Meat Research Laboratory

Dr Stefan Fabiansson
Meat Research Corporation

Market Opportunities for 'Processed Meats'

The Meat Research Corporation has always maintained a strong commitment to the importance of the consumer and the importance to meet consumer needs to achieve a profitable Australian meat industry of the future.

Hence it is not surprising that the Corporation has undertaken a coordinated market-driven program to exploit the market opportunities perceived for red meats.

This program referred to as the Value Added Meat Products Key Program not only covers new product development both for domestic and export markets but also includes sub-programs on market research, technology management and packaging.

This is seen as the only way to steer the industry away from commodity trading towards innovative marketing of meat as a food.

Over the past 18 months the Corporation has undertaken a pro-active role in directing and financing new product development with a long-term objective of convincing meat companies to establish their own in-house capability.

Projects are closely monitored from the beginning to the end and as much assistance as possible is given to the companies to fulfil their desired goals. In addition to partly funding the project and taking some of the risk up front, the Corporation also offers to subsidise the introduction of Total Quality Management (where it does not exist) up to a value of $25,000.

Therefore, the program as such goes a long way in assisting these companies.

To date, discussions with regard to product development have taken place with twenty-eight companies Australia wide.

As the aim of the program is to obtain commitment from companies in new product development, initially, a number of companies across Australia were approached with the aim of either promoting or assisting product development within those organisations.

Product ideas put forward by the companies themselves, together with the general concepts identified in brainstorming sessions held by the Corporation, were submitted to a focus group composed of advertising/marketing experts for screening.

Ideas with the greatest possible potential were then taken to the next stage and evaluated in detail.

From the initial exercise, the Corporation agreed to support two new product-development projects and one packaging project.

To date, two projects have been completed – one a new product development project and one a packaging project. Both projects have impacted favourably in the market place.

The new product – an all beef and mutton combination meat ball with or without sauce suitable for the retail and food service market (packaged in modified-atmospheric containers) has gained market acceptability quickly.

Whilst it may be too early to gauge whether the meatballs are affecting the sale of existing red meat alternatives, we are of the opinion that it has created a new market outlet for beef and mutton which will be of benefit to the producer in the long run.

The packaging project has also been welcomed into the market place.

The aim of the project was to meet the consumers' needs by supplying shelf-ready vacuum-packed meat in a format to satisfy not only the consumer but also the retailer.

The product has an achievable shelf life of at least 20 days and there is a significant advantage, from a marketing point of view, to red meat currently being sold through supermarkets or the local butcher shop.

The product can be sold where a refrigerator is available and thus fresh meat becomes available to the consumer seven days per week. The product is currently being marketed in Sydney and country New South Wales.

In addition to the above projects, a further four new product-development projects and a packaging project developed for the export market are currently being funded by the Corporation.

Since the beginning of the program, the Corporation has endeavoured to reach as many companies as possible to discuss new product ideas as the companies themselves are the richest source of product ideas suitable for the market place.

They obtain information from their own internal sources, their sales force, as well as information as to the activities of their competitors, customers, resellers and foreign markets.

In order to offer all companies an opportunity to participate in the program, expressions of interest in product development were invited on two separate occasions. The first in December 1990 and the most recent in March 1992. The major difference between the two was the change in emphasis as the latter was more specific in respect to the products which were identified as having market potential.

The expressions of interest received by the Corporation recently, do suggest that there are many good new product ideas just waiting to be exploited.

But like so many things, the difficulty does not appear in the gathering of ideas but in identifying good ones; as the mortality rate of ideas for new products is exceptionally high.

Since the program began, a great deal of information has been collected both at the general level, with respect to trends in consumption of particular products by consumers, and at the specific level involving the research of particular product concepts directly with consumers.

The information collected, with the exception of information provided on a confidential basis, has gone into establishing a database which will be made available to all participants in the meat industry.

This database will contain information and photographs of products currently on the Australian market, together with a listing of manufacturers and suppliers to the industry.

It is the Corporation's intention to constantly update the database so that it provides a reliable source of information for industry.

However, through this research quite a number of opportunities for value adding have been uncovered.

Trends in the Food Service Industry

In summary, changes are happening to reduce costs. In the current climate, there is little doubt that the industry is looking at any way of reducing costs through:

- Technology;
- Staffing;
- Input Costs.

Every dollar is watched and many businesses (e.g. caterers, proprietors of cafes, hotels etc.) must look to find cheaper ways of buying, handling and preparing meals.

There is clearly no one direction that the industry is taking. There are a range of alternatives depending on the organisation's size, target markets, capital involved, cooking facilities, labour usage etc.

However the options appear to becoming polarised:

- For smaller operators with little capital in equipment, lower skilled staff etc. The option is to minimise labour and equipment costs. That means increased usage of:
  - — precooked meat;
  - — lower skilled and lower cost staff;
  - — standardised products with consistency and lower labour inputs.
- At the other end, larger scale operators (RSL clubs, leagues clubs, large caterers) look to buy in bulk and internalise costs. This involves price-conscious provision buying and using the labour inputs to add value, with bulk turnover and marginal pricing.

However, higher labour costs, in time, will also force these operators to look at ways of reducing costs.

Technology inprovements will serve to reduce labour inputs. Already some large operators are moving to buy cooking equipment that results in low labour costs too, such as Niero equipment for virtual instant cooking of meat (like a conveyor cooker).

There are opportunities for any product that can demonstrate value in terms of the purchase price, reduced cooking costs and skill levels, or have advantages in terms of handling, storage etc.

In this market, the Corporation sees opportunities provided by restructuring technology.

As advertised in the press, we see an opportunity for products such as roast lamb or roast beef utilising a high level of added-value component. Pre-cooked steaks are not excluded from this list!

In addition we are of the belief that there are even more opportunities in the food service area.

For example:

- Production of a basic mix for curries using lamb as the main ingredient to take account of the growth in hot chili goods. It would not be a problem to market the product in the industrial/institutional market.

- Meat could also be provided to the pie market in a plastic casing ready to be used in pies i.e. the meat would be ground, coated and cooked.

Similarly, opportunities also exist in the retirement home industry where there is a great pressure to contain costs.

Meals could be prepared, tenderised, portion controlled, fat controlled and cooked off the premises. At the retirement home, an extended use of microwave ovens for final meal preparation would allow an accompanying reduction in labour costs and prove a boon to the retirement home industry as well as the meat industry.

If you can produce standardised products of consistent quality, then the market will be out there.

However, to succeed, what is required is communication between the manufacturer and the customer.

The Retail Market

As a result of increased consumer awareness for nutrition in food:

1. Consumers around the world are demanding products low in fat and salt content.

One area that the Corporation has been investigating is the smallgoods market which has traditionally not had a good image in respect to fat and salt content.

Corporation interest primarily stems from the fact that smallgoods products contain a significant quantity of red meat.

Moreover, it is a known fact that the addition of beef into smallgoods products does enhance the flavour of the finished product.

For health and medical reasons, a large number of middle and late middle age people who in the past have been traditional smallgoods consumers have had to change their behaviour begrudgingly.

We believe that if the critical issues of quality and taste meet the expectation of these consumers, significant inroads can be made in this market. This will not only be advantageous to the industry but also to the consumer.

It is not surprising that the Corporation is prepared to fund projects which will lead to low-fat/low-salt smallgoods.

2. Cooking methods have changed significantly over the past twenty years.

There has been a move away from frying to grilling, microwaving, steaming and boiling. Food processors have manufactured an enormous assortment of heat-and-eat products, shelf stable, chilled or frozen, which are especially developed for convenience of microwaving or conventional heating.

Whilst the convenience meal segment of the market has had considerable growth and will continue to do so in the future, we are of the opinion that not enough is being done in the way of innovation to increase the market share of red-meat-based products.

For example, whilst red meat is cut into small pieces, there is a lack of restructured products as is common in the chicken industry.

Moreover, except for hamburgers there is no red meat convenience product for the lunch time market – perhaps some form of nugget could take advantage of this situation.

The Corporation is currently funding a restructured red meat product which we believe will have a significant impact in the market place.

In respect to microwaves, the red meat industry is behind in taking advantage of this form of cooking compared to the chicken industry.

Here, there is a need to tailor red meat products to take advantage of the microwave i.e. change in the shape and the form of products currently on the market.

For example:

(i) For breakfast, develop a product in the form and size of a crumpet (crumbed) which is reheatable and toasted. Basically, it would be a restructured product and be a high-fibre replacement. The product could be used either in the home or at fast food outlets.

(ii) Produce a small flavoured meat product (mutton based) by masking taste or smell with a sugar coating, thereby selling a protein meal.

Export Market

But whilst there are opportunities on the domestic markets, there are even greater opportunities on the export market.

Currently, the Corporation is funding a project which aims to provide a considerable economic benefit to the red meat industry by extending existing packaging technology to retail-ready consumer packs towards both local and export markets.

An extended storage life for retail-ready consumer portions of beef and lamb, will allow ample time for assembly, sea transportation and distribution at the export destination. The export of retail-ready packs will provide an opportunity to capitalise on the benefits of a valued-added fresh-meat commodity.

Whilst the project is aimed at the export market, the success of the project will provide an opportunity for centralised packaging of meat with the associated cost-saving benefits.

This technology will be made available to a number of companies once the project is completed so that a significant impact can be achieved in the export market.

The Corporation is also examining the feasibility of a number of new product proposals for the Japanese market.

Having identified the particular market niche for one product, the Corporation together with the commercialiser are assessing the product requirements in terms of taste, texture, appearance as well as the packaging for final presentation in the target market.

All this work is being undertaken in Australia using Japanese tasting panels so that a go/no-go decision can be made prior to further development and testing of the product in Japan. This will result in a significant saving of capital if the product proves to be a failure.

We believe that if the majority of the screening and development work can be undertaken in Australia, then the product will have a better chance of success.

The Corporation is also funding work on technology to enable meat and vegetable products to be shelf stable. This project is specifically targeted on the Japanese market.

However, it would appear that too much attention is being given to the Japanese market and too little to the other Asian and Middle East Markets, especially those countries which are traditionally sheep meat consumers.

We believe that there is a demand for cheap stable-shelf-life products in the Middle East market. Meat could be freeze dried for export basically to keep its colour, and subsequently re-hydrated during the cooking process.

Research has indicated that current dishes would complement the re-hydrated mutton.

Moreover, whilst we have recognised that there are opportunities in the domestic market for basic curry mixes, there is a definite opportunity for the export of this product where sheep meat is currently being consumed.

Summary

In summary, we are of the belief that there are significant opportunities in the market place for processed products, both domestically and overseas.

However, we are of the opinion that the manufacturer must ensure that the following checklist of positive attributes is included:

- Consistency in terms of quality of the product;
- Must have the appropriate taste for the target market;
- Must be convenient;
- Microwavable;
- Environmentally friendly;
- Natural/fresh;
- Nutritious;
- Value for money for both the consumer and the processor.

Given such a broad topic, I have tried to demonstrate the direction which the Corporation is moving with respect to opening up opportunities for the industry, whether it be by funding improved packaging technology or new products.

Unfortunately, whilst much more could be said about products and opportunities which the Corporation is presently considering, the Corporation must ensure that commercially confidential information of its commercialising partners is kept confidential.

Dr Raymond Mawson
Victorian Dept of Food & Agriculture
Food Research Institute

New Generation Meat Products

Developments in food processing and food ingredients technology are offering opportunities for new meat product developments which have not been seen before. In a competitive consumer-focused world where products must be developed to satisfy consumer needs and wants in order to establish sales, the call to apply these new developments has never been greater. Some of the opportunities discussed in this paper have been developed for industries which compete with the red meat industry but this should encourage rather than preclude their implementation.

Other speakers in the program will discuss important developments in aseptic meat processing, meat in prepared meals and packaging technologies for new meat products. In this paper the concepts of combined processing technologies, new butchery, novel cooking techniques and salt, cholesterol and fat reduction will be introduced.

Combined Preservation Methods

In Germany, the processed meat industry has evolved processing technologies to relieve themselves of dependence on the refrigerated display cabinets in supermarkets. The technology combines different processing techniques to achieve shelf stability at ambient temperatures. The concept has been taken further in Japan with the use of computer modelling to assist with the design of safe processing strategies. The term 'hurdle technology' has been coined to describe these combined processes. In traditional meat processing, fermented meat products are a notable example of the use of combined preservation strategies to achieve safe shelf stability. Barry Shay will be discussing this process in detail and highlighting the consequences of failing to adequately achieve the hurdles which are included in the process of manufacture.

Where it is desired to make a shelf-stable processed meat product without the sharp taste of fermented meat products, this can be achieved by including different processing hurdles. There are nine recognised processing hurdles: water activity, redox potential, pH, storage temperature, heat processing, irradiation, preservative agents, nutrient availability and contamination prevention. Processing protocols can combine as many of these in sufficient intensity as required to achieve shelf stability and safety. By combining processes appropriately, synergies can be achieved where the combined effect is greater than might be expected. This occurs where micro-organisms are injured by one treatment in a way which renders them more susceptible to a succeeding treatment.

The German processed meat industry has used a combination of reduced water activity, lowered redox potential, preservative and heat treatment to good effect. Luncheon-type sausages are formulated with sodium nitrite to a water activity <0.95, chopped under vacuum and vacuum filled into high-oxygen-barrier casings and given a mild heat process in a pressurised retort at 105°C. The heat process is insufficient to kill spore formers but the reduced water activity and residual nitrite is sufficient to see their gradual removal over time. The absence of any head space, bubbles or voids within the product prevents the formation of local zones of reduced water activity where spore formers could proliferate. Shelf-stable frankfurters can also be made following the same principles. Vacuum packaging smoked and cooked franks (in natural or collagen casings) in a high-oxygen-barrier film and subsequent heat processing is used. The reduced water activity formulation reduces the unsightly fluid purge which would be expected in conventional vacuum-packed franks if they were stored at ambient temperature. The cost implications of formulating to a higher water activity and the heat processing are offset against the removal of the requirement for chilled cabinet storage.

In America, a variation of this idea is used in the post-packing pasteurising 'PPP' process where a conventional frankfurter formulation is used and the franks are subjected to a milder heat process at 75°C to give the product a longer chilled storage life. The PPP process uses a combination of storage temperature, reduced redox potential, preservative and mild heat process in order to achieve preservation.

The potential exists with combined processing techniques to present the freshness-conscious consumer with products of 'fresher less processed appearance'. The use of computer-aided process modelling and process control will enable the combination of even milder processing than has been used to date. These reduced processes will achieve safety and present products with a fresher appearance. Increasing use of automation and robotics in critical areas of processing will eventually permit completely aseptic processing environments to become a commercial reality.

In the fresh red meat industry, automated boning and butchery in super-cold, very clean processing environments, coupled with automated packaging, will permit retail-packaged meat to have very much longer storage and distribution life than is presently possible. Additionally, if the meat can be packaged in a pre-rigormortis state while the natural antibodies in the meat are still active, and bacteriostatic shrink packaging film is used, exceptionally long storage life could be achieved. Novel biochemical strategies (possibly based on controlling calcium ion availability) would need to be devised to control cold shortening, toughening and aging.

New Butchery

The Australian Meat and Livestock Corporation's 'Aus-meat' program and the new butchery methods being developed under it are crucial, from a marketing point of view, in encouraging a 'healthy' lean image amongst consumers towards red meats. The novel butchery and trading specifications developed by the program can also have important impacts on further processing developments.

At the retail level, innovative butchery rather than the 'processed' image of restructured and formed meat, is a strategy more likely to succeed in adding value to the less popular portions of the carcase. Techniques which might be used include seaming out individual muscles, trimming them of fat and sinew, membrane skinning and 'butterfly' cutting. The cuts produced will be unfamiliar to consumers and extensive promotion, including cooking demonstrations and recipe ideas will be required. Movement in this direction is already under way, up-market restaurants are requiring their meat suppliers to prepare meat to stringent specifications like these, and developing an appropriate cuisine around it. In time, these requirements will filter down through the more discerning retail consumer to the market in general.

The processing required to create restructured and formed meats radically alters the eating character of these meats and colour retention is poor in raw meats. Colour preservation in meat will be discussed in depth by Graham Trout later in this seminar.

With restructured-meats manufacture, there is a problem of the cost of the additional processing required to produce the product which is frequently perceived to have lower value than the established 'quality' cuts of meat. Opportunities exist for these products but dilution with extending ingredients is usually required to achieve economic viability. The most successful restructured meat product is undoubtedly the hamburger, and as retail consumer items, the 'Bernard Mathews Roast' in the United Kingdom and the 'Salisbury Steak' in the USA.

At the retail level, consumers are suspicious about the amount of salt in restructured meats and the presence of non-meat ingredients. It remains to be established whether salt-free binding systems becoming available for restructured and formed meats will adequately overcome the consumer objections to these products.

Cooking Techniques

Society is changing. It is becoming more accepting that women consumers in particular do not like handling raw meat, and, unfortunately for their health, an increasing number have stopped eating it all together. The processed meat industry can help counter this trend to reduced red meat consumption by marketing it in pre-cooked, pre-browned and convenient heat-and-eat forms. The idea is not new but new processing opportunities are available.

An issue with all non-cured precooked meats is that they are prone to rapid flavour deterioration which is apparent long before the onset of microbial spoilage. The term 'warmed over flavour' has been used to describe these effects, but the product does not necessarily have to be reheated for them to be apparent, as anyone who has eaten cold roast lamb or beef will observe. The changes in pork and chicken are less objectionable to the palate. The flavour changes are due to oxidation of complex lipids in the meat.

Working in the red meat processors favour are the facts that some Maillard browning-reaction products inhibit the oxidative processes responsible for the flavour change, and that total exclusion of oxygen by sauces, gravy and/or packaging is effective in halting the deterioration. Some flavouring ingredients including hydrolysed vegetable proteins, spice oils (such as rosemary) and citrus components can also inhibit oxidation in cooked meat. For example, warmed over flavours do not develop in canned meat stews due to the high heat processing and the anaerobic packaging and gravy.

Pre-browning

The evolution of continuous impingement ovens for frozen pizza cooking and cooking frozen, cooked chicken portions permits the pre-browning of individual servings of red meat. The meat is surface browned but not cooked through and may be distributed chilled or frozen. To avoid off flavours, the surface must be truly browned and the zone of cooking must not penetrate far into the meat. The high velocity impinging stream of air in the oven must be no greater than 325—345°C to avoid the development of 'burnt rubber' flavours. Direct natural gas firing has advantages in providing oxygen-free heating gases, and nitric oxides generated by the combustion processes provide a thin 'cured' layer of meat under the browned surface. The meat should be cryogenically chilled or frozen immediately after exiting the oven, to minimize cooking-on and exposure to oxygen while it is still warm.

An alternative surface-browning process uses contact searing between browning rollers. To achieve the seared hot-barbecue effect, ridged browning rollers may be used in combination with an impingement oven.

Anaerobic packaging and enrobing or glazing with a marinade, sauce or gravy are appropriate strategies to maintain quality during chilled or frozen storage and distribution.

It is anticipated that the consumer would heat these products in a microwave oven, steamer or fan oven before consumption.

If these products are prepared for chilled distribution it would be prudent to process them so that the internal meat temperatures reached during browning satisfies the regulations for rare roast meats. If this is not done the consumer risks food poisoning if the product is only warmed rather than reheated.

Roasting

Roast meats can be prepared under similar conditions to pre-browned meats where only the surface of the meat is browned and the body of the meat is very rare. A humidity-controlled forced-convection oven rather than an impingement oven is used because of the larger size of the pieces of meat and the need to insure sufficient heat penetration. The meat may also be lightly smoked during cooking to add flavour. The history of these products is longer than for pre-browned meats and minimal processing requirements have been laid down by authorities such as the United States Department of Agriculture. In specifying requirements, their principal concern has been for the destruction of Salmonella, as the product is likely to be consumed thinly sliced in a sandwich without further heating. The product can be vacuum packaged and distributed chilled or frozen.

The opportunity also exists to make roast meats for reheating either as whole roasts or as sliced roast meats in gravy or sauce. The method just described can be used, but the accumulation of red juices in the packaging can be unattractive to the retail consumer. To overcome this, the product must be cooked medium to well done. The cooking losses are higher due to the longer cooking time, and after reheating by the consumer the meat tends to be dry. The poultry industry overcomes dryness even in meat cooked from the raw state by injecting basting solutions into the meat. A similar technique works for red meats. An oil or fat emulsion, to which a suitable thickener or protein has been added, is injected into the meat prior to cooking. The thickener prevents the baste from purging out during cooking. The meat can then be reheated and still retain an attractive succulent eating quality. To maintain a low-fat image, gum solutions rather than an oil/fat emulsion can be used. Some gums are relatively expensive and can only be used in moderation to avoid sliminess.

The technology exists to roast and rapidly slice hot roast meat and enrobe it in a sauce of gravy using continuous hands-off processing. Humidity control minimises evaporative losses, and cooking juice losses can be cycled into the gravy formulation. The product can be included into ready-meal formulations, used for hot-roast-meat sandwich fillings, served as it is in canteen or fast food restaurants, or packaged in individual serves for retail sale. The eating quality is excellent and better than would be expected from cooked meat which has been sliced cold then reheated with added gravy. This is probably because in the hot sliced roast the slices of meat effectively marinate hot in the hot gravy. The product can be distributed chilled or frozen and as long as an appropriate thickener is used for the gravy, there is no quality loss from having been frozen. There is also the opportunity to connect the process directly to a UHT acetic processing line to create a shelf-stable product.

Electronic Ovens

Industrial microwave ovens possibly have a role in meat processing if they were to be used to cook meat through after pre-browning with an impingement oven. They have also been used to pre-crisp bacon for institutional catering. Radio-frequency ovens are a recent innovation which may have application in completion of drying in jerky manufacture or in bacon crisping. The principle use of this technology had been for crisping snack foods and biscuits.

Cook 'In the Bag'

The technology to 'roast' uncured meat in a cooking bag has been available for a number of years and probably finds its greatest use in the international meat trade where it is necessary to cook meat to eliminate the possibility of it containing foot and mouth virus. The meat is cooked without any additives and distributed frozen. The product is aesthetically unattractive and its use is largely in the institutional trade and for providing pre-cooked meat in ready-meal formulations. The opportunity exists to make the product more attractive by adding a dry self-thickening gravy base to the pack which reconstitutes during cooking. However, the issue still remains that it is a messy product for the user to handle. There is the opportunity to use the technology for individual serve packs were fresh or frozen/ tempered meat is sliced into the pack, a gravy mix is included and it is left to the consumer to cook the product as a 'boil-in-the-bag' item.

Sous Vide

Sous vide processing was developed to provide freshly prepared character to factory-prepared meals for the restaurant trade. In terms of 'hurdle technology', reduced storage temperature, redox potential and very mild heat processing are used to provide a prepared meal or meal component with enhanced shelf life. The product requires only heating to prepare it for consumption. A concern with this technique is that its success is very dependant on the maintenance of chilled distribution and that it does not adequately control the outgrowth of spore forming bacteria. Unlike the PPP technology for frankfurters, there is no preservative to control such growth. For the retail market, 'Sous Vide' products carry the name but are in fact subject to a sufficient level of heat process to safeguard against limited exposure to near ambient temperatures. The safety of the process is currently being subjected to international scrutiny.

Batters, Crumbs and Marinades

Red meats have not traditionally been associated with batters and crumbs, except in the fresh meat trade with crumbed sausages, schnitzels and lamb cutlets. Marinated meats have recently become available in the fresh meat trade. Consumers seem to be suspicious of coated red meat products while white meats are accepted with little hesitation. As processed products, battered and crumbed red meats tend to be dry and lack meaty flavour, faults which can be corrected by appropriate ingredient selection. The type of batter and crumbing selected should be made with reference to the method of reheating. Reduced-fat coatings work well with oven reheating but are not suitable for hot-plate heating. Coatings which do not absorb fat should be used for heating by deep frying to avoid greasiness. Coatings for microwave reheating tend to be texturally harder and are used with specific packaging technologies including responder and moisture-absorbent systems.

Salt, Fat and Cholesterol Reduction

Satisfactory processed meats can be made containing 1% salt and 10% fat using existing technology with little sacrifice to yield and stability, providing they are made with all meat and there is little meat extension. The flavour is very bland but appropriate spicing can create an acceptable product. The storage life is reduced. The cost of making such a product confines it to the top of the market. To create products for a wider market with reduced fat and salt content, extension with functional ingredients is required. Suitable ingredients include: starches, gums, food fibre, emulsifiers, non-meat proteins and cholesterol-free vegetable fats. Where functional synergies between the various non-meat ingredients and meat proteins can be found, these should be exploited. Salt and fat reduction both result in raising the water activity in processed meat products, increasing the likelihood of microbial spoilage. Sodium lactate can offset the water activity reduction and may have specific activity against *Clostridia* species. Unfortunately, flavour constrains its usage level. Maltodextrins which have little sweetness may also be used to reduce water activity.

None of these processing techniques results in products with the same eating qualities as the original processed meats they simulate. From a marketing point of view, this difference could be used to promote the credibility of the changes which have been made. The key consumer concern seems to be that flavour, as opposed to eating texture, should be maintained. The development of successful reduced salt and fat products lies very much with the skill of the food technologist in developing ingredient and processing combinations which will satisfy the expectations of the consumer on the one hand, and the capacity of the manufacturer to make the product profitably on the other. Food regulations will have to be liberalised to permit the inclusion of a number of ingredients which have not been traditionally associated with processed meats, and if cholesterol reduction is an accepted target, to reduce the levels of meat tissue required in these products.

Unfortunately, it may prove to be technically feasible to make reduced salt and fat processed meats but too difficult in practice. Should this be the case, it should be established as soon as possible, and the processed meat industry should direct its attention to developing alternative product opportunities. What those opportunities might be for its survival, are indicated in this paper and by other speakers at this seminar.

Mr Barry Shay
CSIRO Division of Food Processing
Meat Research Laboratory

Factors Affecting the Growth and Survival of Salmonella in Fermented Salami Manufactured Under Australian Conditions

Fermented salamis manufactured under Australian conditions have been associated with food-poisoning outbreaks due to Salmonella. These micro-organisms are easily destroyed by heating and provided post-cooking hygiene is of a reasonable standard they should not normally pose a problem in heat-treated foods. Fermented salami receive no heat treatment and as such must rely on other environmental conditions for their microbiological safety and stability.

Funded by the Pig Research and Development Corporation, we have been examining the environmental factors controlling the growth and survival of Salmonella in salami manufactured under Australian conditions.

The two main factors contributing to the safety and stability of this product are low pH and reduced water activity (a_w), however the environmental conditions prevailing in the first 24—48 h are critical with regard to the growth and subsequent survival rate of this pathogen.

At formulation, the product has a pH of approximately 6.0 and a water activity of 0.960—0.965. At these levels these parameters neither alone or in combination are sufficient to prevent the growth of salmonellae. Reduction in water activity to control Salmonella growth is brought about by controlled moisture loss through the permeable casing. However this must be achieved slowly (about 2%/day average) otherwise uneven drying and consequent case hardening will occur.

This rate limiting a_w reduction cannot be used to control Salmonella growth in the early critical stage of manufacture, therefore pH must be reduced rapidly if Salmonella growth is to be prevented.

A number of approaches to the elimination of salmonellae from fermented salami have been examined. After formulation, the product is first fermented then it undergoes a drying process. This whole procedure usually takes a minimum of 14 days and depends to a large extent on the diameter of the product. The aim of these investigations has been to arrive at a set of recommendations that will ensure that the product is free of salmonellae by the end of the minimal ripening period and before it is released for retail sale.

The areas investigated include:

(i) the mechanism of pH reduction;

(ii) rate of pH reduction;

(iii) low temperature pasteurisation.

The pH of salami can be reduced by one of three methods. The first is the use of the food grade acidulent glucono-delta-lactone often referred to as Gdl. This is a cyclic compound which hydrolyses on contact with water to yield gluconic acid which brings about a reduction of about 0.6 of a pH unit within a few hours. The usual concentration used is 0.5%.

Alternatively the pH can be reduced by the use of starter cultures which consist of micro-organisms which utilise the added carbohydrate in the salami mix and produce lactic acid via the glycolytic pathway. The third method often referred to as back slopping consists of using ripened salami from a previous production batch in a similar way that starter cultures are used. Once again in this case, acidification occurs as a result of lactic acid production.

Apart from the mechanism of pH reduction, we have examined the effect of the rate of pH fall on the growth and survival of salmonellae. In addition to investigating the mechanism and rate of pH reduction, the effectiveness of a mild heat pasteurisation (following the ripening process) has also been examined.

Methodology

The experimental protocol consisted of manufacturing salami to a generic recipe and inoculating with a variety of Salmonella serotypes (Table 1). These particular serotypes were chosen because they were the ones most frequently isolated from salamis implicated in the outbreak of the early 1980s.

Following stuffing into moisture-permeable casing, sausages were fermented at 27°C and 90% R.H. for 48 h then dried and ripened for a further 12—14 days at 15°C and 75% R.H.

Table 1 Salmonella Serotypes – Inoculation Experiments

1. *S. anatum*	7. *S. typhimurium* phage type 1
2. *S. derby*	8. *S. infantis*
3. *S. muenchen*	9. *S. schwarzengrund*
4. *S. newport*	10. *S. ohio*
5. *S. johannesburg*	11. *S. havana*
6. *S. adelaide*	12. *S. livingstone*

In this first series of experiments (Figure 1), acidification using glucono-delta lactone was compared with use of starter culture which produced lactic acid at a relatively slow rate. In all experiments a control batch of salami made from the same mix but containing neither Gdl or starter culture was always included. In this case pH reduction had been brought about by the activity of the natural background bacteria present on the meat.

When acidification was achieved by Gdl the effect on the destruction of Salmonella was only marginally better than that brought about by the natural background flora. In the case of the slow acid producing starter culture a reduction of approx. 90% was observed, however in all cases a significant number of salmonellae still remained at the end of the ripening period. In no case did any growth of Salmonella occur.

In the next series of experiments (Figure 2), acidification of salami with Gdl was compared against the use of starter culture capable of rapid acidification. Once again a control batch was included. Elimination of Salmonella during the normal ripening period was minimal in the case of control and Gdl treatments. In the case of the control sausages, Salmonella numbers increased during the first two days. In contrast to these two treatments, when rapid acidification was achieved by a starter culture a 99.9% reduction in Salmonella numbers was observed.

In the experiments already discussed, the Salmonella cultures were added to the meat mix immediately after cutting and under these circumstances did not have an opportunity to adapt to the environment before the fermentation process commenced and the pH was reduced. Such is the case if frozen meat is used to make salami. However it is also very common to use chilled meat in the process and it has been found that chilled meat can be held for up to 5 days prior to use. Whilst at these low temperatures Salmonella cannot grow, it is possible

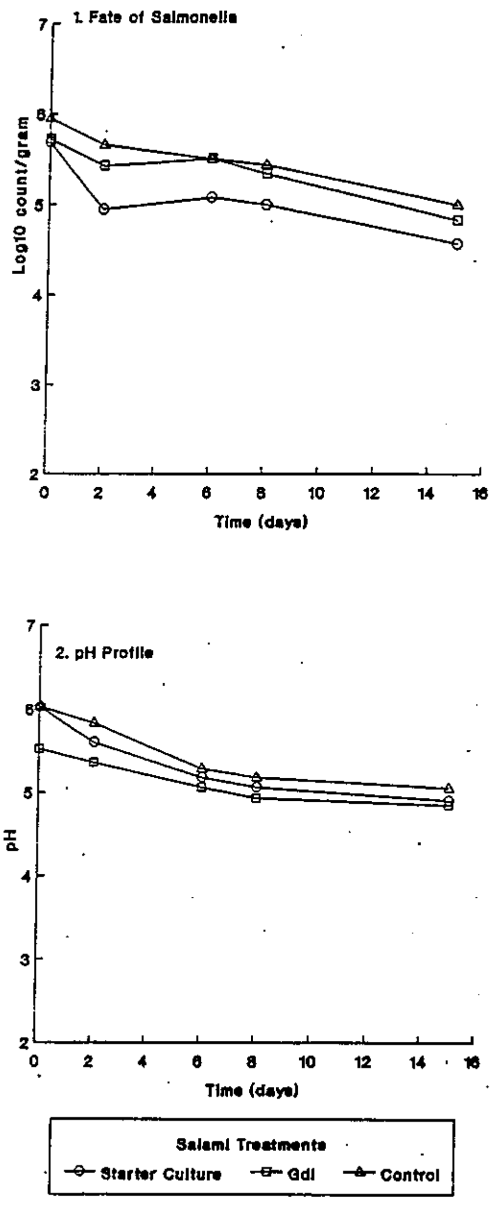

Figure 1 Effect of Slow Acidification Rate and Method on Salmonella spp. in Salami

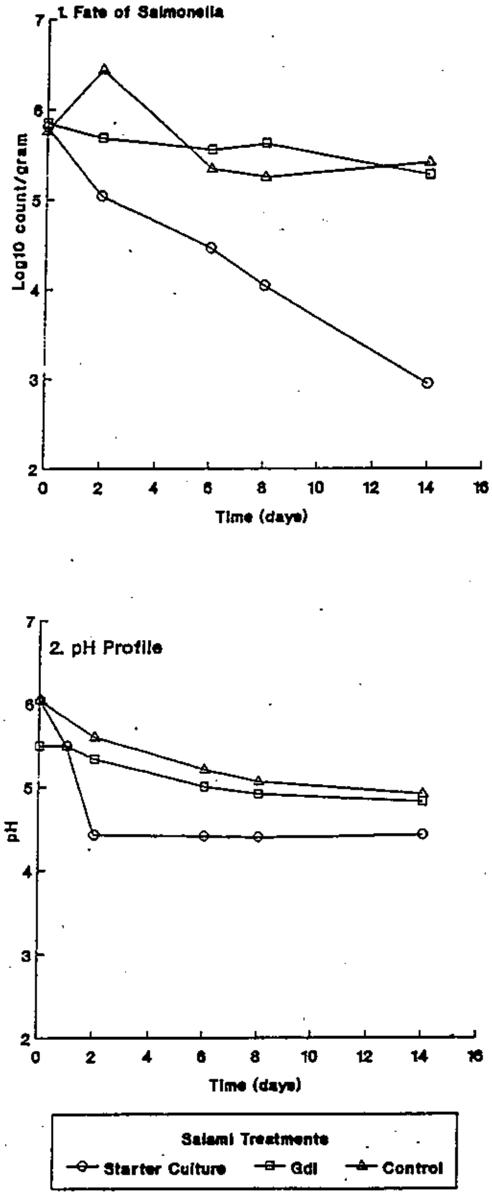

Figure 2 'Effect of Rapid Acidification Rate and Method on Salmonella spp. in Salami

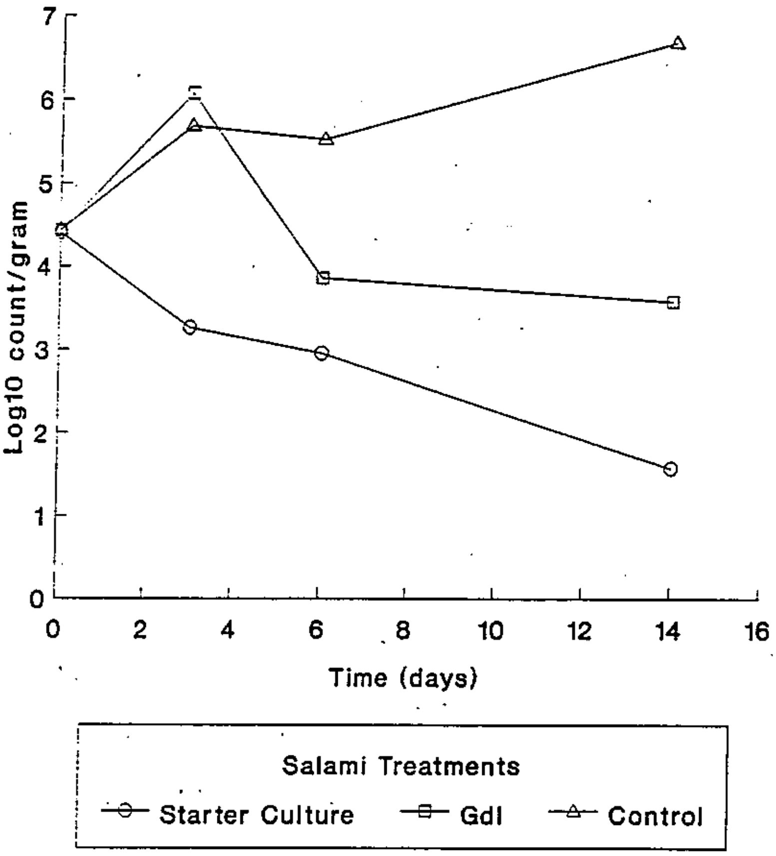

Figure 3 Effect of Rapid Acidification Rate and Method on Pre-adapted Salmonella spp. in Salami

for the cells to adapt to the meat environment. This situation was simulated by inoculating Salmonella onto meat and holding it at 0°C for three days. Salami was manufactured in the normal manner and held under conditions identical to those in the first series of experiments.

The results of a typical experiment designed to examine the effect of acidification rate and method on pre-adapted Salmonella are contained in Figure 3. In the case where product was acidified rapidly with starter culture, a similar effect on survival of inoculated Salmonella was observed. . However when product was acidified with Gdl we observed a significant increase during the first three days. The number of viable Salmonella then declined, however by the end of the ripening period the level of these organisms decreased only slightly over what was originally present. In the case of sausage made without either Gdl or starter culture, the Salmonella numbers had increased more than 100-fold over what were originally present.

In summarising this section of the work, rapid acidification brought about by lactic acid production by starter culture is effective in preventing the growth and reducing the survival rate of salmonellae in fermented salami, regardless as to whether chilled or frozen meat is used. In contrast, acidification brought about initially by Gdl can result in growth if the contaminating salmonellae are given an opportunity to adapt to the environment (as can be the case when chilled meat is used). Regardless as to whether chilled or frozen meat is used, acidification brought about by Gdl results in much less death of these organisms during the normal ripening period.

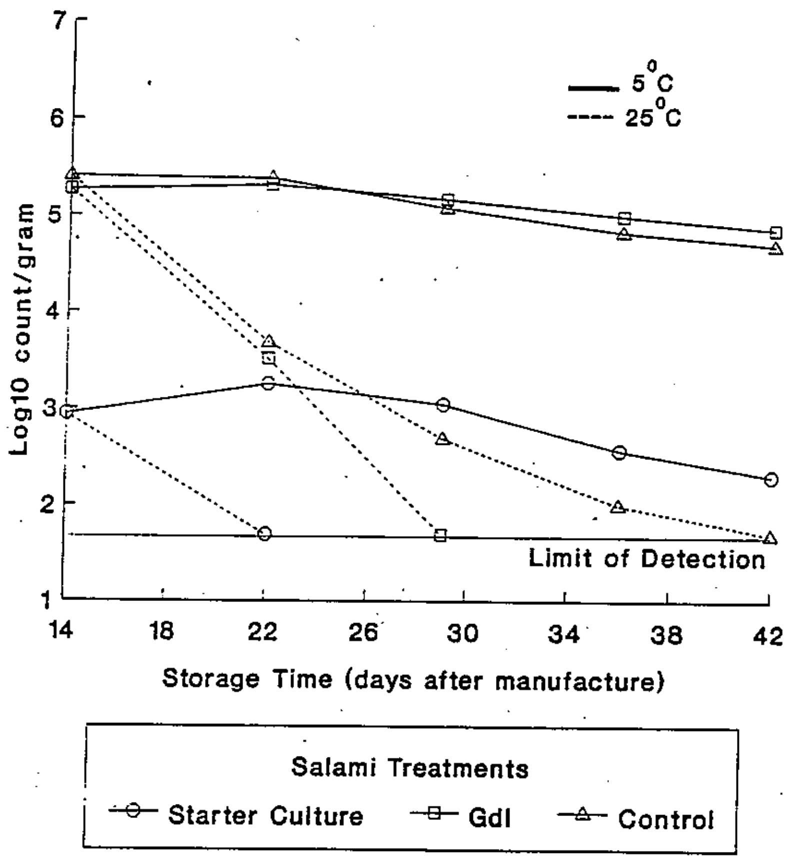

Figure 4 'Survival of Salmonella spp. Post-ripening Effect of Retail Storage Temperature

As a corollary to this work, the death rate of Salmonella in fermented salami as a function of retail storage temperature was investigated. Salamis are often vacuum packaged after ripening to prevent further weight loss and whilst they should be shelf-stable at this point it is common to store them at the normal retail chill temperature (5°C). The results in Figure 4 demonstrate that the survival duration of Salmonella is affected by post-ripening retail storage temperature. At 5°C Salmonella remain viable in products such as these for a very much longer period than at 25°C, in fact in excess of 42 days after manufacture, whereas when product is stored at 25°C the death rate is accelerated.

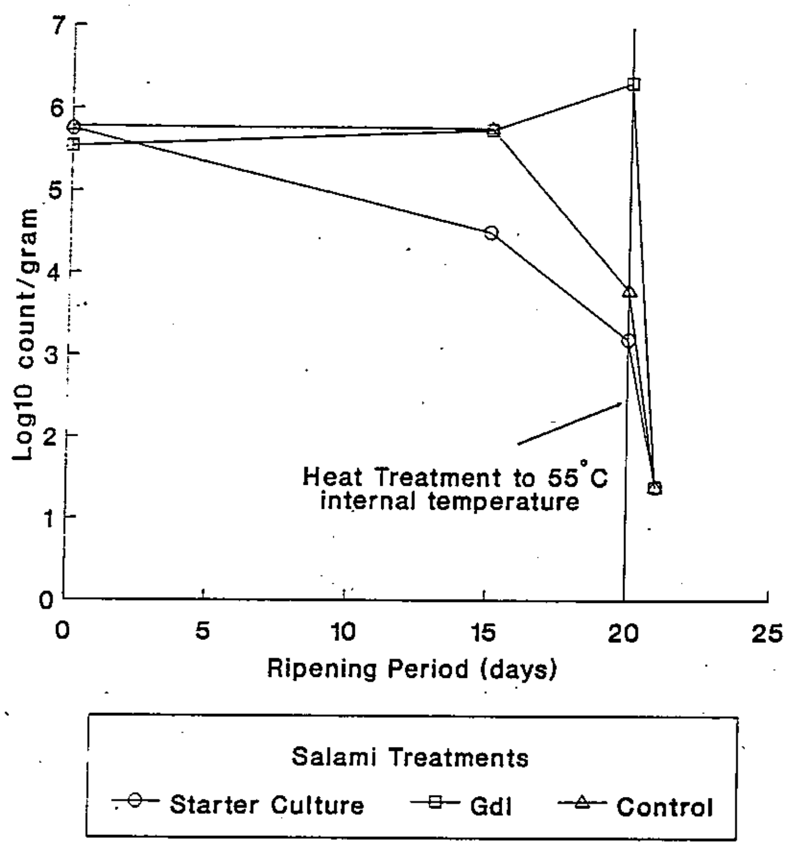

Figure 5 Reduction in Salmonella Numbers in Salami as a Result of Low Temperature Pasteurisation

Low Temperature Pasteurisation

The possibility of using low temperature heat treatment as a means of eliminating Salmonella that survive the ripening period has been investigated. The rationale for this approach was that any surviving Salmonella will be acid injured and hence more susceptible to a mild heat treatment that under normal circumstances would not be sufficient to result in significant destruction.

When heating salami there are two problems to overcome. One is the prevention of 'fat out' or fat separation as a result of heating, and the other is minimising the sensory changes that occur.

From the point of view of destruction of salmonellae, the heat treatment arrived at has to be a compromise between the extent of death of salmonellae and acceptable sensory changes.

Through experimentation it was found that the minimal effective heat treatment for Salmonella destruction under these conditions involved thermally processing the product to an internal temperature of 55°C. If this was achieved in a chamber set at 65°C and 90% R.H., it was possible to heat treat fermented salami acidified with rapid acid producing starter cultures without fat separation occurring. However the same heat treatment applied to Gdl acidified salami results in fat-out occurring. The results of the antibacterial effect of this heat treatment are shown in Figure 5. Up to a 5 log (99.999%) reduction was observed in the numbers of salmonellae following heat treatment at 55°C but it must be emphasised that this type of thermal processing is limited to salamis that have undergone rapid acidification to a pH of less than 5.0 within the first 24 h. In order to determine the sensory acceptability of the heat treatment, heated and non-heated salamis from the same batch were evaluated by a trained analytical taste panel.

Table 2 Attributes used to evaluate salami before and after heat treatment

Appearance	**Texture**
1. Colour	7. Initial Bite
2. Fat Content	8. Chewiness
3. Appearance Acceptability	9. Greasiness
	10. Texture Acceptability
Aroma	**Flavour**
4. Acid Aroma	11. Acid Flavour
5. Other Aroma	12. Other Flavour
6. Aroma Acceptability	13. Flavour Acceptability
	14. Overall Acceptability

The panel was asked to rate both treatments according to the attributes contained in Table 2. Where the particular attribute in this table is underlined, the panel considered the treatments to be significantly different from each other.

In summary, whilst panellists rated the colour of non-heat-treated salamis slightly higher than heat-treated product, they greatly preferred the texture of heat treated samples and rated them firmer than the non-heated counterpart. They also considered heat-treated samples to be less greasy. However it was the assessment of the flavour attribute that showed the most difference. Panellists strongly preferred the flavour of the heat-treated samples and overall considered the mild-heat-treated salami to be superior. Hence mild heating cannot only be used to reduce Salmonella numbers; according to our taste panel results it improves the sensory attributes of the product.

Subsequent to the outbreak of salmonellosis in the early 1980s, the National Smallgoods Council of the Meat and Allied Trade Federation of Australia issued a code of practice for the hygienic manufacture of dry and semi-dry sausage. Section III of this code of practice under point 8(c) contains the following:

> *pH measurements should be utilised to assure that processes attain a pH of 5.2 within 48 hours. One or more of the following means can be used to achieve this level of pH drop if these pH measurements establish that current practice is not allowing for the required rate of acid production.*
>
> *(i) Acid producing cultures which are free of contaminants and consistent in growth and acid production (starter culture);*
>
> *(ii) chemical acidulants which are thoroughly blended into the meat mixture (e.g. glucono-delta-lactone);*
>
> *(iii) inoculum from previous production of known bacterial count and pH value.*

With regard to the use of Gdl, these results have demonstrated that under certain conditions, acidification brought about by this method can result in increases in the numbers of salmonellae– a highly undesirable situation.

The American Meat Institute has issued a guideline for good manufacturing practices for fermented dry and semi-dry sausage. These guidelines recommend that pH reduction in salami be brought about through the action of lactic acid bacteria alone.

In the light of these results and in line with practices used overseas, it is perhaps timely to review our own code of practice with special regard to recommendation for pH reduction in these types of product.

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Aseptic Processing of Meat Products

Summary

Aseptic processing involves sterilising the product (most meat products being low-acid foods containing particulates) and package separately, and filling under sterile conditions. Advantages include better product quality compared with canned products, lower transport and storage costs compared with frozen products, and virtually no restriction on package size. Problems include ensuring adequate heat penetration into the particles to ensure sterility, preventing separation of particles from the carrier liquid, and retention of particle structure and shape. Particulate foods can be sterilised in scraped-surface heat exchangers. Other methods involve heating the particles separately, and combining them during filling. The effects of aseptic processing on meat product quality (colour, flavour, texture, and nutrition) are outlined in this paper.

Introduction

Aseptic processing involves sterilising the product and package separately, and filling under sterile conditions. This is in contrast to conventional canning where the product is sterilised in the can. Pflug et al. (1990) have defined aseptic processing 'the shorthand name for the food production system where product moves in continuous flow through a heat-hold-cool thermal process and is then filled into a sterile package. The package is sterilized, filled, and sealed in a sterile environment'.

For the purpose of this seminar, meat products will be considered to be low-acid (above pH 4.6) foods containing particulates. Some companies are producing aseptically processed low-acid foods containing particulates packaged in semi-rigid containers on a pilot-plant scale. As more experience is gained with the process, foods containing larger particulates such as beef stew, spaghetti, ravioli, chilli and chinese meat and vegetables will become available (Anon. 1988). Aseptic low-acid products of the future are likely to be products that are now frozen or canned (Hannigan 1983) and demand for such products will increase in future as consumers look to convenient and high-quality products in alternative (cheaper) forms of packaging (Murray 1985).

Aseptic processing of meat products presents special heat-transfer and quality-retention problems. This paper aims to review the advantages, problems and technology of aseptically processing foods containing particulates.

Principles of Meat Product Sterilisation

The reason for heating meat products to sterilisation temperatures is to allow for their distribution, storage and consumption at ambient temperatures without risk to public health from food poisoning. The time and temperature of heat processing to obtain sterility depends on the temperature history at the point in the product slowest to heat, on the chemical composition of the product, and on the types and numbers of micro-organisms contaminating the product at the time of heat processing.

The most important compositional factor determining the heat processing requirements of a food is its acidity (or pH). Foods are classed as 'high-acid' if the pH is 4.6 or less and 'low-acid' if the pH is greater than 4.6. High acid foods include most fruits and tomato products while low-acid foods include most vegetables, meat, fish and some dairy products. Low acid foods require a more severe heat treatment than acid foods to render them sterile because bacterial spores are more heat resistant under low-acid than under high-acid conditions.

Heat sterilisation processes for low-acid meat products are designed to inactivate spores of *Clostridium botulinum*. This organism will grow at ambient temperatures. If this organism survives the heat sterilisation process, there is a risk that toxins will be produced, sometimes without swelling the food package or noticeably changing the nature of the product. As this organism presents a major public health risk, recommended heat processes for low-acid foods are designed to reduce the probability of a spore of *C. botulinum* surviving to one in a million million (Board 1989).

Different time temperature relationships are used to achieve the same sterilising effect. Conventional canning utilises temperatures of 116—121°C while aseptic processing technology is performed at temperatures ranging from 130-150°C. A shorter holding time at these higher temperatures will result in a similar sterilising effect as conventional methods.

Advantages of Aseptic Processing

The advantage of using aseptic processing for meat products over conventional heat-processing methods include:

(i) Improved product quality (reduced loss of flavours, aromas, natural colours or volatiles);

(ii) Energy savings;

(iii) Consumer convenience;

(iv) New marketing opportunities;

(v) Bulk packaging

(Wernimont 1983; Anon. 1988)

Economic Considerations

Heat-processed products (canned, retort-pouched, and aseptically packaged) are stored at ambient temperature, and therefore storage costs are lower than for frozen foods. Aseptically packaged products have the additional economic advantage of virtually unrestricted package size. Aseptic bulk packaging is possible as the heat process is independent of pack size, unlike conventional canning.

Energy consumption during processing, packaging, storage, and transport has been compared for aseptically packed, canned, and frozen foods. (Gadsden Rheem 1991). Comparative data in KWh/tonne for the aseptic 'Combibloc' pack and conventionally processed foods, are shown in Table 1.

The data indicate that conventional canning incurs the highest processing and packaging energy use, but low storage consumption. Freezing has low processing and packaging energy use, but high energy consumption during storage. Energy consumption during aseptic packaging is lower than canning but greater than freezing for processing and packaging. Energy consumption during storage is lower than freezing, and similar to canning. Toledo and Chang (1991) compared steam and electricity consumption for a product

TABLE 1

	Canned Foods		Frozen Foods		Aseptic
	Steel Cans	Glass Jars	Poly Bags	Cartons	Cartons
Processing	1,860	1,860	315	315	500(approx)
Packaging Material	3,880	6,240	1,360	1,800	2,500(approx)
Storage	120	120	1,740	1,740	120
Transport (500 km)	230	230	160	160	160
Consumer Storage	–	–	720	720	–
Total	6,090	8,450	4,295	4,735	3,280

(Source: Gadsden Rheem, 1991)

throughput of 2 275 kg/hr. Steam consumption was 0.21 kg/kg of product for canning compared with 0.14 kg/kg of product for aseptic processing. This represented a saving of $US1.20/h. However, electricity costs for conventional canning were negligible compared with a power consumption of 0.0374 KWH/kg for aseptic processing. This represents a comparative loss of $UK5.91/h for aseptic processing.

Overall, aseptic packaging appears economically viable for high throughout, bulk (institutional) packs. Advantages of low steam consumption, low package cost, and high quality have to be balanced against the disadvantages of high capital cost, and high electricity usage. The economic advantages would appear to favour exported bulk aseptic particulate products. However, for retail-pack, low-volume products, conventional technology may be more economic. The final decision has to be made on a combination of economic, technical and quality considerations.

Problems with Aseptic Processing of Meat Products

Heldman (1989) has highlighted critical factors affecting aseptic processing of foods containing particulates. Factors affecting heat transfer are the particle size, shape, thermal properties of the particle (thermal conductivity and specific heat) and the thermal properties of the carrier liquid (surface or convective heat transfer coefficient). There are also various factors affecting the residence time of particles in the heat exchanger used, and the configuration of the holding tubes (length and number of bends). Lee and Singh (1991) reported that particles travelled faster than carrier liquid in a horizontal scraped-surface heat exchanger, but the opposite occurred in a verticle scraped-surface heat exchanger. Flow rate, mutator speed, particle size and concentration all affected residence times.

Sastry et al. (1987) have considered microbiological problems in continuous sterilisation of low-acid (pH > 4.6) foods containing particulates. The product, including particle interiors, must receive a heat process adequate to inactivate spores of *Clostridium botulinum*. There is no reliable method to measure the internal temperature of particles flowing through a heat exchanger. However, computer modelling has been used to predict particle internal temperatures during aseptic processing (McKenna & Tucker 1991; Manvell 1990).

An alternative way of determining the lethality of the heat sterilisation process is to inoculate the particles with heat-resistant bacterial spores before processing, and test for sterility after processing. A method of immobilising bacterial spores in calcium alginate gel has been described by Dallyn et al. (1977), who used *Bacillus stearothermophilus* as the test organism. The gel was formed into beads containing randomly distributed spores. The organism had high heat resistance, and the beads were robust enough to withstand passage through a scraped-surface heat exchanger at temperatures up to 140°C.

Sastry et al. (1988) considered that a suitable bio-indicator should be in the form of a particle, possessing at least the following necessary and/or desirable characteristics:

(i) large size (about 2.5 cm), containing immobilised bacterial spores throughout the interior, and especially at the slowest heating zones;

(ii) geometry, thermal properties and responses similar to real food particles;

(iii) visual distinguishability from real particles, permitting easy recovery from processed product;

(iv) retention of spores without leakage through all process steps;

(v) shelf-stability, (this is more a desirable, rather than necessary characteristic);

(vi) physical durability, possessing the ability to withstand process stresses without disintegration.

According to Murray (1985) the widespread development of particulate thermal processing has been limited by a number of constraints.

These include:

(i) The different penetration rates for different particulates and for the carrier liquid phase. Therefore the liquid phase is often overprocessed;

(ii) The possibility that although harmful micro-organisms are destroyed, enzymes will survive that can be detrimental to the product;

(iii) The fragile nature of particulate products once heat treated and the difficulty in transporting such products without damage;

(iv) The possible separation of particulate and liquid phases either during processing or in storage prior to packaging.

The difficulties outlined in (iv) could be overcome by processing the particulates in a liquid of higher viscosity than the desired end product and blending back with a diluent at the filling stage. The difficulties outlined in (i) could be overcome by processing the solid and liquid phases separately.

Process Technology

(i) Scraped-surface heat exchangers (SSHE)

Scraped-surface heat exchangers will continuously process products that:

(a) Are very heat sensitive;

(b) Form film on the heat exchange surface;

(c) Are highly viscous or become highly viscous during processing; or

(d) Have a particle size or delicacy that can't be accommodated by other heat exchangers. Products containing up to 40% particulate content, and particle sizes up to 20 mm can be handled.

(Anon. 1989)

SSHE are expensive heat exchangers to buy, operate and maintain but are the most versatile. Scraped-surface heat exchangers can effectively handle any products presently batch processed in kettles or tanks and can be pumped. The scope of application applies to heating, cooking, cooling, freezing or aseptics. Areas within the meat industry where scraped-surface heat exchanger technology can be used are gravies and slurries, ground meats, soups and stews, stroganoff, pate, meat and fish spreads, pet food and blood plasma (Day 1970; Volan & Ziemba 1970; Hall 1972, Hannigan 1983; Anon. 1989). Applications include heating to either increase shelf life or achieve sterilisation. Therefore, a processor who runs a range of products might install one SSHE system because it could do the work of several other simpler systems.

The SSHE consists of concentric product and media tubes, a rotating scraper (mutator) and a suitable mutator drive. The product tube contains the product, provides a heat exchange surface and an enclosure for the mutator. The media tube contains the heating or cooling media. The mutator continuously scrapes product from the heat exchange surface In operation, the SSHE assures rapid heat transfer to a relatively small volume of product (Anon. 1989).

Information on processing conditions is scant. Generally products are preheated to approximately 50°C before pumping through the scraped-surface heat exchanger where the product is heated to 143—149°C. Holding Murray (1985) states that the optimum process is based on a processing temperature of approximately 130°C. This requires a sterilising time of approximately 5 min for a 20 mm particulate.

Other Aseptic Processing Systems

(ii) Fellows (1988), and Hersom and Shore (1981) have described the 'Jupiter Process' which uses a double-cone heat exchanger. In a sequence of microprocessor-controlled operations, solid pieces of food are fed into the double-cone vessel, which is then rotated slowly on a horizontal axis. Steam at 206 kPa is introduced and the product is tumbled through the steam. Steam in the jacket is at the same temperature to prevent the food from burning onto the cone. Liquor is added during sterilisation to prevent damage to the solids by the tumbling action. After sterilisation the product is rapidly cooled with cold water and sterile air, and the condensate-water-stock is removed. The liquid portion of the product is sterilised separately in a plate or tubular system and added to the solids. The cone then acts as a mixer. The blended solids-liquids are discharged to an aseptic filler using an overpressure of sterile air. This avoids pumping the softened product and further reduces damage to the food. Cooking liquor from the solids is used to make sauce, to top up containers, or to inject into solids during subsequent processing.

(iii) Another system, still in the developmental stage, is ohmic heating. In ohmic heating, a conducting fluid is heated directly by electrical energy. An alternating current is passed from electrodes, through the fluid which is contained in a non-conducting pipe. There is sufficient resistance in the fluid for energy losses to occur, and the fluid heats evenly. This process enables solid particles to heat as fast as liquids, thus making it possible to use high-temperature short-time sterilisation techniques on particulate foods (Halden et al. 1990). Conversion efficiencies from electrical energy to heat of greater than 90% are claimed, and particulate fees may be processed without shearing forces associated with some other types of heat exchangers.

(iv)Another system, the 'Stork Steripart' system (Anon. 1989), allows liquid and particulate fractions to receive different heat treatments. The liquid fractions can flow at a high velocity and are subjected to a heat treatment comparable to that of an Ultra-High Temperature process. The particulates, which may vary in thermal size, can be held in the main flow during preset times and are subjected to a heat treatment suited to their relevant size. The system incorporates heat exchangers with one or more 'Rota-Hold' type or 'Spiral-Hold' type Selective Holding Sections and operates in conjunction with an aseptic buffering/delivery system. The particulates are added to the liquid with the help of a metering system, and the blend is conveyed through the heat exchanger system by means of a positive-displacement pump.

Packaging

Various types of aseptic packaging fillers are available, which can handle particulate materials. These include the 'Intasept' and 'Scholle' fillers which pack in laminate bags (Anderson, 1985) and the 'Combibloc' filler, which packs in laminate cartons.

Foil laminates used for bulk catering service packs are sterilised by gamma irradiation and the food contact surface cannot be contaminated prior to filling. However, plastic thermoformed trays for use in retail packs would require sterilisation immediately prior to filling. Bockelmann (1985) found that extruded plastic products had microbial counts ranging from 0.3 to 10 micro-organisms per 100 cm^2. On paper based laminates loads ranged form 2 to 5 micro-organisms per 100 cm^2. Superheated or saturated steam could be used for sterilisation of packaging materials and has been applied for the sterilisation of polystyrene cups.

Quality Considerations

Colour

In canning, heat has to penetrate to the centre of the can (the 'cold' spot) to sterilise the product. The heat has to be removed after processing. Low-acid foods, such as meat products, require quite a severe heat process to ensure sterility. The time / temperature combinations used in heat processing have a substantial effect on most naturally occurring pigments. In meats, the red oxymyoglobin pigment is converted to brown metmyoglobin, and purplish myoglobin is converted to red-brown myohaemochromogen. Maillard browning and caramelisation also contribute to the colour of sterilised meats.

However, this is an acceptable change in cooked meats. In aseptic processing, meat pigments change colour, but there is little caramelisation or Maillard browning.

Flavour

In canned meats there are complex flavour changes (for example pyrolysis, de-amination and decarboxylation of amino acids, degradation, Maillard reactions and caramelisation of carbohydrates to furfural and hydroxymethylfurfural, and oxidation and decarboxylation of lipids). Interactions between these components produce more than 600 flavour compounds in ten chemical classes. In aseptically sterilised foods, the changes are again less severe and flavours are better retained.

Texture

In canned meats, changes in texture are caused by coagulation and a loss of water-holding capacity of proteins, which produces shrinkage and stiffening of muscle tissues. Myofibrillar protein shortening during heating results in meat toughening. Softening is caused by hydrolysis of collagen, solubilisation of the resulting gelatin, and melting and dispersion of fats through the product. Polyphosphates are added to some products to bind water. This increases the tenderness of the product and reduces shrinkage.

The relatively long time required for collagen hydrolysis and the relatively low temperature needed to prevent toughening of meat fibres are conditions found in canning but not in aseptic processing conditions. Toughening of meat is therefore likely under aseptic processing conditions (Hersom 1984). Dawson et al. (1991) found chicken breast meat was tougher and drier when aseptically processed at 145°C, than at 130°C and 121°C. The texture of meat purees is determined by size reduction and blending operations and is not substantially affected by aseptic processing.

Nutrition

Generally, canning results in greater nutritional losses than aseptic processing. Aseptic processing allows a substantial reduction in the time necessary to accomplish sterilisation and thus results in increased nutrient retention and food quality. Canning causes the hydrolysis of carbohydrates and lipids, but these nutrients remain available and the nutritive value of the food is not affected. Proteins are coagulated and, in canned meats, losses of amino acids are 10—20%. Reductions in lysine content are proportional to the severity of heating but rarely exceed 25%. The loss of tryotophan and, to a lesser extent, methionine, reduces the biological value of the proteins by 6—9%. Vitamin losses are mostly confined to thiamine (50—75%) and pantothenic acid (20—35%)

During storage, various changes occur including oxidative darkening, rancidity, and gradual nutrient losses. The rate of change will be affected by storage temperature, packaging material, and pack size. An advantage of aseptic processing is that bulk packaging is feasible. This means a high ratio of product to package surface area, and potentially decreased rate of changes during storage.

References

Anderson, I.M. (1985). Intasept-aseptic integrity in bag-in-box packaging. *Food Technology in Australia*, 37.(9), 399-401.

Anon (1988). New technology for NZ processors. *Food Technology in New Zealand*, 23, (1), 16-17.

Anon (1989). Stork Innovation ready for the market. *Food Processing*, 58,(6), 41-42.

Board, P. (1989). Canned foods are commercially sterile. *Asia Pacific Food Processing and Packaging*, November, 29-32.

Bockelmann, B., Von (1985). General aspects on aseptic packaging in flexible containers. Proceedings IUFOST Symposium on Aseptic Processing and Packaging of Foods, Tyloesand, Sweden, p. 196-202.

Chandarana, D.I., Gavin, A., Bernard, D.T. (1987). Aseptic processing of particulates-approval procedures. In 'Food Protection Technology'. Felix, C.W. (Ed.), Lewis Publishers Inc., Michigan, p. 387-391.

Cherry-Burrell (1989). Aseptic processing equipment manual CR-1586 R1/89.

Dallyn, H., Falloon, W.C. and Bean, P.G. (1977). Method for the immobilisation of bacterial spores in alginate gel. *Laboratory Practice*, 26, 773-775.

Dail, R. (1985). Calculation of required hold time of aseptically processed low acid foods containing particulates utilizing the Ball method. *Journal of Food Science*, 50, 1703-1706.

Dail, R.V. and Steffe, J.F. (1990). Rheological characterisation of crosslinked waxy maize starch solutions under low acid aseptic processing conditions using tube viscometry techniques. *Journal of Food Science*, 55, (6), 1660-1665.

Dawson, P.L., Sheldon, B.W., and Milkes, J.J. (1991). Effect of aseptic processing on the texture of chicken meat. *Poultry Science*, 70, (11), 2359-2367.

Day, R.H. (1970). Scraped surface heat exchangers for high temperature short time processing of foods. *Food Trade Review*, 40, (7), 33-38.

Decio, P. (1989). Third generation of aseptic fillers for viscous pumpable products and particulates. *Food Marketing and Technology*, November, 58, 62.

Dutta, B. and Sastry, S.K. (1990). Velocity distributions of food particle suspensions in holding tube flow: distribution characteristics and fastest-particle velocities. *Journal of Food Science*, 55, (6), 1703-1710.

Everson, G.J., Chang, J., Leonard, S., Luh, B.S. and Simone, M. (1964a). Aseptic canning of foods. II. Thiamine retention as influenced by processing method, storage time and temperature, and type of container. *Food Technology*, 18, (1), 84-86.

Everson, G.J., Chang, J. Leonard, S., Luh, B.S. and Simone, M. (1964b). Aseptic canning of foods. III. Pyridoxine retention as influenced by processing method, storage time and temperature, and type of container. *Food Technology*, 18, (1), 87-89.

Fellows, P. (1988). Food Processing Technology: Principles and Practice. Ellis Horwood, U.K. p. 242-246.

Gadsden Rheem (1991). Combibloc - the package for the consumer. *Food Australia*, 43, 194.

Halden, K., DeAlwis, A.A.P. and Fryer, P.J. (1990). Changes in the electrical conductivity of foods during Ohmic heating. *International Journal of Food Science and Technology*, 25, 9-25.

Hall, C.E. (1972). The role of scraped surface heat exchangers in the food industry. *Australian Food Manufacture*, 41, (7), 11-12, 14.

Hannigan, K. (1983). What's coming in aseptics. *Food Engineering*, 55, (7), 85.

Heldman, D.R. (1989). Establishing aseptic thermal processes for low acid foods containing particles. *Food Technology*, 43, 122-123.

Hersom, A.C. and Shore, D.T. (1981). Aseptic processing of foods comprising sauce and solids. *Food Technology*, 35, 53-62.

Hersom, A.C. (1984). Problems and possible solutions to aseptic processing of low acid particulate food products. Proceedings of the International Conference and Exhibition on Aseptic Packaging Aseptipak '84. p. 249-262.

Larkin, J.W. (1989). Use of a modified Ball's formula to evaluate aseptic processing of foods containing particulates. *Food Technology*, 43, (3), 124-131.

Lee, J.E. and Singh, R.K. (1991) (a). Process parameter effects on particle residence time in a vertical scraped surface heat exchanger. *Journal of Food Science*, 56, 869-870.

Lee, J.E. and Singh, R.K. (1991) (b). Scraped surface heat exchanger orientation influence on particle residence time distributions. *Journal of Food Science*, 56, 1446-1447.

Mans, J. (1988). Aseptic processing; the proof is in the pudding. *Processed and Prepared Foods*, 158, (5), 95-96, 101-103.

Manvell, C. (1990). Sterilisation of food particulates - an investigation of the APV Jupiter System. *Food Science and Technology Today*, 1, 106-109.

McKenna, A.B. and Tucker, G.S. (1991) (a). Computer modelling for the control of particulate sterilisation under dynamic flow. Campden Food and Drink Research Association, U.K., Technical Memorandum No. 587.

McKenna, A.B. and Tucker, G.S. (1991) (b). The right model for sterilisation. *Food Manufacture*, **February**, 42-43.

Murray, S.A. (1985). Thermal processing of particulate containing liquid foods. Proceedings IUFOST Symposium on Aseptic Processing and Packaging of Foods, Tyloesand, Sweden, p. 81-90.

Pflug, I.J., Berry, M.R. and Dignan, U.M. (1990). Establishing the heat preservation process for aseptically packaged low acid foods containing large particulates, sterilized in a continuous heat-hold-cool system. *Journal of Food Protection*, **53**, 312-321.

Reuter, H. (1989). Aseptic packaging of food. Technomic Publishing Co. USA, p. 59-66, 205-206.

Sadeghi, F. and Swartzel, K.R. (1990). Time-temperature equivalence of discrete particles during thermal processing. *Journal of Food Science*, 55, (6), 1696-1698.

Sastry, S.K., Li, S.F., Patel, P.., Konanayakam, M., Bafna, P., Doores, S. and Beelman, R.B. (1988). A bioindicator for verification of thermal processes for particulate foods. *Journal of Food Science*, **53**, 1528-1536.

Sastry, S.K., and Zuritz, C.A. (1987). A review of particle behaviour in tube flow: applications to aseptic processing. *Journal of Food Process Engineering*, **10**, 27-51.

Subramaniam, G. and Zuritz, C.A. (1990). A study of drag forces on solid spherical particles in power law bounded flow: applications to aseptic processing. *Journal of Food Process Engineering*, **12**, (2), 137-158.

Toledo, R.J. and Chang, S.Y. (1990). Advantages of aseptic processing of fruits and vegetables. *Food Technology*, **44**, 72-76.

Volan, R. and Ziemba, J.V. (1970). Improves cooking of semi-solids. *Food Engineering*, **42**, (11), 94-95.

Wagner, J.N. (1984). Breaking the low-acid barrier. *Food Engineering*, **56** (10) 106-107, 109-110.

Wernimont, D. (1983). Choosing an aseptic process. *Food Engineering*, **55**, (7) 87-88.

Wrightcel Aust. Pty Ltd (1991). Intasept Food Service 32-5/30 Aseptic filler (brochure).

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Enhancing Colour & Preventing Colour Defects

Summary

The perception of meat and meat product quality invariably starts with visual affect. The importance of meat product colour has remained undiminished in today's developing market; however, new product development often puts pressure on colour stability and understanding of meat colour defects is a sound basis for their prevention. This paper discusses colour defects found in fresh meat, restructured meat products, precooked meat products and cured meat products, indicates possible causes and suggests ways of preventing the defects.

Introduction

Colour is a major criterion consumers use when purchasing meat and meat products. Although the colour consumers expect for different meat products differ, the colour must be consistent with what they expect for a particular product. For example, consumers expect fresh beef to be bright cherry red and cured meat products to be bright pink. Moreover, if the products do not appear as consumers expect, they will discriminate against them. In this paper I will briefly outline colour defects found in fresh, restructured, precooked and cured meat products; indicate possible causes of these problems; and suggest ways of reducing the colour defects.

Fresh Meat

Myoglobin is the pigment responsible for the typical red colour of fresh meat. Myoglobin undergoes a spontaneous autoxidation reaction which converts it to metmyoglobin, the pigment responsible for the brown colour of discoloured meat. In living muscle, metmyoglobin is reduced back to myoglobin by an endogenous reducing system present in the muscle (Haggler 1979). In meat, however, the reducing system becomes less effective as the meat ages and eventually the myoglobin will oxidise and the meat will become completely discoloured. The rate at which meat discolours is determined by both the rate of autoxidation and the rate of reduction of myoglobin.

Factors Influencing Discolouration Rate

Storage temperature is the most important factor influencing discolouration rate. This is mainly because myoglobin oxidation is extremely temperature dependent; the rate increases by a factor of five for every 10°C increase in temperature (Livingston & Brown 1981). Higher temperatures also increase bacterial growth with the result that bacterial metabolites contribute to the increased oxidation rate. Storing meat at temperatures between -1°C and 1°C greatly increases shelf life.

Muscle pH also affects discolouration rate; meat discolours at a slower rate as the meat pH increases above normal pH (5.5) (Livingston & Brown 1981). Although meat discolours less rapidly at higher pH levels, high pH can produce other colour problems. If the muscle pH is greater than 6.0, the meat appears dark firm and dry (DFD). Moreover, if DFD meat is vacuum packaged and stored for any length of time, it may turn green as a result of interaction between myoglobin and hydrogen sulphide produced by bacteria which grow preferentially at the elevated pH.

Other factors also influence discolouration rate. The rate differs in different muscles, for example, the psoas major which is in several of the most expensive meat cuts has one of the most rapid rates of discolouration (O'Keeffe & Hood 1982). Exposure to light also increases the discolouration rate – directly by reacting with myoglobin and also by increasing the surface temperature of the meat (Hunt & Kropf 1987). Contamination of meat with multivalent ions such as copper, iron and aluminium, oxidising agents such as peroxide and hypochlorite and curing agents such as nitrite and common salt (NaCl) also greatly accelerate the rate at which meat discolours. Additionally, meat that has been vacuum packaged for extended lengths of time will discolour more rapidly when exposed to air than fresh meat because the endogenous reducing system becomes less effective with ageing.

Restructured Meat Products

Converting lower value meat cuts into restructured meat products is an innovative way of increasing their value. However, a major problem with marketing restructured meat products is that they must be sold frozen and during frozen storage they discolour rapidly – up to twenty time faster than similar intact muscle products (Chu et al. 1987). Consequently, restructured meat products may be completely discoloured after only 1-2 months of frozen storage (Chu et al. 1987).

Hence it appears that steps in the restructuring process contribute to the rapid discolouration rate. Restructured products are manufactured by mixing comminuted meat (particle size 5-50 mm) with water, salt (usually sodium chloride), and/or phosphate. The meat is mixed until the muscle fibres on the surface of the meat disintegrate and form a tacky layer. After mixing, the meat mixture is stuffed into a mould or casing, and frozen. The frozen log is then either cut into steak-size pieces with a band saw or tempered to -1 to -2°C, formed into an appropriate shape, sliced with a power cleaver and then refrozen.

Several recent studies have been carried out to determine which aspects of the restructuring process contribute to the rapid discolouration (Chu et al. 1987; Chu et al. 1988). This research showed that mixing the meat caused the initial discolouration (presumably because of the incorporation of air during mixing); salt had no effect on the initial discolouration but greatly accelerated the rate of discolouration during frozen storage; had no effect on the initial discolouration but also greatly accelerated the discolouration during frozen storage. Hence, it is possible to reduce discolouration by eliminating tempering, however, it is more difficult to eliminate mixing and the use of sodium chloride since they are both needed to ensure the cooked product binds together satisfactorily (Pepper et al. 1975).

One alternative to using salt in restructured meat products is to use non-meat binders to bind the product together. Binders that have been used for this purpose include:

(i) Whey protein concentrate (Trout & Chen 1989);
(ii) Surimi (Trout & Chen 1989);
(iii) Wheat gluten (Siegel et al. 1979);
(iv) Soy protein isolate (Trout & Chen 1989);
(v) Extracted beef myosin (Turner et al. 1979);
(vi) Calcium alginate (Means & Schmidt 1986).

The drawback with these binders is that they increase the cost of the product, they do not completely prevent discolouration and in some cases they alter the flavour and/or texture of the products (Trout & Chen 1989).

Of the binders mentioned, calcium alginate is the most effective at binding the product together and reducing both the initial discolouration and the rate of discolouration during frozen storage (Means & Schmidt 1986; Trout 1989b; Trout et al. 1990). Additionally, calcium carbonate, one of the components of the alginate binder is extremely effective at preventing discolouration – both initially and during frozen storage. It appears to do this by reacting with lactic acid in the meat to release carbon dioxide which displaces oxygen and hence prevents the myoglobin from oxidising (Trout 1990).

Most other approaches to preventing discolouration in frozen restructured meat products have had only limited success. The addition of phenolic antioxidants, such as butylated hydroxy anisole (BHA) (Chastain et al. 1982) or phosphates (Schwartz & Mandigo 1976; Chu et al. 1987) to the products during manufacture, reduces, but does not completely prevent discolouration. Preparing and or storing the products under vacuum (Booren et al. 1981; Chu et al. 1988) or in non-oxygen atmospheres (either nitrogen (Chu et al. 1987 or carbon dioxide (Chu et al. 1988) also does not completely prevent the rapid discolouration. The reason the latter approaches are not completely successful is that they allow low concentrations of oxygen to remain in the products after manufacture – which actually accelerates the discolouration rate (Livingston & Brown 1981).

Cooked Uncured Meat Products

Variation in the colour of precooked meat products cooked to the same internal temperature has been a problem in the meat industry for over 30 years (Pool 1956; Anon. 1983; Hunt & Kropf 1987). This problem occurs sporadically and is characterised by variations in redness in highly pigmented muscles such as beef muscle (Anon. 1983) and variations in pinkness in the less pigmented poultry muscles (Cornforth et al. 1986). Although the cause of this problem has not been determined, two possibilities exist: the myoglobin has been converted to a pink haemochrome during heating, or the myoglobin has not been completely denatured.

Several researchers have suggested that nitrosohaemochrome is the cause of this colour problem. Nitrosohaemochrome, the pigment responsible for the characteristic colour of cured meat, is produced when either nitrate, nitrite or nitrous oxides are present in meat during cooking. Suggested sources of such contamination in precooked meat products are extremely varied and include the following:

(i) nitrate or nitrite contamination from processing equipment and water supply (Brant 1984);

(ii) nitrate or nitrite in the diet (Froning et al. 1967);

(iii) nitric oxide from freezing equipment (Everson 1984);

(iv) nitric oxide from exhaust fumes inhaled by animals just before slaughter (Froning 1983);

(v) nitric oxide produced in gas-fired ovens (Pool 1956).

However recent research using reflectance spectroscopy to characterise the pigments present in commercially prepared precooked turkey breast indicates that nitrosohaemochrome may not be the pigment responsible for this colour defect (Cornforth et al. 1986).

Other types of haemochromes may be responsible for this colour defect. Under appropriate conditions denatured myoglobin can react with certain amino acids, denatured proteins, and other nitrogen containing substances to produce pink haemochromes (Drabkin & Austin 1935; Barron 1937; Dymicky et al. 1975).

It is unclear, however, why pink haemochromes form only sporadically in precooked meat products. One recent explanation is that the pink haemochrome is formed by the reaction, under reducing conditions, between the haem from myoglobin and nicotinamide normally present in muscle and that the sporadic formation of the pigment is due to variation in nicotinamide concentration (Cornforth et al. 1986). However, data in this research did not fully support this conclusion since the spectrum of the pigment found in turkey muscle with this colour defect did not completely match that of nicotinamide haemochrome. Another possible explanation is that certain conditions such as high pH (Trout 1989b), bacterial growth, cooking temperature or cooking environment produce reducing potential in the meat which, as Cornforth et al. 1986 have shown, favours haemochrome formation.

The pink colour defect may also be due to incomplete denaturation of myoglobin during cooking. A recent study showed that, even when cooked to the same internal temperature, high-pH beef, pork and turkey muscle (pH > 6.0) was redder than low-pH muscle (pH 5.5) and appeared undercooked (Schmidt & Trout 1984). Subsequent research showed that undenatured myoglobin was responsible for the more intense red colour in high pH meat and that at normal cooking temperatures (60—70°C), two to three times as much undenatured myoglobin was present in high-pH meat as in low-pH meat (Trout 1989b). Additionally, high pH has been shown to produce similar effects in both commercially-produced cooked turkey muscle and precooked pork sausage (Trout 1990).

Other explanations for this colour problem have been suggested:

(i) carbon monoxide contamination from either gas-fired ovens (Pool 1956) or exhaust fumes (Froning 1983);

(ii) addition of dried egg albumen during processing (Froning et al. 1968);

(iii) preslaughter stress leading to elevated muscle cytochrome concentration (Babji et al. 1982);

(iv) natural variation in the concentration of muscle myoglobin (Froning et al. 1968).

Although some of these factors may be responsible for isolated outbreaks of this problem, they do not fully explain its widespread occurrence.

Cooked Cured Meat Products

Nitrite added to meat products reacts with myoglobin and haemoglobin to form, on cooking, the characteristic bright pink cured-meat colour (Dryden & Birdsall 1980). When nitrite is first added to meat, the colour changes from bright red to brown as the oxymyoglobin is oxidised by the nitrite to metmyoglobin. This reaction and other reactions with reducing compounds in the meat converts nitrite to nitrous oxide which then reacts with both the oxy- and metmyoglobin to produce the dark red pigment nitric oxide myoglobin. When heated, this compound is converted to the cured meat pigment nitrosohaemochrome. Cure accelerators such as sodium erythorbate, ascorbate and sodium acid pyrophosphate are often used to reduce the curing time by increasing the rate of conversion of nitrite to nitric oxide. Most colour defects in cured meat are the result of incomplete conversion of myoglobin to nitrosohaemochrome or conversion of nitrosohaemochrome to other compounds.

Pale Colour

One of the common defects with cured meat products, is that the surface colour fades rapidly and the interior colour ranges from faded pink to gray or light green (Holland 1980). The most common reasons for this problem are:

(i) insufficient nitrite in the cure;

(ii) too low a curing temperature;

(iii) insufficient time between curing and cooking;

(iv) PSE (pale soft and exudate) meat was used;

(v) meat pH was too high.

This problem can be greatly reduced by using a cure accelerator such as erythorbate and maintaining the temperature at 2-3°C during curing. The problem with PSE meat is incomplete absorption of the cure. This may be overcome by increasing brine retention by changing the processing procedures, such as mixing and tumbling times, and salt levels so that at least 70% of the meat pigment is cured.

Fading During Storage

Fading is a major problem with cured meat products during refrigerated display and storage. The colour changes from bright pink to a pale pink-gray. The two major causes of this problem are light and oxygen. This problem can be reduced by either reducing exposure to light or excluding oxygen. Other causes of fading are use of rancid fats, storage at elevated temperature and exposure to oxidising compounds such as hydrogen peroxide and hypochlorite. With rancid fats the lipid oxidation products such as peroxides destroy the pigment. With elevated temperature, the metabolites from elevated bacterial growth which destroys the pigments.

Green Patches

The most common cause of green patches in cured meat products is nitrite burn (Wilson 1960). This may be caused by too high a nitrite level in the cure or poor cure distribution resulting from low injection pressure or poor massage, mixing or tumbling. Green patches may also occur due to under-curing as a result of too short a curing time or too cold a curing temperature.

Surface Greening

This defect appears as a greenish-grey discolouration which may be accompanied by slime. Surface greening may appear soon after processing or later during retail display. In general, it does not show up until five days after processing and may appear after several weeks. Surface greening increases and spreads with elevated temperature and is common in summer.

Surface greening is a bacterial problem and is due to the growth of relatively salt-resistant bacteria which can grow at refrigerated temperature. The common causes of this problem are:

(i) improper hygiene of racks and working surfaces;

(ii) too low a cooking temperature;

(iii) surface contamination after cooking;

(iv) inadequate refrigeration;

(v) contamination of freshly prepared product with returned product (Holland 1980).

Green Rings and Cores

Green rings and cores are due to excessive growth of the bacteria *Lactobacillus viridescens* (Wilson 1960). The problem is usually caused by:

(i) the product being held too long before cooking;

(ii) the use of poor quality raw material such as rework;

(iii) insufficient thermal processing;

(iv) elevated storage temperature.

Green rings generally appear as continuous rings at 2—4 mm depths beneath the surface. The depth of the rings is limited by the depth to which oxygen can penetrate. Green cores appear a few hours after slicing when the product is exposed to air. They are not apparent at the time of slicing.

Both of these problems can be reduced by cooking to an internal temperature of at least 67°C and up to 71°C if the problem persists. The problem can also be reduced by improving the quality of the raw materials.

References

Anonymous (1983). *Meat Industry.* 29(10):76.

Babji, A.S., Froning, G.W., and Ngoka, D.A. (1982). *Poultry Sci.* 61:2385.

Barron, E.S.G. (1937). *J. Biol. Chem.* 12:285.

Brant, W. (1984). *Meat Industry.* 30(1):102.

Booren, A.M., Mandigo, R.W., Olson, R.G. and Jones, K.W. (1981). *J. Food Sci.* 46:1673.

Chastain, M.F., Huffman, D.L., Hsieh, W.H., and Cordray, J.C. (1982). *J. Food Sci.* 47:1779.

Cornforth, D.P., Vahabzadeh, F., Carpenter, C.E., and Bartholomew, D.T. (1986). *J. Food Sci.* 51:1132.

Chu, Y.H., Huffman, D.L., Trout, G.R., and Egbert, W.R. (1987). *J. Food Sci.* 52:869.

Chu, Y.H., Huffman, D.L., Egbert, W.R. and Trout, G.R. (1988). *J. Food Sci.* 53:705.

Drabkin, D.C. and Austin, J.H. (1935). *J. Biol. Chem.* 112:89.

Dryden, F.D. and Birdsall, J.J. (1980). *Food Technology* 34(7):29.

Dymicky, M., Fox, J.B., and Wasserman, A.E. (1975). *J. Food Sci.* 40:306.

Everson, C. (1984). *Meat Industry.* 30(1):102.

Froning, G.W. (1983). *IFT Muscle Foods Division Newsletter* 9(2):2.

Froning, G.W., Hartung, T.E., and Sullivan, T.W. (1967). *Poultry Sci.* 44:1261.

Froning, G.W., Daddario, J., and Hartung, T.E. (1968). *Poultry Sci.* 47:1827.

Haggler, L., Coppes, R.I. and Herman, R.H. (1979). *J. Biol. Chem.* 254:6505.

Holland, G. (1980). *Meat Industry.* 30(11):33

Hunt, M.C. and Kropf, D.H. (1987). In 'Advances in Meat Science', p.139, Editor A.M. Pearson; (AVI Publishing Co., Westport Ct).

Livingston, D.J., and Brown, W.D. (1981). *Food Technology.* 35:244.

Means, W.J. and Schmidt, G.R. (1986). *J. Food Sci.* 51:60.

O'Keeffe, M. and Hood, D.E. (1982). *Meat Science* 7:209.

Pepper, F.H. and Schmidt, G.R. (1975). *J. Food Sci.* 40:227

Pool, M.F. (1956). *Turkey World.* Jan:68

Schmidt, G.R., and Trout, G.R. (1984). *Meat Industry.* 30(8):30.

Schwartz, W.C., and Mandigo, R.W. (1976). *J. Food Sci.* 41:1266.

Siegel, D.G. Church, K.E., and Schmidt, G.R. (1979). *J. Food Sci.* 44:1276

Trout, G.R. (1989a). *J. Food Sci.* 54:536.

Trout, G.R. (1989b). *Meat Science* 25:163.

Trout, G.R. (1990). Unpublished data.

Trout, G.R. and Chen C.M. (1989). Proceedings of the 50th Annual Meeting of Inst. of Food Technologists. Abstract 51.

Trout, G.R., Chen, C.M. and Dale, (1990). *J. Food Sci.* In press.

Turner, R.H., Jones, P.N., and Macfarlane, J.J. (1979). *J. Food Sci.* 44:1443

Wilson, G.D. (1960). In 'The Science of Meat and Meat Products' p.269, (W.H. Freeman and Co. San Franscisco Ca.)

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Industry Case Study I

I have been asked to talk about the development of value-added meat products, using case studies to highlight potential problems, and give some tips for developing successful products.

Successful product development is difficult. There are many pitfalls and the success rate is small. I do not have any figures for Australia but in the United States 92% of new food products fail within the first year. That is the figure for products that are actually launched. Many large food manufacturing companies estimate that only 2 or 3% of the products they develop actually reach the market. That means for every one successful product on the market 4,000 new products have been developed. Even if the figure was only half this bad, you may well ask 'with odds like these, why do we bother?' But as we all know, product development is essential for any company to retain and improve business in an ever-changing market. Product development is especially important to the meat industry which is under attack by a wide range of alternate meal products, whether prepared in the home or prepared by take-away or restaurant outlets.

In order to understand some of the pitfalls, I want to outline the steps involved in product development. Many products that should succeed fail because of very basic problems. Problems that should have been recognised and overcome during the development process.

Many companies follow the steps of product development indicated by '*' in Table 1. Someone comes up with a *product concept*, for example, 'I think we should make a cheese flavoured "pluto pup"' (a cheese flavoured, battered frankfurt on a stick). So *prototype* products are developed. A cheese-flavoured predust and batter is developed to go on an ordinary frankfurt, and diced cheese is put into the frankfurts, and a standard batter is used. The question is asked, 'I wonder which type would be best?' The company then moves on to *developing the*

Table 1 Product Development

#	Definition of Project Aims
	Definition of Project Constraints
-	Generation of Product Ideas
	Initial Desk Evaluation
-	Screening of Products
	General Description of Products
#	Detailed Study of Market, Product and Process
-	Collection and Analysis of Information
#	Project Costing
	Project Evaluation
-	'Go / No-Go' Decision
-*	Product Concept
#	Program Planning
-*	Development of Prototype Product
	Critical Analysis
	'Go / No-Go' Decision
-*	Development of Process
	Critical Analysis of Product and Process
	'Go / No-Go' Decision
#	Final Planning of Production and Marketing
#	Prediction of Possible Outcomes
	Final Evaluation of Marketing and Production
-*	'Go / No-Go' Decision
	Organisation of Final Launching
	'Go / No-Go' Decision
-*	Launching the Product

process. It is easiest if the frankfurt emulsion comes straight from out of the emulsifier into the filler. So because of processing, the decision is made, 'I think the cheese-flavoured predust and batter is the best option'.

Should the company make this product? 'Well I asked Joe, Julie and John and they all think that it's a good idea – they liked the taste and think it will sell so I think we should make it'.

So then the company moves to *launching the product.* 'Tell everyone that the week after next we will have these terrific cheese-flavoured pluto pups. There will be 24 in a carton and the price will be $20.00 per carton.'

This is a very simple example, but this particular product failed in Victoria because it wasn't sufficiently different to the ordinary pluto pups for people to pay the higher price. Eventually, the few tonnes of product that was produced was sold at a loss to clear the stock.

We do not know, but the product with the diced cheese may have succeeded because people perceived extra value for the extra money. More customer consultation may have shown that it was worthwhile to change the processing – to place the frankfurt emulsion in a mixer and add the cheese prior to filling out the frankfurts. The equipment was available.

In this simple case study, the problem was not only the lack of customer consultation, another problem was that only one person was involved at most stages. There was no input from a wide range of people except, of course, Joe, Julie and John. Generally, the decision of whether or not to go with a product is made by one person, in consultation with others, but the more people involved at all the various stages, the better. People may have opposing views, and there may have to be compromise but that, in itself, is a reflection of the market. It would be terrific if consumers were entirely 'like-minded' wanting exactly the same thing but they don't, so the more we can cater for the diversity, with the product being developed, the better. No single person whether they be the Managing Director, Marketing Manager, Sales Manager, Factory Manager or Food Technologist has all the necessary insight into what the market wants.

A number of years ago I was involved in developing a cevaphichi for a particular customer. Cevaphichi is a Yugoslavian sausage. It is a spicy, fresh, skinless sausage. The customer I was working with was Yugoslavian and knew exactly what he wanted.

He remembered the flavour of the Cevaphichi he had grown up with and was keen to reproduce it. The customer had done some research asking the various retail shops he supplied, whether they thought the Cevaphichi would sell, what price they thought they could sell it for, and the volume they thought they could sell.

After a few trials, we produced the Cevaphichi exactly as the customer remembered – it was perfect, just what he wanted. Promotional material was printed, and the product was launched. The initial sales were terrific, especially amongst the Yugoslavian community. However, there were no repeat sales. After a few weeks, the retail shops asked their customers why they didn't buy it again. Most customers said because it wasn't a traditional Cevaphichi, it was too hot without enough garlic and pepper flavour.

Further investigation revealed the particular Yugoslav village that the customer came from was in a small region which used lots of chilli in all of their smallgoods. The Cevaphichi in that region was very different to the Cevaphichi in the rest of Yugoslavia.

The one person had made the decision about what the market wanted. He had correctly determined the fact they wanted a traditional Cevaphichi. His error was that he thought he knew exactly what a traditional Cevaphichi was. The irony in this instance was that this customer had a number of other Yugoslavs working for him who could have alerted him to the difference in flavour if he had involved them.

No one person has a monopoly on wisdom. Many companies cannot afford extensive market research. If you cannot do market research with the actual consumer group you are targeting, use the people around you. There are people in your factory and in your office, your sales force, supermarket buyers, distributors, large and small customers and even your friends. The more people you can get input from, the better. But, you need to be very careful how you assess the information. There is not much point asking someone who never eats sausages, which sausage they prefer – or someone who never does the shopping whether or not they would buy a particular product.

Select the people you ask to make sure they are appropriate for the information you are seeking.

If you are developing a product for school kids to snack on when they get home from school, don't only ask the Managing Director and the sales force, seek out the parents with school children and ask them to take some home, get their children to try them and bring their comments back.

If you are deciding on the design for new packaging, ask the people who actually go shopping. Don't rely on the opinion of people who haven't been into a supermarket for six months or in some cases, even longer. If you are involved in product development and especially in a decision making position, visit supermarkets regularly to keep up with what is happening in the retail market.

Smokers, people who drink large quantities of tea and coffee, and people who eat lots of chilli, generally do not have sensitive taste buds. So, don't ask them if you are trying to determine whether or not a small change in the flavour of a product is perceptible to consumers.

In addition to asking the appropriate people for the information you require, also ask why? The answers to the question 'why?' can give you a lot of insight and assistance with the product and packaging.

For example, if parents had come back to you after their children had tried the afternoon snack product and said they didn't like the flavour, all you would know from that was that the flavour was not acceptable. If you also asked 'why?' you would then have some direction – it was too bland or it was too spicy, or it didn't taste meaty enough and so on.

It is generally most helpful to ask a number of specific questions and why? For example, you had only asked the parents whether or not they would buy the product and they had said no – the reasons could be endless:

- The flavour was too bland, too spicy or too hot or whatever;
- The flavour was great but it was too dry;
- The heating instructions specified a microwave, and we don't have one. There are only five in a packet and my two kids had a big fight over the fifth one;
- My kids go to a friend's house every afternoon;
- The specks of parsley on the outside went black and the kids didn't like the black bits;
- And so on...

All of this information is helpful in changing the product to make it work, rather than throwing out the concept because people said no they wouldn't buy the product in its current form.

Again, I want to stress that one person should not be the only person involved, they cannot know all the aspects of the market.

Incorporating a number of other steps into the product development process also improves the likelihood of a successful product.

Many companies go through the additional steps indicated by '—' in Table 1 in developing products, they *generate ideas* through sales meetings, brain storming, supermarket surveys, reading overseas journals, travelling overseas, trade shows, etc. They then *screen* these products to determine which are realistic. They *collect information* about possible sales, market trends and prices. Some basic research may be done by talking to large customers, supermarket buyers and employees. Other factors such as determining whether additional equipment may be required and whether the correct packaging material is available may also be considered.

A *decision* is then made as to whether the product is likely to be viable or not. If it is decided to continue with the product, the other steps are followed including *organising the final launching*. Unfortunately, often the organisation of packaging materials is left until this stage and the long lead times hold up the product launch.

Using all these steps is an improvement over only using the steps marked with an '*', however all the steps in Table 1 can and should also be included. These particular steps are suggested by Mary Earle in the book 'Product & Process Development in the Food Industry'. Mary Earle is a well-known expert in the area of product development. In my experience, the steps indicated by '#' are generally not done well by most companies in Australia.

I want to take you through a case history using this product development model. Even though I may seem to, I do not wish to overly labour the theory of product development, or promote a rigid following of this particular model. But I do want to stress the importance of using a model, at least as a guide to remind you and your company of the aspects that need to be considered. Most products that fail, do so because of problems that could have been overcome if they were foreseen. Using a model can help us to foresee potential problems. This particular case study relates to the development of some small, flavoured roasts.

The *aim* of the project was to develop a new value-added roast-meat product to be sold through supermarkets.

The major *constraint* was that there was to be no capital expenditure. Only existing factory equipment could be used. In addition, the product needed to have a seven (7) day shelf life.

There was a meeting of the manufacturing company and ingredient supply company to *generate ideas.* Many ideas were generated and some may be developed at a later stage for different applications but the main ideas were:

- Raw, large-family, flavoured roasts;
- Raw, small (individual or '2-people'), flavoured roasts;
- Cooked, large-family, flavoured roasts;
- Cooked, small, flavoured roasts;
- Any of the above with stuffing inside and/or a coating on the outside.

The ingredient supply company then did an *initial desk investigation* in consultation with the manufacturing company and the supermarket buyers. Relevant market information was gathered, information such as:

- Whole roasts are already available in supermarket meat cabinets but there are very few small roasts available.
- Approximately one-third of Australian homes only contain one adult, a high proportion of families have both partners working and consequently, there is a trend for quickly cooked food products that require a minimum of preparation by the consumer, and the desire for value for money.

Relevant technical information was also investigated. It was found that:

- All the products could be made with existing equipment although some steps would be labour intensive.

- The temperature control in the supermarket meat cabinets was variable so shelf-life would be a potential problem.
- It was also found that according to literature, and experience, a vacuum packaged product would be best for shelf-life.

From this initial desk investigation we already know that shelf life and price are among the critical issues.

The ideas that were generated earlier were then *screened* to determine the best options to pursue. In this case, it was decided by the manufacturing company that small, raw, flavoured roasts with a good stuffing would be the best option.

Cooked products were ruled out because to ensure the necessary shelf-life and for public health safety, the temperature control is critical. The supermarket buyers could not guarantee a consistent low temperature.

It was decided to go for small roasts because it was part of the market not being catered for and the statistics suggest it is a reasonable sized market, and in addition smaller roasts cook more quickly. Two small roasts could be used for a family of four. It was also decided to use stuffing in order to lower the raw material costs.

The *product description* was then developed. The product was to be a small, raw roast, injected with a flavoured injectant. It was to contain stuffing and be vacuum packed.

Market research was carried out by a small team of people who surveyed supermarket customers using a questionnaire. The survey was carried out at five supermarkets and included both week-day and Thursday night or Saturday shoppers. The survey was not extensive and statistically did not cover all the demographic groups in the community. However, it did provide an indication of the requirements of the shoppers buying meat at those particular supermarkets.

The information sought in the survey is outlined on the overhead, although, obviously the questions asked during the survey were not as blunt as stated here. Most people surveyed thought the product should serve two people, or perhaps, two adults and a small child. A weight of 300—500 grams was considered reasonable. There was no specific preference for the type of meat. Beef, lamb, pork and chicken were all suggested and a number of customers said all of them should be available.

- The flavours requested fell into two distinct categories:
  - very traditional flavours (generally suggested by elderly people);
  - more gourmet flavours.

  In order to interest both groups of consumers, both traditional and gourmet flavours would need to be available.

- There were two major methods of cooking - oven roasting and microwaving.
- Customers said they wanted the product to be natural and fresh.
- They wanted to see what they were buying, not have it hidden by the packaging.
- The majority of people who said they would buy the product, either lived alone or as a couple. A number of people with families said they would buy it. The single people and couples were both young and elderly. The buying frequency would be once a fortnight, on average.
- The price was related to the cost per serve rather than the price per kilo by most people. (As an aside, people who buy meat from supermarkets, rather than butchers, often do so because they relate more to the price per serve, or total price to feed their household, rather than the price per kilo, as it is displayed by the butcher.) Many people doing this survey said the product would need to cost less per serve than steak.
- Other comments made by those surveyed were that
  - there should be cooking instructions on the packaging;
  - the product should be lean and not shrink away to nothing.

All of the information obtained so far was then *collected and analysed.*

The next step was to *cost out the project.* The actual costings would now be out of date, as well as being confidential so I cannot be specific. The factors that need to be considered when costing out a project are not only the obvious things like raw materials, packaging material, artwork and promotional material. Other costs such as research and development time, and material and factory trials need to be considered and costed in. The cost of lost production and/or overtime due to factory trials is often overlooked. The cost of product that may need to be reworked, or disposed of. During the development stages it is generally ignored completely, except by the accountants when it is too late and then they blame the food technologist. 'But, it is not in the budget' they complain.

When project costing was done and the other information had been analysed the *project was evaluated.* It was decided that the company was capable of producing the product, it met the project aim and there was strong market interest. It was *decided to continue* the development process.

The *product concept* was then defined to ensure everyone had a clear understanding of what was required. The concept was 'small (300—500 grams) boneless pieces of beef, lamb and pork that are injected with flavoured injectants and rolled around a stuffing. The range of flavours includes both traditional and gourmet. The product is vacuum packed attractively with cooking instructions'.

A *program was then planned* for the remainder of the development steps. The product needed to be ready to launch for winter so a schedule was worked backwards from that date. When a program is being worked out there needs to be a balance between being realistic about the time required and building in some additional time, and getting the product out in a commercially acceptable time. For example, it is no good allowing so much time for prototype development that the perfect product is developed but it is then launched at the wrong time of the year. Equally, it is no good if a very sub-standard product is launched because there was no time to improve the prototype. The difficult balance needs to be achieved, and it is different for each project.

The lead time for artwork and packaging materials needs to be included in the program. I am sure you have all experienced the frustration of not meeting a launch date because the packaging material has not arrived. But what if you need to use a new film or special high-quality graphics, the lead time can be even longer. Shelf-life testing is another time-consuming factor that is often forgotten.

Only then, after all the above steps had been completed, were the *prototypes developed*. It may seem a waste of time doing these other steps first, and in some projects it may be unnecessary, but completing those stages means you know what the market wants, and the prototype can be developed accordingly. A lot of time and money can be wasted developing many different prototypes that are nothing like what the market wants or that cannot be successfully produced. Months could have been spent on developing and evaluating a 'sous-vide' product. Market research could have shown a positive consumer response, limited shelf-life tests may have been done and the product even launched only to find tonnes of product spoiling on the shelves due to inadequate temperature control within the meat cabinets.

In our case study, there was specific information guiding the development of the prototype. Flavoured injectants and stuffing mixes were developed for lamb, pork and beef. For lamb, an apricot and a rosemary and mint stuffing were developed. For pork, apple, sage and onion and for beef a garlic and wine, and a home-style flavour were developed. It was important to make the flavours distinctive yet have the same flavour levels as could be achieved if the product was prepared at home.

The stuffing mixes all had good colour contrast, and distinguishable ingredients such as pieces of dried apricots and apples.

Some very cheap cuts of meat were found to be too labour intensive to trim. It was decided to use boned-out lamb forequarters, pork necks and beef rounds. These cuts later varied in production depending on price and availability.

The necessary extension was achieved by both the stuffing mix and the pick-up due to the injection of the flavoured brine. The final pump rate was a compromise between the desired extension and minimising any weeping during distribution and storage.

The stuffing-mix ingredients needed to be selected to ensure there was no microbial problems. It was found that the stuffing mix was a potential problem in regard to the shelf-life. The seven day shelf life was achieved with the prototype, but good handling and hygiene in the factory would be essential.

The shelf-life tests involved sending the product out to a supermarket in the truck with other products, in an attempt to reproduce the handling of the product once it is launched. The product was then stored in the supermarket's chiller and the necessary tests performed. It is far easier to achieve the required shelf-life under ideal conditions, but commercial products are not subject to ideal conditions. The product needs to achieve the required shelf life when exposed to the worst conditions, (within reason), it is likely to experience.

Netting was used to hold the product together, and give a traditional appearance. A rub was also developed to overcome the discolouration problems resulting from the vacuum packaging. The rub also assisted the appearance of the cooked product when it was microwaved. Printed vacuum bags were found to give a better appearance than plain bags with a label attached.

Table 2 Process Development

- Bone out meat, trim off fat and cut to size.
- Inject
- Place rehydrated stuffing in the centre
- Roll up
- Net, using a bazooka
- Roll in rub
- Vacuum pack

The other things that were done as part of the prototype development were:

- writing specifications for the meat and dry ingredients;
- specifying laboratory tests;
- doing proximate costings;
- ingredient listings;
- checking relevant legislation;
- performing taste tests to evaluate the particular prototype flavours.

The appearance was also evaluated.

The project was then *analysed critically*, and it was *decided to proceed.* The *process of manufacture* was then developed. The process was very simple. The steps are outlined in Table 2. The process was *critically analysed*, and found to be labour intensive but able to be done and worthwhile, so it was *decided to continue with the project.*

The next stage was to do the *final planning of production and marketing.* The planning included organising the factory trials, shelf-life trials and consumer testing of the factory-produced product. The market potential was reassessed to determine the initial quantity and the follow-up quantities required. The final costings and price analysis were done. The marketing plan was designed as was the promotional material. The packaging artwork was finalised and the production schedule was checked to make sure the product could be made when required.

The *prediction of possible outcomes* is generally difficult. In this case it was thought the estimated sales would be achieved because we had been able to produce the required product. In some other instances, it may be impossible to produce exactly what the customer wants, so only a proportion of previously estimated sales will be achieved. A prediction of revised sales is important to the final steps.

A *final evaluation of the marketing and production* was done basically asking the question 'are we on track?' It was decided the product could be made consistently to the desired quality and price and that the product would sell sufficiently. The *project was to proceed.*

The final launch was organised. Five stores were selected to test market the product for one month. The raw materials, packaging and promotional materials were ordered. The production schedule and quality control were organised and everything was double checked to ensure they were on schedule for the launch date. So it was *decided to proceed.*

The *product was then launched* on schedule. The sales people and retailers were trained and the promotional material distributed. The product was made and distributed and the sales were closely monitored.

Now this case study is unusual in that all these development steps were followed. By following these steps a product that the market wanted was developed and many potential problems were foreseen and overcome. In order to develop a successful product you need to know what consumers want and be able to supply it. We all know that consumers are after reduced salt, lean, lite 'healthy products'. But that is only part of what they want – that is only one aspect of the product.

Consumers want reduced-salt products but only if they are as tasty as the standard product and have the same shelf life. Consumers want low-fat products, but they want the same mouth feel and texture and they do not want to pay a high price. Consumers want products without preservatives and with a minimum of packaging but they want it to last for a week once they get it home from the supermarket.

We need to be careful we do not make assumptions about what consumers want without finding out the specifics as they relate to the particular product we are developing.

Successful products are products customers want, rather than the products that are not convenient for us to make.

My best tip for developing a successful product is to find out exactly what the customer wants and develop that product, looking for all the potential problems and overcoming them before they eventuate.

Good luck in this difficult area. May we all work at improving the odds for success!

Mr Bob Hamilton
Earlee Products Pty Ltd

Industry Case Study II

Over the next hour, I would like to relate a few real-life experiences regarding FOOD PRODUCT DEVELOPMENT. Some are my own personal experiences and some are the work of others with whom I have been associated. Because this seminar concerns value-added meat products, I have tried to include some cases which are directly or indirectly meat related.

However, before I begin discussing the food-product-development industry's successes and failures, it's important that we define some of the terms and idea-generating processes used, and hurdles to be jumped, in the development of so called new products.

What is Product Development? Product Development involves the selection and definition of a concept, its formulation in the laboratory and its progression through pilot plant and finally through process-line manufacture.

Product development can be initiated in several ways.

New Product Need: Many new products come from a keen knowledge of the marketplace that enables a marketeer to spot the innovation to produce a new product. One example of the fulfilment of an obvious need is in the development of a natural, safe ingredient that will bind meat together in the cold (uncooked) state for reformed steaks.

Raw Material Utilisation: This would incorporate the use of an abundant under-utilized food or food by-product – for example excess fruit production, cheese whey or meat trimmings.

Reformulation of an Existing Product: It may be necessary to reduce product cost or reformulate a product because of the unavailability of an ingredient or perhaps because an existing product is to be presented in a different form.

Commercialization of a Domestic Product: The development of value-added meat products based on popular meat recipes. Or perhaps a famous 'home-made' Christmas cake recipe reformulated for mass production.

Idea Generation

New Product Development results from the generation of ideas. Look for new product ideas that fit your company's structure and production capabilities – ideas relevant to your companies needs.

Sorting out and evaluating good ideas from bad is an almost unmanageable task and to embark on the development of too many ideas without proper evaluation and screening is almost certainly a road to disaster. The odds against success are something like 100:1.

Good new product ideas may arise from various sources on a random basis, many coming from outside the company's sphere of interest. No individual has a monopoly on idea generation. Ideas can come from consumer groups and in-depth interviews, lateral brainstorming sessions, consultants and published literature.

New product ideas can come from the food technologist who can see the possibility of a new product in a new ingredient or a new process.

Idea generation should also embrace potential imitation product opportunities.

Product Innovation vs Product Imitation

The needs of today's society are complex. There are a host of regulations with which we must comply. One would be forgiven for thinking that with new discoveries, improved technologies and better understanding of today's social needs, there would be unlimited opportunities for the introduction of new products. However this is not so. This is not to say that there should not be entirely new products, nor that there will not be new ones, but today there seems to be less opportunity for entirely new food products. If a new food product is invisaged, it must be remembered that the expense of proving its safety and cost of its launch will be so great that it must be demonstrably better than other products on the market and ultimately profitable to the company.

It seems likely that we will see less new food products in the coming years and that product development will consist more in the continuous upgrading and imitating of existing products. This might not be as satisfying as the launching of a totally new idea, but new ideas are now so expensive to develop and so uncertain of acceptance that company leaders are sticking with established products. Traditional raw materials will disappear, increase in price or at least be in short supply or they will also be subject to new food regulations which may effect their use.

Nutrition

Nutrition has emerged as an important factor in food choice and consumption behavior. Nutrition aspects must meet genuine consumer needs which give the product a competitive advantage.

New Product Hurdles

However, the new product concept is generated or the product to be positioned, there are three basic hurdles to be jumped before a new product has been developed.

These are:

- Technical feasibility;
- Production capability;
- Profitibility.

The most important to me as a chemist is technical feasibility, but it must not be considered in isolation. It must be remembered that product development is neither marketing, laboratory, nor production driven. It can be initiated by any of the three groups but from then on it must be a team effort coordinated by the project leader. The key to a succesful project is communication and coordination.

Case Study No. 1 – The Asian Lamb Project

This project was initiated because of the abundance of cheap mutton meat in New Zealand – the 'Mutton Mountain' as it was called.

Some of New Zealand's brightest food technologists and experienced marketing people were employed to develop a series of mutton-based products for Asia, initially Singapore, then Hong Kong.

Local consumer groups were set up in Singapore and questionaires were designed and destributed. Results of these indicated a strong interest in BBQ type products with an Asian flavour. Also, as a result of the surveys it was found that there was a preference for 'satay stick' style products.

Armed with this information, the food technologists back in New Zealand began developing product concepts. The product would have to be simple and inexpensive to make and require a minimum of labour. Thus it was decided to mechanically debone the sheep carcasses, use phosphate technology to prepare the meat and to use an elaborate forming and shaping machine to imitate the shape of the genuine article.

Suitable flavours were matched using the best Asian recipes. Test products were refined and finally sent to Singapore for test marketing. A large supermarket in Singapore was chosen and product offered to the eager consumers. Consumer reaction was very promising to say the least with all tasters pledging their patronage should the products become commercial.

Word was sent back and the first 20 tonne container despatched. Upon arrival in Singapore, the first product, a traditional Peanut Satay was displayed prominantly in the supermarket with the usual western fanfare and low introductory price. The product sold like hot cakes and so another container was despatched as soon as more product could be made. But alas, the second week into the launch sales were slow and, in fact, not even half the first container had been sold. Frantic efforts were made to stop the next container but it was already on the water.

What had gone wrong?

Had the consumers changed their minds, and if so, why had they changed their minds?

Something was wrong somewhere.

The marketing people misread the market and the technologists misread the product. Good as it was, it wasn't the genuine Asian article. It may have been acceptable to Australians or Kiwis but not the people of Singapore. In addition, mutton is not popular in this application. It is more often used in hot-pot-type foods.

The surveys undertaken in Asia, particularly in Singapore, were not accurate in that the polite people who were asked either didn't fully understand the questions or just gave polite or expected answers. Even today, most locals purchase fresh raw materials from street markets rather than supermarkets. When they do it is to buy western-style BBQ items in much the same way we could go 'Chinese' for a change. It is also a sign of affluence to have outdoor BBQs.

Case Study No. 2 – Reformed Meats

Fortunately not all new food products are failures. A Brisbane food-manufacturing company has pioneered the utilization of a new process technology to join meat pieces together in the cold (uncooked) state. The bonding process itself has been around since 1988 for all to use, but this small, entrepreneurial, innovative company was the only one to see its immediate potential in local and export value-added meat products.

Without wishing to give away any of their proprietary developments let me just say that they have thoroughly researched their markets, kept their products simple and capitalized on the changing import regulations of the target countries.

There is still, I believe, huge potential for the development of other cold-meat binders, particularly those based on meat proteins.

Case Study No. 3 – Fermented Rice Flour

Another ingredient which has recently been utilized by the smallgoods industry is fermented rice flour. This is rice flour which has been turned bright red by its fermentation with the mould Monascus. The product has been around in Japan many years and is, in fact, the colouring found in red sake. As you may know, picnic or shoulder ham products (manufactured hams) incorporate wheat or potato starch. It was found that by replacing a small portion of these starches with fermented rice flour (also high in starch) the finished ham had a superior colour which lasted longer in the refrigerated display cabinets. It has also been used in non-nitrite frankfurts for people who are sensitive to nitrites or wish to eat an alternative product. It should also be noted that closer bacteriological control needed to be placed on this product because it had now lost the protection of the nitrite.

In talking about smallgoods, we must be careful also that we don't deplete some of the natural protection afforded by salt and sugars in products such as salt-reduced hams, fermented salamis, dried meats and traditional semi-dried hams and ham products such as Coppa, Prosciutto or Parma hams.

Case Study No. 4 – Some Healthy Alternatives

Let's now look at the track record of some new value-added health foods. The marketing people tell us there is a niche market for healthier versions of some of our staple foods such as the humble pie and the fresh sausage. Now I must point out that if you head down this path you're in for a few surprises.

Whenever a product is designated as having some health benefit such as low fat, low salt, low cholesterol – nutritional labelling is required and not just on the claim being made but on all key nutritional aspects. These controls, I'm glad to say, are going to be tighter. In addition, there are those who wish to place the Heart Foundation tick of approval on their product, which also comes with its list restrictions.

A famous Australian pie manufacturer decided to make a healthy pie. They laboured for months over the ingredients, the taste, the size the pastry and the price. In its final form, it was a vegetable pie with a cholesterol-free pastry. They decided to launch the product at the Australian Aussie Rules Finals in Melbourne. It was a disaster. No one wanted them. Perhaps it was not the place for such a fine product. It was promoted around the school tuckshops as the healthy alternative to the meat pie. Again it didnt sell. Now I'm not saying there isn't a market for vege pies but this certainly wasn't the product for the two biggest pie markets in Australia.

There have been many attempts at designing low-fat, low-salt, low-cholesterol, fresh-meat sausages and, with the the latest alterations in the regulations, it is quite easy to do so. The hard part is to make them taste the same an the perceived less healthy, popular product!

The real challenge is to develop and market more desirable products with high ratings in terms of consumer acceptance and nutrition. The reality is that consumers will choose pleasing products for specific meals in the belief that on an overall basis they are selecting foods which meet their goals of a healthy diet.

Case Study No. 5 – Honey Meat Products

As well as my involvement in the red meat area, I have done a considerable amount of work in the Chicken Industry and we can learn much from their approach to product development and marketing strategies. One such chicken-processing company wished to expand its value-added products from rissoles and sausages to a range of chilled, supermarketable, microwavable, packs of wings, thighs and legs, which would sell retail for under $2 a pack.

The product brief went on further to say that they had limited processing equipment and that limited resources were available. The products were to be 'home treat' styles based on popular domestic recipes with no artificial flavours, added MSG – in fact all natural ingredients.

In all, seven products were developed and are now enjoying sales in the NSW areas. The one which is most popular; and I might add the one which was the most difficult to develop, was the honey soy wing snacks. You see the product had to be applied as a powder, which meant that the honey and the soy sauce also had to be in powdered form. The soy sauce was easy to procure but the honey powder which was imported, was expensive and inferior. So we decided to develop our own honey powder. I had experience in spray drying and access to some excellent Australian Honey.

Our many honey-drying trials finally proved successful and the powder was incorporated into the final product along with all the other natural ingredients necessary to make the product stick and hydrate into a tasty glaze.

Initially, we only produced enough honey powder for the chicken product, however, before long, further applications became apparent and several tonnes had to be produced. Honey had long been used in ham manufacture both to maintain the pink colour and enhance the taste.

Our honey powder was incorporated with the other dry ingredients in a new ham cure. The powder combination proved to be very stable during storage and dissolved easily in the brine. Demand for this cure has now outstripped our stocks of honey powder.

In addition, we have found it to work well in powdered fresh beef sausage meals where the sausages take on a delicate oriental honey tang. Word has also spread within the food industry that we have a premium honey powder available and outside orders have been received from interstate and now from Japan and Korea. The export products are to be made from slightly different honeys to suit the Asian palate, but the process will be basically the same.

The point I wish to make is that although our initial aim was to develop honey soy wings, we saw even greater potential for this ingredient once it was commercial reality.

Tips on Successful Product Development

- Look for products that fit your company's structure and production capabilities.
- Try to use formulation ingredients that your company already holds in stock. Every new ingredient on the inventory increases the stock holding and incurs extra buying costs.
- The technical and marketing people must write the product concept together and continue to communicate throughout the project.
- Don't leave the final palatibility decision to the Chief Executive. He probably is least qualified to make a final decision on the taste acceptability of the product. Leave it to a trained taste panel, a targeted consumer group or a trained chef.

- Keep the product development project on track and on time and know when to stop. No product will ever be perfect or to everyone's taste.

Conclusion

Good product development requires accurate research, the coordination of a team of people, expert in their fields, with an appreciation of the management disciplines essential in effective and successful new product development in a commercial organization.

Mrs Sheryle Rogers – Food Technologist
Queensland Department of Primary Industries
International Food Institute of Queensland

Chilled, Frozen & Shelf-stable Prepared Meals

The increase in consumer demand for prepared meals has been evident for some time, with this sector of the market continuing to grow. The reasons for this demand include the increase in the number of women in the workforce; the increase in single-person and one-parent family units; and a decrease in the number of sit-down, formal family meals. With less time available, consumers are seeking products that are quick, convenient and easy to prepare. Conversely, there is also the desire for healthy and natural foods. Convenience tends to equate to microwave oven use, however, although consumers like the convenience and time saving associated with microwaveable products, it appears that they are not prepared to sacrifice the quality of traditionally prepared food.

The advantages to the meat processor in manufacturing products that fit into the frozen, chilled or shelf-stable prepared-meal sectors are obvious. Either ready-meal or prepared-meal concepts can be developed. With the ready-meal concept, the product forms part of the meal, for example sliced beef in sauce, where the consumer would prepare and cook vegetables if these were required. With the prepared-meal concept, the product forms the whole meal or snack.

Chilled Products

In Australia, chilled products are developed predominantly for the food service sector. The requirements for distribution and storage temperatures of no greater than 3°C precludes many chilled products from the retailing system.

Many systems are available for the production of chilled, prepared and ready meals. The term sous-vide has gained popularity in recent years and encompasses products cooked-in-bag or bagged-after-cooking and stored at refrigeration temperatures.

Overseas, chilled products have become increasingly popular due to the advantages in energy saving and improvement in food quality over frozen products, despite the microbiological risks being higher than in frozen products.

Sous Vide Processing

The literal French meaning is 'under vacuum'. Fresh food is vacuum sealed in impermeable plastic pouches, cooked at length at a low temperature in circulating water, chilled and held at refrigerated temperatures for up to three weeks. The term 'sous vide' is used for both the processing method and the final food product. The process was initially developed in Sweden for the institutional catering sector and has been in existence for over 20 years. Sous vide production refers to both cook-in-bag and bag-after-cooking processes. However, there is a tendency for the term to apply to cook-in-bag processes.

In its simplest form the process involves:

(i) the preparation of high quality raw ingredients;

(ii) pre-cooking (browning), if necessary;

(iii) placing the food into heat stable, air and moisture barrier pouches;

(iv) vacuumising and sealing the pouch;

(v) either:

- (a) steam cooking at specific times and temperatures to ensure pasteurisation of the food; or
- (b) cooking for immediate consumption;

(vi) immediate rapid chilling, within 90 minutes, to 0—3°C;

(vii) labelling and controlled refrigerated storage within this temperature range until required for consumption, but within the shelf-life period.

Since sous vide contains no preservatives, strict precautions must be taken during the procurement, manufacture, distribution and storage of the product. Because of the danger of mishandling, sous vide must be manufactured and distributed under Hazard Analysis Critical Control Point (HACCP) procedures. The areas of concern with this process relate to microbiological quality. The cooking process for sous vide kills some of the harmless micro-organisms whose odour warns of spoilage, but does not kill many micro-organisms that cause food poisoning. With the largely anaerobic environment within the pouch, there is an increased risk of food poisoning from organisms such as *Clostridium botulinum* and facultative aerobes such as *Salmonella spp.* In the bag-after-cooking process, the potential for food poisoning is greater since there is a greater risk of post-cooking contamination. Therefore factors such as work place and personnel hygiene become critical. In these products, organisms of concern include *Yersinia enterocolitica*, *Listeria monocytogenes*, *Aeromonas hydrophila* and *C. botulinum.*

Vacuum packaging, both pre- and post-pasteurisation, allows a longer storage life to be achieved, particularly with products such as meat in which the major spoilage changes applicable in conventional cook-chill are oxidative in nature. However, juiciness may be diminished due to the vacuum effectively pulling water out of the food.

The cooking time for meats vary between conventional and sous-vide processing. In general, tender meat cuts require shorter cooking times than conventional cooking. Tougher meats generally require at least double the cooking time of conventional cooking. Joints of meat should weigh no more than 2.5 kg as rapid chilling of heavier joints would exceed 90 minutes. The slow cooking used in the sous-vide process enables the soluble proteins to coagulate gradually rather than to shrink rapidly as in conventional cooking, resulting in less shrinkage and moisture loss from the meat.

Cooking times and temperatures must be well regulated in order to achieve sufficient internal temperature to ensure microbiological soundness but also to ensure that the meat is not overcooked with resultant loss in quality attributes such as texture and juiciness. The most accurate way to ensure that the internal temperature is reached is to insert a thermocouple through the centre of one product per cooking/chilling cycle.

In all countries where sous vide processing is practised, the major problem appears to be within the distribution system, not the in-plant processing. In the United States, sous vide may include freezing the final product, whereas in Europe sous vide is generally a chilled food product.

To succeed, the sous vide processor first needs good-quality ingredients, and then must handle those ingredients properly to limit contamination, use the HACCP procedure at every stage, use appropriate storage and refrigeration methods and include a time/temperature indicator to assure that the product is used within its limited shelf-life period.

Cook Tank System

This system is used for whole-muscle meats as well as prepared-ready meals.

The meat or prepared product is vacuum sealed in Cryovac casings. Vacuum packaging allows for greater heating efficiency as air is a poor conductor of heat. The packages are lowered into the tank in baskets, either manually or by means of a hoist.

The Cook Tank holds up to 350 kg per batch and uses 1 000 litres of tap water which is heated up to steam cook the meat. Roast beef is steam cooked at a temperature of 57°C, with cooking times of approximately six hours. The water temperature used in the cooking process is always 2°C higher than the meat. Temperature is controlled throughout the cooking process by means of a time/temperature recorder, which also controls cooking time and cold water cooling. After cooking, the product is chilled to 2°C, at which temperature it is recommended to be stored. At this temperature a shelf life of 60 days for roast beef can be obtained.

By using this process, yields are improved. In a conventional oven, yields of 70 to 75% are generally achieved when cooking roast beef. Using the Cook Tank, yields as high as 90% are claimed.

Prepared meals are generally given a 45 day shelf life. Suitable applications for this system are poultry products, barbecued spare ribs, meat balls and other types of meat and non-pumpable recipe dishes.

CapKold System

This system is suitable for dishes such as Chilli Con Carne, stews and soups. Cubes of meat or vegetable must be no larger than 30 mm for this method. This system incorporates a batch-cooking kettle, case filler and a chilling chamber.

A steam-jacketed kettle is used for batch cooking. Automatic temperature controls ensure uniform cooking, and the angle of the agitator inside gives even distribution of food particles throughout the batch, by means of the lifting and folding action of the paddles.

When the contents of the kettle have been cooked for the designated time, the product is pumped to the next stage at a temperature of approximately 83°C. The mixing action is maintained throughout pumping. The product is pumped through a pipeline to a nozzle under which the operator holds each bag to be filled. The bags are formed by clipping the end of a tube of co-extruded 5-ply flexible tube. Product is then filled into each bag and the top clipped. Bags are usually six kilogram capacity.

The mixture is filled quite loosely into the casings (not vacuum packed), and after clipping, the bags of product are put into the chilling apparatus, which resembles a giant washing machine. They are massaged and tumbled in cold water, which brings the temperature down from just under 83°C to 4°C in less than one hour. This rapid chilling retards bacterial growth and overcooking. When stored at 2°C, these products have a recommended shelf life of up to 45 days.

Frozen Products

Frozen prepared meals available in Australia fall into two categories; casserole style and traditional. The first category contains products where diced or sliced meat and vegetables are mixed in a sauce. Examples of products are chinese and hot pot/stew types. The second category contains plated products where the meat and vegetables are not mixed and are generally in separate compartments of the plate. Normally only the meat component of the meal contains a sauce.

Casserole style products can be packaged using form-fill seal lines while traditional products require manual labour to arrange each component of the meal onto plates before sealing and freezing.

In the USA, a variety of frozen sandwiches containing meat are available, which only require microwave defrosting before consumption.

Shelf-stable Products

Microwaveable shelf-stable ready meals have shown considerable growth, both in the USA and in Australia. In the USA, shelf-stable products have taken market share from frozen meals. It appears that the main reason for this trend is consumer dissatisfaction with frozen meal product quality. Shelf-stable products have a higher acceptability in Europe than in the USA and Australia.

Products are available in retort pouches and plastic retort trays and tubs. Shelf-life of these products is approximately one year at ambient temperatures. The advantage of retort trays and tubs over pouches is that the trays and tubs are in a table-ready format.

Plastic trays and tubs are made from co-extruded plastic consisting of a polypropylene structure with multiple layers including SARAN as its barrier. For trays, the lidding material is a co-extrusion containing aluminium foil as the barrier with polypropylene on both sides. This packaging is suitable for heating in the microwave oven and in boiling water.

Sealing the lid to the tray is the most critical point in the process. The seal has to be perfect yet allow for easy removal by the consumer. Hormel in the USA, the manufacturers of the Top Shelf brand of shelf-stable meals uses a system of high resolution video cameras to detect food particles as small as 1 mm on the tray seams before lidding. If any product is detected on the seam, the lid is not applied and the trays are automatically rejected. The processing techniques and considerations applicable to conventional tin-plate canning operations are similar for plastic trays and tubs.

In the USA, shelf-stable meals in plastic packaging have been developed and marketed directly at children between 5 and 12 years of age. Consumer studies had shown that parents believed microwave ovens to be a safer form of cooking for their children than the traditional oven. A further requirement was that the meals were nutritionally balanced.

References

Alfa-Laval. 1989. Alfastar - the ready meals system. *Fd. Man. Adv. Supp.* 4, (3), S7.

Anon. 1989. Mom, can I have a bucket of lunch, please? *Fd. flavourings, Ingredients, processing and packaging.* 11, (9), 45,47.

Baird, B. 1991. Sous vide: What's all the excitement about? *The Fd. Technol.* 21, (1), 19.

Burfoot, D., Griffin, W.J. and James S.J. 1988. Microwave pasteurisation of prepared meals. *J. Fd. Eng.* 8, 145-156.

Burfoot, D. and James, S.J. 1990. Developments in microwave pasteurisation systems for ready meals. *Eur. Fd. and Drink Review Summer.* 12-15.

Byrne, M. 1985. A meat processing revolution. *Fd. Man. Int.* 2, (4), 33,35.

Byrne, M. 1988. Preserving that 'homemade' taste. *Fd. Man. Int.* 5, (2), 45-46.

Corlett Jr, D.A. 1989. Refrigerated foods and use of hazard analysis and critical control point principles. *Fd Technol.* 43, (2), 91-94.

Darrington, H. 1989. Ready meals: Ambient the way forward says CWS. *Fd. Man.* 4, (10), 39,41.

Friedman, M. 1991. Life in the fast lane prompts eating on the run. *Prep. Fd.* 160, (6), 80-81.

Hrdina-Dubsky, D.L. 1989. Sous vide finds its niche. *Fd. Eng. Int.* 14, (9), 40-42, 44, 46, 48.

Jeffries, D. 1987. New products with microwave potential. *Fd. Sci. and Technol. Today* 1, (4), 212-217.

Mason, L.H., Church, I.J., Ledward, D.H. and Parsons, A.L. 1990. Cook-chill catering systems. *Fd. Aust.* 42, (11), 525-527. Reprinted from an article The sensory quality of foods produced by conventional and enhanced cook-chill methods. 1990. *Int. J. Food Sc. Technol.* 25, 247-59.

Moberg, L. 1989. Good manufacturing practices for refrigerated foods. *J. Fd. Prot.* 52, (5), 363-367.

Nash, J. 1992. Competition hotting up over stable containers. *Fd. Man. News* 19, (1), 10-11.

Salvage, B and Mans J. 1987. Top Shelf: A new product for a new category. *Prep. Fd. New Prod. Annual* 196-198, 200.

Schafheitle, J.M. 1990. The sous-vide system for preparing chilled meals. *Brit. Fd J.* 92, (5), 23-27.

Sumner, J. 1990. Sous vide: Microbiological risk assessment. Proceedings of Sous Vide in Australia. The Conference. Melbourne, 14 November 1990. p 39-50.

Warne, D. 1990. Sous Vide: The HACCP approach. Proceedings of Sous Vide in Australia. The Conference. Mebourne, 14 November 1990. p 17-32.

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Packaging of Prepared Meat Products

Introduction

Significant changes in both processing and packaging technologies have occurred over the last decade. These changes have included new ways to process foods, new packaging materials, new combination of standard materials, and novel methods of manufacturing containers. The terms of change are now appearing on store shelves – retortable, dual ovenable, microwavable, 'fresh', 'long-life', aseptic, etc. To consumers these terms are synonymous to convenience and high quality attributes. Consequently, the food processor must meet the challenges and/or opportunities of these new technologies to progress and remain viable in today's competitive marketplace.

While none of the basic food packaging materials has escaped change, more change has occurred in the area of plastics than any other. Today, nearly all types of food packaging have plastics as part of their construction. The greatest opportunity offered by plastics is the limitless options in pack presentation e.g., compartments, various sizes and shapes, glass-like appearance. Hence, the discussion in this paper will be limited to plastics and other materials which use plastics as part of their construction.

Some of the new packaging technologies which could offer significant potential for the preparation and sale of meat meals and related products consist of modified atmosphere (MA), vacuum-skin, retort pouch, aseptic, microwavable and/or ovenable containers, and the use of new plastic packaging materials for retort or sous vide processing.

MA Packaging for 'Fresh' Appeal

Consumer willingness to pay more for foods that are perceived as fresher, or of greater value has necessitated new technologies based on packaging. One most discussed method for shelf life of chilled products is modified-atmosphere (MA) or gas packaging.

MA packaging implies introducing a gas that is different from normal air as a one-time change. This is usually accomplished by vacuum and subsequent gas-flushing operation of a package before sealing. Maintenance of initial package atmosphere would depend largely on the type of packaging material used and the nature of the product. For non-respiring products, the most commonly utilised gases are carbon dioxide and nitrogen in various percentages (Table 1).

Shown in Table 2 are the various parameters and critical points that would determine the viability of a chilled product under MA. The quality of the raw ingredients (both microbiological and organoleptic quality), coupled with proper temperature control throughout the food chain, usually account for about 50—60% of the total synergy accomplished in a particular MA system. These two factors will normally predetermine the shelf-life of a particular product before it enters the distribution system.

Packaging materials, packaging equipment, and gas mixture are the other parameters which account for approximately 40% of the total synergistic effect. Although their individual contribution is not as significant as initial quality and temperature, their combined effort is critical to maintaining the overall quality. They are the heart of any MA system.

Table 1 Recommended Conditions for MA Packaging of Non-respiring Foods

Food item	Temperature °C	Gas Concentration, % O_2	CO_2	N_2
Thin-sliced Meat	0—2	0	80	20
Red Meat	0—2	30	30	40
Chicken	0—2	0	30	70
Cheese	0—2	0	0	100
Bakery products	20—22	0	100	0
Chilled cooked meals	0—2	0	20	80
White fish	0—2	30	40	30
Oily fish	0—2	0	60	40

Generally, the packaging of non-respiring foodstuffs involves barrier materials, where the atmosphere of the head space is not in any gas exchanger with the outside atmosphere.

Temperature fluctuation is a major critical concern in the success of any MA system. The segments of the food chain that is the cause of the majority of MA product failures are retail display and consumer handling. In UK, it has been documented after a survey that household refrigerators and refrigerated retail display cabinets produced a temperature range of 1.7—20.2°C and -0.8—18.4°C, respectively. These data reconfirm the need of absolute temperature control throughout the food chain. This is an area in which some 'active' packaging materials could play an important role (See 'Active' Packaging – p 88).

With a mathematical certainty that a product will face abusive conditions somewhere in the food chain, it is recommended that additional safety hurdles or barriers such as water activity, acidity, thermal processing and preservatives be incorporated to any MA system.

Prepared Meat and Related Products

Generally, MA in conjunction with refrigeration and other hurdles of spoilage is reported to be capable of delivering shelf-life extensions in the range of 1.5—10 times that in air at the same temperature.

Processed Meat. Delicatessen products such as pâtés can be kept in good condition up to 3 weeks in MA packaging of 20—50 CO_2 and 50—60% N_2.

Table 2 Product Optimisation Parameters & Critical Points within a MA System

A. Product Parameters
- Organoleptic and microbiological quality of raw material
- Temperature control throughout the food chain
- Packaging material
- Packaging equipment
- Appropriate gas mixture

B. Critical Points
- Microbiological safety and shelf life of product
- Food chain (distribution system)
- System in place monitoring all points of sale
- Temperature control at point of sale
- Consumer handling between sale and consumption

Meals, Entrees. Because these products contain so many components including seasonings and spices, they are contaminated with a wide variety of micro-organisms whose count is only reduced, not eliminated by heat pasteurisation. With no MA packaging, refrigerated shelf life is in the order of 3—6 days. With MA packaging, shelf-life can be extended to 3 weeks or possibly longer.

In North America, cooked chilled chicken in microwavable MA containers is sold with a shelf life of 30 days. In France, MA packaging is also used for main-course foods such as beef stew.

Pastry Products. Commercial experience in France with precooked pasta-based products or meat and pastry combination exemplifies the benefit of MA packaging in extending the shelf life from a few days to 2—3 weeks (Table 3).

FRI's commercial experience with pasta-based meat products (e.g. Tortellini) confirms shelf-life extension of these products for at least 3 weeks (4°C) with MA packaging using medium-barrier materials. MA packaging was found to inhibit microbial growth in partially pasteurised tortellini by at least 3-fold compared to similar product packaged in air.

Materials for MA Packaging

Selection of materials based on their barrier properties depends on the degree of protection required for the product and the target shelf life (Section 8).

Table 3 Some MA Products in France

Food Item	Temp. (°C)	Shelf life (days)* Air	Shelf life (days)* MA	Gas concentration (%) CO_2	Gas concentration (%) N_2
1. Roule au Fromage (cheese roll) bakery products stuffed with ham pieces and grated cheese	5	5	>10	50	50
2. Bouchee a la Reine (Danish pastry) pastry stuffed with chicken pieces and bechamel sauce	5	5	>10	50	50
3. Pizza and quiches	5	6	21	50	50
4. Pasta with meat	4	5	>14	80	20

* French standard >3.0 x 10^5 Total Aerobic Count

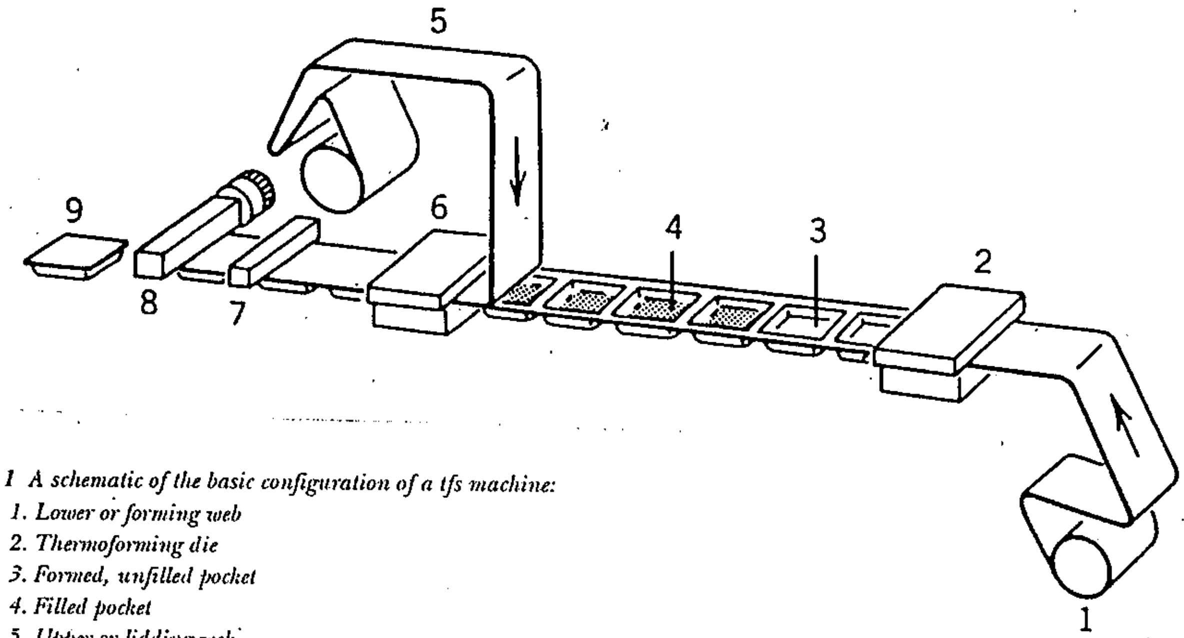

Figure 1 *A schematic of the basic configuration of a tfs machine:*

1. *Lower or forming web*
2. *Thermoforming die*
3. *Formed, unfilled pocket*
4. *Filled pocket*
5. *Upper or lidding web*
6. *Vacuum / sealing die*
7. *Flying knife for across-the-machine direction package cut-off*
8. *Highspeed rotary knives for package cut-off in-the-machine direction*
9. *Finished package.*

For semi-rigid containers, the bottom web should be thermoformable. Unplasticised PVC (usually with PE) is commonly used because it is cheap and has medium barrier properties to gases and water vapour. Usually 400—800 um has suitable structural and barrier properties (350 um PVC/50 um PE = 10cm^3/m^2 (24 h) (atm) at 23°C, 75% RH). Other medium barrier materials such as PET and high barrier multilayer materials such as HDPE/Barrier/HDPE, PP/Barrier/PP, PP/Barrier/PE, and HIPS/Barrier/PP could be used, while the most common thermoformable flexible bottom webs are nylon-based materials.

The top web (or cover film) of the package could be nylon or polyester-based material with an oxygen permeability of 10 (cm^3/m^2 24 h) or better.

A measurement of actual package permeabilities to oxygen, carbon dioxide, and water vapour at actual storage conditions is recommended since the properties of the bottom web may be altered by thermoforming and storage conditions.

Package Design and Packaging Equipment

Generally, carbon dioxide is required at a minimum level of 20%, however, when using semi-rigid packages, it is recommended that the maximum carbon dioxide level be 80% in order to avoid package collapse due to the dissolution of carbon dioxide in the water of the product and its permeation out of the package (carbon dioxide transmission rate compared to oxygen for most materials ranged from 2-5). Low residual oxygen is important. A residual oxygen level of 0.5% or below is generally recommended for meat and pastry combinations. Recommended head space for MA packages is about 40—60% of the package volume.

Packaging equipment for MA operations could be classified into two main broad categories: Chamber, and thermoform-fill-seal (tfs) systems.

The chamber packaging system is used with preformed pouches. These machines are relatively cheap, and the operation is simple, but slow. A variety of imported and locally made machines are available.

By far the most common machines for MA packaging are the tfs which could produce a variety of trays and/or cups. Tfs systems used in western Europe include those from Multivac, Kraemer and Grebe (Tiromat), Dixie Union and Waldner.

Tfs machines use two continuous webs or rolls of film (Fig. 1). Typically the lower web is formed to create a cavity, which is then filled with the product. The upper web becomes the lid. Although 90% of all tfs machines are run with formed bottom webs and unformed lid stock, it should be mentioned this is not always the case. After loading the product, the unsealed package is indexed automatically into a vacuum chamber, then all the air is removed from the package. Once the air is removed, the desired gas mixture is injected into the package, usually until the pressure of the gas inside the package reaches the desired setting.

'Active' Packaging Materials

New packaging materials which interact with the surface of the food as well as the head space atmosphere inside the package could be used as an alternative or supplementary technique to vacuum and/or gas flushing. These 'active' materials generally act either in the packaging material or within inserts (sachets) in the package. The effects of current materials are mostly specific: oxygen removal, carbon dioxide removal/release, water removal, gas indicator, anti-microbial action, preservative release, and aroma release.

Most of the technologies used in the manufacture of these modifiers originated in Japan and the materials had been used in that country for many years before introduction into North America.

Oxygen Absorbers. The basic system consists of finely divided reduced iron powder (one gram of which will react with 300 cc of oxygen) contained in a sachet like a desiccant. When placed in packages, they are capable of removing oxygen from the package interior down to less than 0.01 per cent. Further, the presence of oxygen absorbers obviates the effects of any oxygen entering as a consequence of permeation or transmission after package sealing. Some commercially available oxygen absorbers are 'Ageless' (Mitsubishi Gas Chemical Co., Japan), 'KF-Pack' (Toppan Printing Co., Japan), and FreshPax (Multiform Desiccants, USA).

Carbon Dioxide Absorbers/Generators. A complimentary approach is the incorporation of a carbon dioxide generating or scavenging system into the film or sachet as with the case of the oxygen sachet. Current oxygen absorber series also consists of types which absorbs oxygen and generate an equal volume of carbon dioxide.

The CSIRO National Centre for Food Processing is currently developing processes to incorporate the scavenging medium into the packaging material.

Antimicrobial Agents. If the spoilage is strictly surface growth, then a film or sachet that emits an antimicrobial agent such as is done with antioxidants would be of value. The major commercial system is the ethanol (a germicidal agent) emitter sold under the trade names 'Ethicap' or 'Antimold 102' (Freund Co., Japan). 'Ethicap' is a sachet that releases ethanol vapour into the package head space. The vapour deposits on the food surface thus eliminating the growth of mould, yeast and other pathogens. Traces of vanilla or other flavours are usually added to mask the odour of alcohol. For apple turnovers, a shelf life of 21 days was reported when 'Ethicap' was used in combination with MA packaging. The reported disadvantage of using this system was its absorption by the product. However, heating the product prior to consumption would eliminate most of the ethanol. Therefore, the use of 'Ethicap' as a food preservative may be limited to 'brown and serve' products.

Indicator Systems. Another 'active packaging' approach is to place a time-temperature indicator system on the package to warn the consumer when the product is spoiled or possibly dangerous to eat. One such device is manufactured and marketed by 3M Co. based on diffusion of a dye down a wick. However, work is still needed to come up with time / temperature sequences which are indicative of spoilage or safety so that the cut-off point on the device can be set.

Microwave Liquid Absorbers. There is a new microwave container in Japan that holds a piece of chicken. The base layer of absorbent paper mops up the liquids which emerge during the cooking process and provides a dry, crispy prepared product.

Freezer/Chiller to Microwave Materials

'Heat set' PET (polyethylene terephthalate) containers are reported to tolerate 121°C without significant distortion occurring (normal PET shrinks at 65°C). The process is generally slower, resulting in higher cost than standard PET containers. This so called APET is ideal for hot-fill applications, and microwave heating/re-heating.

Another fast growing application of PET is 'dual-ovenable' trays (CPET – crystallised PET) for frozen and prepared meal. These trays are thermoformed from cast PET film and crystallised. The main advantages of CPET include suitability for both conventional and microwave oven, light weight, and superior aesthetics (as compared with foil trays). They are temperature stable between -40 and 220°C. And like any other plastics, they can be produced in a variety of configurations, and they are dishwasher-proof, which means they can be re-used.

These generations of PET have moderate barrier properties, therefore their application would be limited to MA (chiller to microwave/oven) and freezer to microwave/oven applications.

Vacuum-skin Packaging

Vacuum-skin packaging (VSP) is a new form of vacuum packaging that is rapidly becoming popular. The plastic material used takes the shape of the product with effectively no head space in the package. This packaging technology lends itself to purchase and storage of portion-controlled products. Since all the contact area between the top and bottom layers is sealed, VSP offers a variety of attractive packaging options.

The packaging materials available range from permeable (for products that need oxygen) to high-barrier materials. The bottom half or base could be semi-rigid or flexible material.

The Retort Pouch

Often called flexible packaging's 'most major failure', the retort pouch now seems destined for commercial success in the 1990's. The environmental era with its intense concentration on source reduction has suddenly made the retort pouch of the 1960s, the most dynamic new package of the 1990's.

The retort pouch is now available in various forms.

Opaque (Foil). The most widely used flexible laminate for the retort pouch consists of a three-ply construction based on PET/foil/PP. The PET is used for strength and puncture resistance, foil for both an oxygen and moisture barrier, and PP for high seal strength at retorting temperatures. Alternative structures may include nylon or HDPE as the sealing ply. There are also constructions available including a nylon ply between the PET and foil for additional strength and puncture resistance (PET/nylon/foil/PP).

Transparent. There are many different transparent retort pouches on the market world-wide. Generally, these materials do not have barrier properties as foil. They are commonly used to packaged products sold at refrigerated temperatures.

Materials now on the market include:

PET/PVDC/PP (mostly for chilled products)

Nylon/PVDC/PP

MXD-6 (Nylon)/PVDC/PP

SiO_2/PET/PP

Meats are quite popular in retort pouches because the product generally withstands heat sterilisation quite well, and there is a market demand for smaller size portions for which the pouch is ideal.

Representative packers using retort pouches (four side seals) include Miss Molly Foods and Star Foods (US), Waitrose (UK), Snow Brand (Japan) and Magic Pantry (Canada).

Pieper Fruedrich in Germany uses a Multivac pouch with an easily formable bottom web of Nylon/PVDC/PP combined with a PET/ foil/PP lidding web for entrees and other meat products. A shelf life of six months is reported even without a complete foil structure.

The gusseted pouch (Doypack) is quite popular in both Japan and other nations. In the UK, RHM Foods is using four-ply Doypacks to package its 'Bistro Casserole Saucery' range of retortable cook-in sauces.

The main advantages of the retort pouch include:

- improved product quality (less overcooking)
- 40% savings in weight and volume (no brine/sauce)
- savings in storage space and weight
- easy to open (scissors or tear notch)
- boil-in-the-bag application

Plastics for Retort/Sous Vide Processing

In-container sterilisation using rigid or semi-rigid plastic containers is one of the most significant packaging developments with the enormous market at present supplied by glass jars and cans. Plastics offered limitless options in pack presentation (e.g. 2 to 3 compartments) and shape.

Plastic material for thermal processing must possess both adequate heat resistance and barrier properties (i.e., against oxygen and moisture transmission). Commonly used materials are extruded sheets consisting of two outer layers of polypropylene or propylene copolymer with sandwich barrier layer of EVOH or PVDC copolymer between. At present trend, EVOH is preferred over PVDC because of its ease of recyclability. However, EVOH is not used as coating medium because of its moisture sensitivity, which produces its barrier property.

Current success has been in designing containers to run through existing can — or bottle-filling and sealing/seaming lines. A good example is Edgell's Quick Shots (winner 5th Dupont award for innovation in food processing). Quick Shots are a range of microwavable meals packaged in plastic bowls developed by HiTech Limited of Victoria and produced by ACI Coex. The plastic material consists of 2 PP layer (virgin and reground)/EVOH/2 layersPP. A special cuspation / dilation technique is used to produce this light bowl container that is capable of being seamed using conventional canning lines. Before microwave heating, the container's inner aluminium closure has to be removed and the cover replaced.

Aside from conventional seams, lids could be foil or non-foil laminates. For example, a newly developed non-foil lid will release by itself in the microwave. The material is a laminate using nylon, modified PP, and a co-polymer barrier layer. It is retortable at 121°C and it seals PP containers over a range of 180-195°C.

The above-mentioned materials could be used for sous-vide processing which requires less thermal processing (about 5 min at 70°C compared to conventional sterilisation of 3 min at 121°C).

Aseptic Packaging

Aseptic packaging represents a true synergistic marriage of food processing and packaging. The food and the package are sterilised separately, usually by different methods. The food undergoes continuous heating in a heat exchanger while the package may undergo chemical thermal, or radiation treatments. Since the package need not withstand the same sterilisation process as the food, cheaper paper-based materials can be used. The sterilised food and packages are brought together and aseptically filled and sealed.

Products which suffer during long sterilising heat treatments are the best candidates for aseptic processing. These may include ravioli, spaghetti and meat sauce, stews and beef stroganoff.

The commercial success of paperboard-based aseptically packaged juices and related products has led to the development of new generation aseptic packages. Many of these packages are made from multi-layered, thermoformed materials. These containers are usually heat sealed with a flexible lid material.

Example - Carton Laminates. The most common aseptic packaging material is the composite material for carton, PE and aluminium foil. Typical arrangement from inner side to outside is PE/Al/PE/carton/PE. Carton is the carrier material giving stiffness, grip and stacking stability, while its folding capacity enables forming of the sheets. The inner PE layer provides liquid resistance and facilitates hermetic heat sealing of the seams. The aluminium foil provides primarily a barrier against light and oxygen.

Packaging Materials/Package System

In selecting a packaging material or a package system, many factors must be considered, including the total cost, legal requirements, market requirements, utility, product compatibility, mechanical properties (package integrity) and barrier requirements of the product.

Emphasis towards convenience has added another set of requirements specifically dealing with the consumption habits of the end user. Microwavable, multi-use, easy-to-open and family-sized packages are all being used today to create a market advantage.

Product/package compatibility should be also considered – migration from the packaging material to the product and absorption or adsorption of flavour compounds inherent to the product by the packaging material (scalping). Scalping of flavour compounds is a concern for many aseptic products.

Barrier Requirements. Data such as those presented in Table 4 serve as an estimate of the protection needed which can be used to determine the need for barrier in relation to target shelf life.

Barrier characteristics of several materials are summarised in Tables 5 and 6. Plastics differ widely in their characteristic permeabilities to water vapour, oxygen, carbon dioxide and volatile organics and these permeabilities are affected by temperature and humidity as well. Permeability generally increases with temperature. The effect of relative humidity depends upon the capability of the polymer to absorb moisture (e.g. nylons, vinyls, particularly EVOH).

For multi-layered materials, the overall permeability of the film could be estimated from the following series equation:

$$L_T/P_T = L_1/P_1 + L_2/P_2 + \dots L_n/P_n$$

where $L_1 \dots L_n$ are the thickness of the layers, and $P_1 \dots P_n$ are their permeation rate. L_T and P_T are the values for the entire material.

In closing, it is hoped that these new packaging technologies would be used by Australian processors/manufacturers to produce high-value meat products that are internationally competitive.

Table 4 Degree of Permeation Protection Required by Selected Foods& Beverages

Food/Beverage	Estimated Max. Amt. of O_2 Gain Tolerable (ppm)	Other Gas Protection Needed	Est. Maximum Degree of Water Gain or Loss Required	Requires High Oil Resistance	Requires Good Barrier to Volatile Organics
1. Canned Milk, Canned Meats, Canned Fish, Poultry	1—5	–	3% loss	x	–
2. Baby Foods	1—5	–	3% loss	x	x
3. Beer, Ale, Wine	1—5	>20% CO_2 loss	3% loss	x	x
4. Instant Coffee	1—5	–	2% gain	x	x
5. Canned Vegetables, Soups, Spaghetti, Catsup, Sauces	1—5	–	3% loss	–	–
6. Dried Foods	5—15	–	1% gain	–	–
7. Carbonated Soft Drinks	10—40	>20% CO_2 loss	–	x	
8. Salad Dressings	50—200	–	10% gain	x	x

Table 5 Barrier Polymers

Polymer	O_2 permeation[a]	Water barrier
poly (vinyl alcohol)	<0.01 [<0.04](0% rh)	poor
poly (acrylonitrile)	0.04[0.16]	good
ethylene-vinyl alcohol, 70% VOH	0.017[0.066](0% rh)	poor
PVDC Homopolymer	0.10	excellent
cellophane	0.17[0.66](0% rh)	poor
ethylene-vinyl alcohol, 60% VOH	0.17[0.66](0% rh)	poor
PVDC copolymer (90% VDC)	0.25[0.97]	excellent
PVDC, plasticised	1.3[5.1]	excellent
polyamide (nylon-6)	1.5[5.8](0% rh)	poor
polyamide (nylon-6, 6)	2.5[9.7](0% rh)	poor
poly(ethylene terephthalate) film	3.0[12]	good
polyamide copolymer	4.5[17]	poor
poly(vinylidene flouride)	4.5[17]	excellent
poly(ethylene terephthalate) bottle	5.0[19]	good
polyamide (nylon-6, 10)	6.0[23]	fair
poly(vinyl chloride)	8.0[31]	good
poly(ethylene terephthalate), amorphous	10.0[39]	fair

[a] $cm^3 \cdot mil/100\ in^2 \cdot d \cdot atm$ [3.886 $cm^3 \cdot um/(m2 \cdot d \cdot kPa)$ at 23°C, 50% rh unless noted

Table 6 Permeability of Lower-Barrier Polymers

Polymer	O_2 permeation[a]	Water barrier
polyvinyl(flouride)	15.0[58]	excellent
polyamide (nylon-11)	26[100]	fair
poly(ethylene terephthalate) copolymer	26[100]	poor
polystyrene copolymer (25% acrylonitrile)	65[250]	poor
polyethylene (*d* = 0.96)	110[4270]	excellent
polyurethane, elastomer	135[5250](0% rh)	poor
polypropylene	150[583]	excellent
polycarbonate	225[874]	poor
polybutene	330[1280]	excellent
polyethylene/vinyl acetate	350[1360]	fair
polystyrene	420[1630]	poor
polyethylene (d = 0.92)	480[1870]	excellent
polyethylene ionomer	550[2140]	good

[a] $cm^3 \cdot mil/100\ in^2 \cdot d \cdot atm$ [3.886 $cm^3 \cdot um/(m2 \cdot d \cdot kPa)$ at 23°C, 50% rh unless noted