RURAL INDUSTRIES RESEARCH
& DEVELOPMENT CORPORATION

Adding Value to Venison Forequarters and Trimmings

Using Cold-Set Binders

A report for the Rural Industries Research and Development Corporation

by Dean Gutzke & Aarti Tobin
Food Science Australia

October 1998

RIRDC Publication No 98/102
RIRDC Project No CSS-1A

ISBN 0 642 578133
ISSN 1440-6845

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Published in October 1998
Printed on environmentally friendly paper by the DPIE Copy Centre

Foreword

The Australian meat industry often uses trimmings and under-utilised forequarters to produce relatively low value products because the pieces of meat are either the wrong shape, or are too small to be sold as premium cuts. This reduces profit margins for the meat processing sector.

The following research, by Food Science Australia researchers Dean Gutzke and Aarti Tobin, details the development of cold-set binder technology to manufacture high-quality venison steaks and roasts from lower-grade meats.

The study investigated a number of processing factors and identified two different binding processes that were required to manufacture restructured steaks or roasts that were safe to eat and had acceptable quality with no foreign meat flavours.

The report forms part of RIRDC's Deer R&D program, which aims to foster an Australia deer industry as a highly profitable and efficient mainstream agricultural enterprise.

Peter Core
Managing Director
Rural Industries Research and Development Corporation

Acknowledgements

This work is dependent upon the efforts of a number of people. The people who were of primary assistance in the completion of this research are the members of the Value Added Meats Group of Food Science Australia, Brisbane Laboratory. In particular, the authors wish to acknowledge the significant contribution of Peter Finitsis and Grant Johnson who provided technical assistance in this project. In addition, Peter Torley helped in the preparation of venison samples for microbiological and sensory analyses.

A number of companies must also be thanked for supplying samples and technical assistance in the use of their ingredients. Binders were supplied by Earlee Products and Kelco Pty Ltd. In addition, contributions were made by Oppenheimer Pty Ltd. Lesnies provided sauces and spices for the products used for demonstrations and for photographs. Mountain Valley Venison of Crows Nest in Queensland supplied fresh forequarters and trimmings from a range of breeds for the experiments. In particular, we wish to thank Graham Taylor of Swickers Kingaroy Bacon Factory who assisted in the collection and preparation of venison samples for the experiments. Also, a special thanks to Salm's Continental Butcher of Brisbane for allowing us to have fresh venison samples delivered and stored chilled at their premises until being transported to the laboratory for processing.

Woolworths also contributed to this project. In particular, the Sales Managers of Woolworths Meat Division have assisted in the preparation of the project proposal. In this way, Woolworths supported the cold-set binder technology as a means of portion control of small venison cuts. Finally, Brismeat of Ipswich assisted in the delivery and storage of venison samples in the early stages of the project.

A special thanks also goes to the Food Safety and Consumer Science Groups of the Brisbane Laboratory for their assistance with the sensory evaluation and microbiological analyses of the cold-set bound venison products. Finally, Food Science Australia wishes to acknowledge the valuable insight of the RIRDC in funding this project, which will surely benefit the Australian venison industry as it realises the potential benefits of value-adding methods such as the one used in the current research.

Preface

Venison trimmings contain large amounts of connective tissue and gristle. Upon cooking, this material is often tough and unacceptable to eat. Consequently, venison trimmings are commonly used to produce relatively low value products. Similarly, venison forequarters have limited application in meat products because the pieces of meat are either the wrong shape, or are too small to be sold as premium cuts. This causes economic losses to the Australian meat industry. From a processor's point of view, there is a need for a technology to increase the utilisation and the value of under-utilised forequarters and trimmings. The purpose of this research was to develop cold-set binder technology that could be used by the processor to manufacture venison steaks, slices and roasts from lower-grade meats such as forequarters and trimmings.

It is anticipated that this technology will offer a wide range of applications to the venison processing industry as a new method of value-adding to under-utilised venison forequarters and trimmings.

This report contains processing protocols that can be used by processors to produce cold-set bound venison steaks, slices and roasts from under-utilised forequarters and trimmings.

In the present study, a number of processing factors such as type and concentration of binder, process of forming the bind, meat particle size, optimum temperature and pH, and the effect of different breeds, were investigated. The results of these trials indicated that two different binding processes were required to manufacture restructured steaks or roasts. According to the results of the microbial and sensory evaluation, both steaks and roasts produced in this way were found to be safe to eat and have acceptable quality with no foreign meat flavours. The two cold-set binder processes developed in this project will be transferred to the industry via personal communications with venison processors.

This RIRDC funded project is associated with the Deer Program which aims to foster the continued growth of a viable Australian deer and deer products industry.

Dean Gutzke & Aarti Tobin
Food Packaging and Technology Group
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Abbreviations

Abbreviation	Abbreviated Word
GDL	Glucono-delta-lactone
ECL	Encapsulated calcium lactate
PVC	Polyvinyl chloride
PAMB	Protein Activated Meat Binder
DN	Denuded
Baad Dn	Baader denuded
KP	Kidney plate
DD	Degree of doneness
cfu / cm^2	Colony forming units per cm^2

Executive Summary

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In the present study, a number of processing factors such as type and concentration of binder, process of forming the bind, and meat particle size were investigated in cold-set bound venison products. A number of different cold-set binding technologies were evaluated with venison forequarters and trimmings. Commercially available cold-set binders that were trialed in this research included Pearl F, alginate, ACTIVA, Protein Activated Meat Binder.

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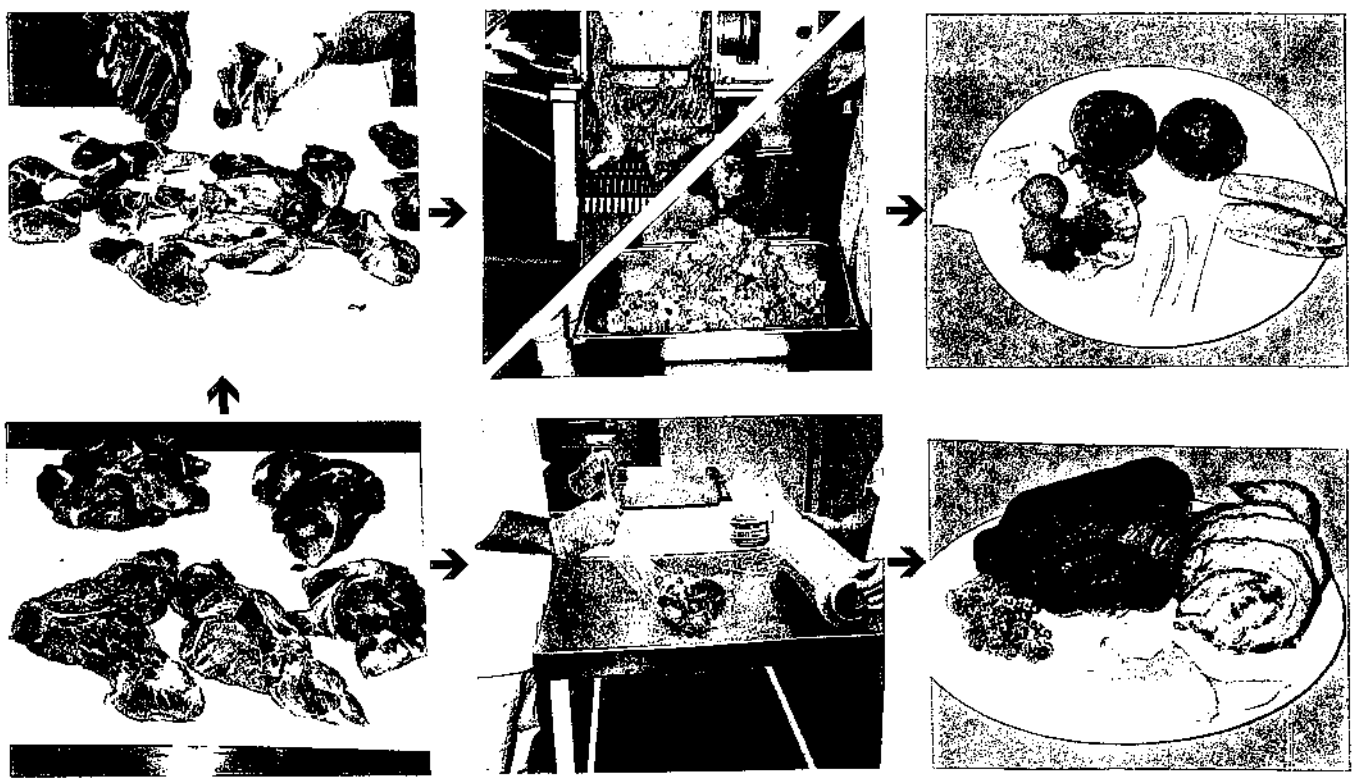

Figure 1: Cold-set binding processes used to manufacture venison products from forequarters and trimmings

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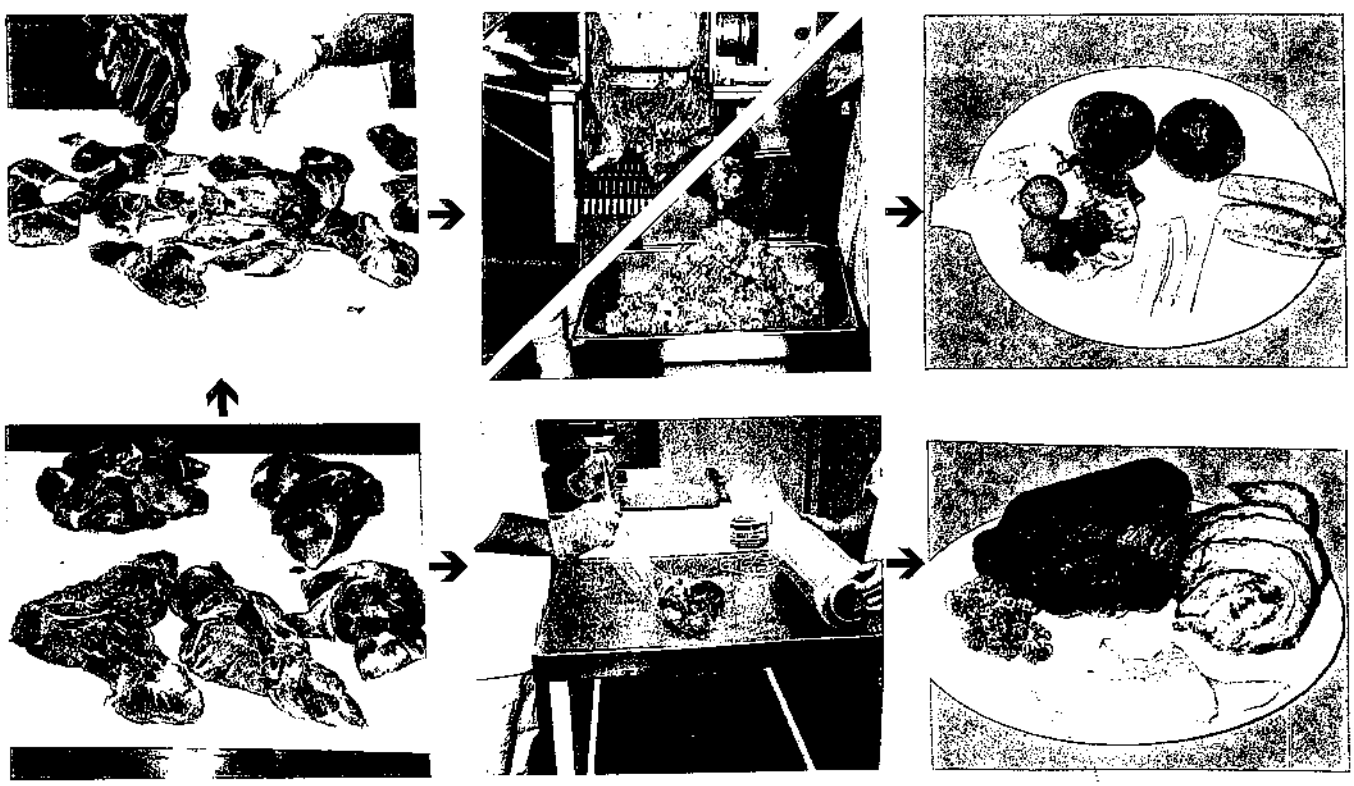

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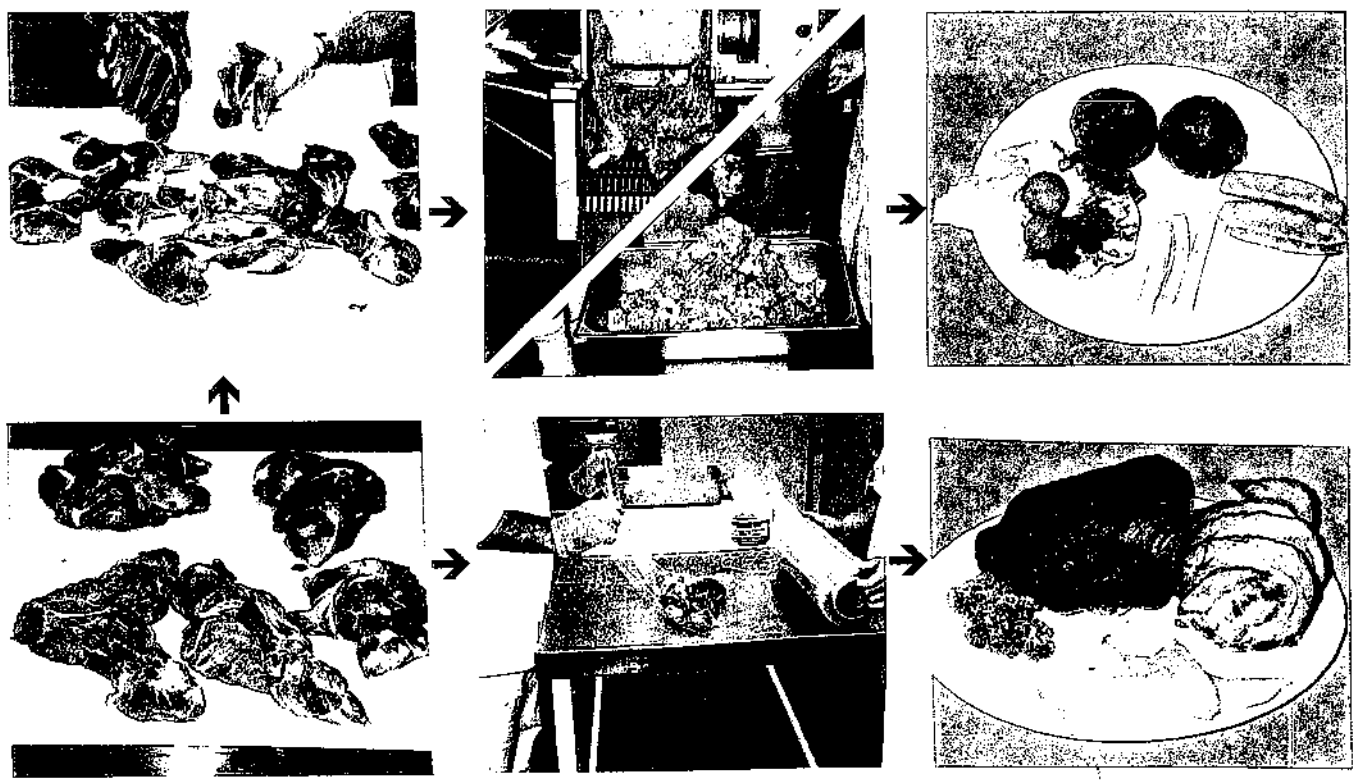

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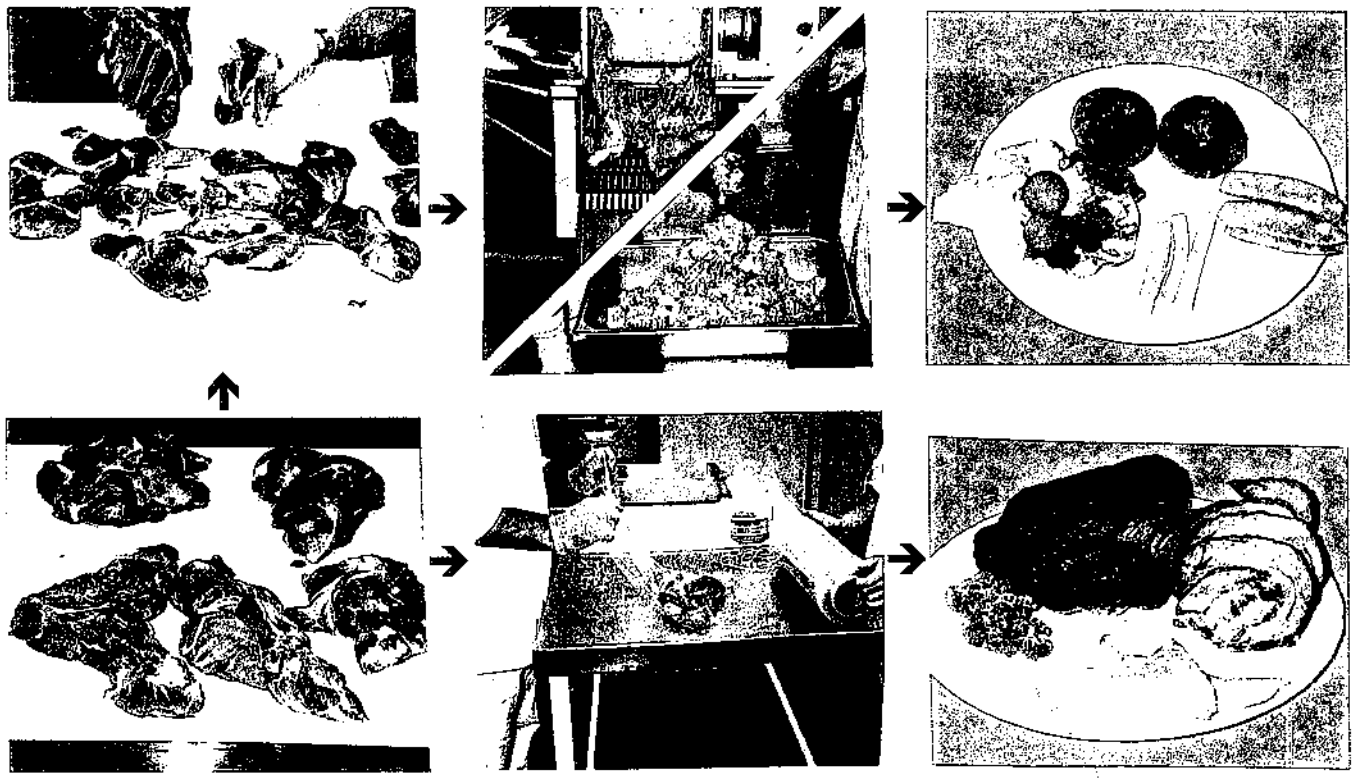

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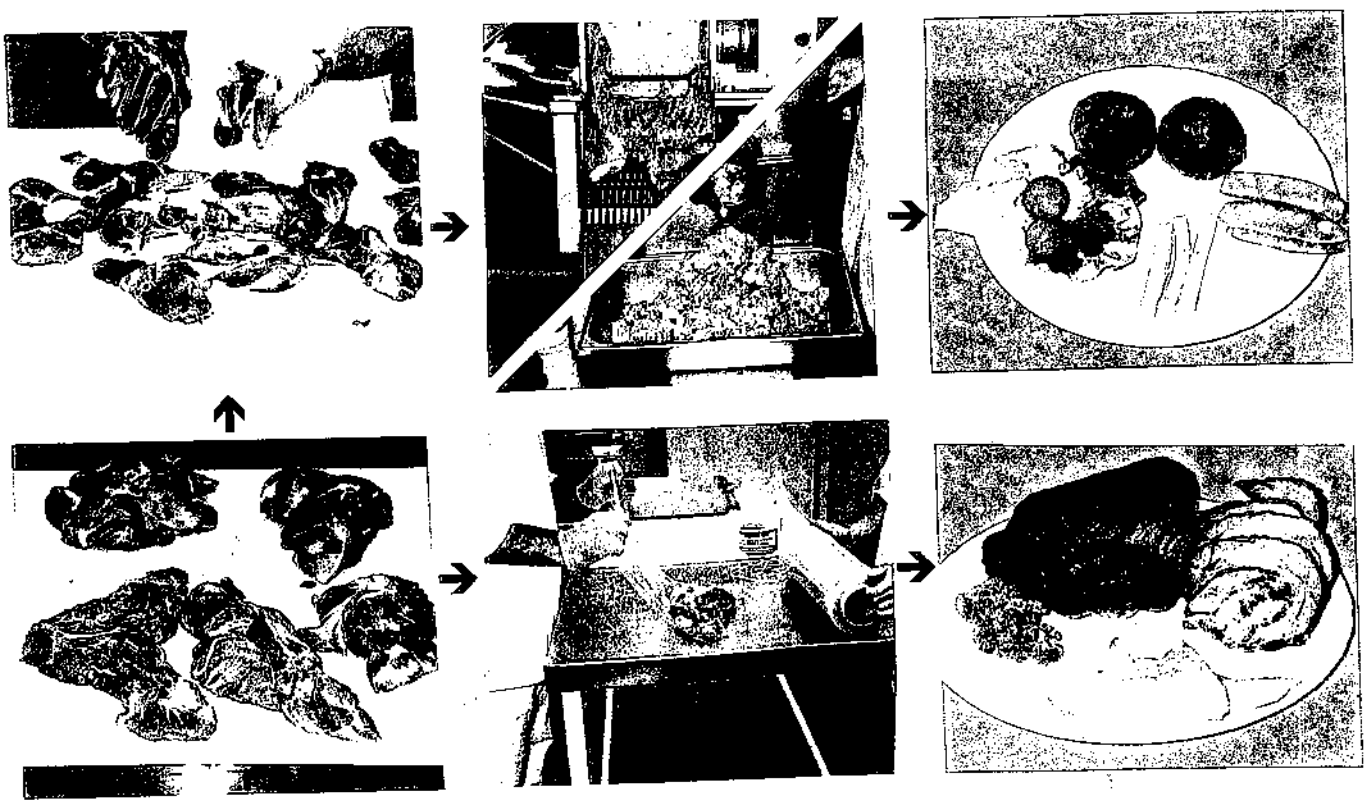


Figure 1: Cold-set binding processes used to manufacture venison products from forequarters and trimmings

Alginate-Bound Restructured Venison Steaks (Photo 1)

The best cold-set binding technology for venison trimmings used alginate as the binder. A summary of the process is shown in Process 1. Initially, venison trimmings were sorted into meat containing connective tissue and meat containing little or no connective tissue. Cartilage was removed during the sorting process. Venison trimmings containing high levels of connective tissue were desinewed (Process 1; step 1); trimmings containing little obvious signs of connective tissue were minced through a kidney plate (Process 1; step 2). A blend of desinewed (30%) and minced (70%) meat was mixed for 1 minute in a Hobart Mixer at medium speed (setting of 2) using the dough-hook mixing attachment (Process 1; step 3). Alginate was then sprinkled on to the meat and mixed for 1 minute. Calcium carbonate ($CaC0_3$) was dispersed in water and then added to the meat, and the meat was mixed at medium speed for 1 minute. Finally, GDL was added and mixed for a further 1 minute. The meat containing the binder was filled into 60mm diameter casings using a hand sausage stuffer (Process 1; step 4), and both of the casing ends were clipped. The product was stored overnight in the chiller (0°C), or frozen, to allow the bind to form (Process 1; step 5). Once the bind had formed, the restructured logs were sliced or band sawed into steaks of uniform size and shape (Process 1; step 6).

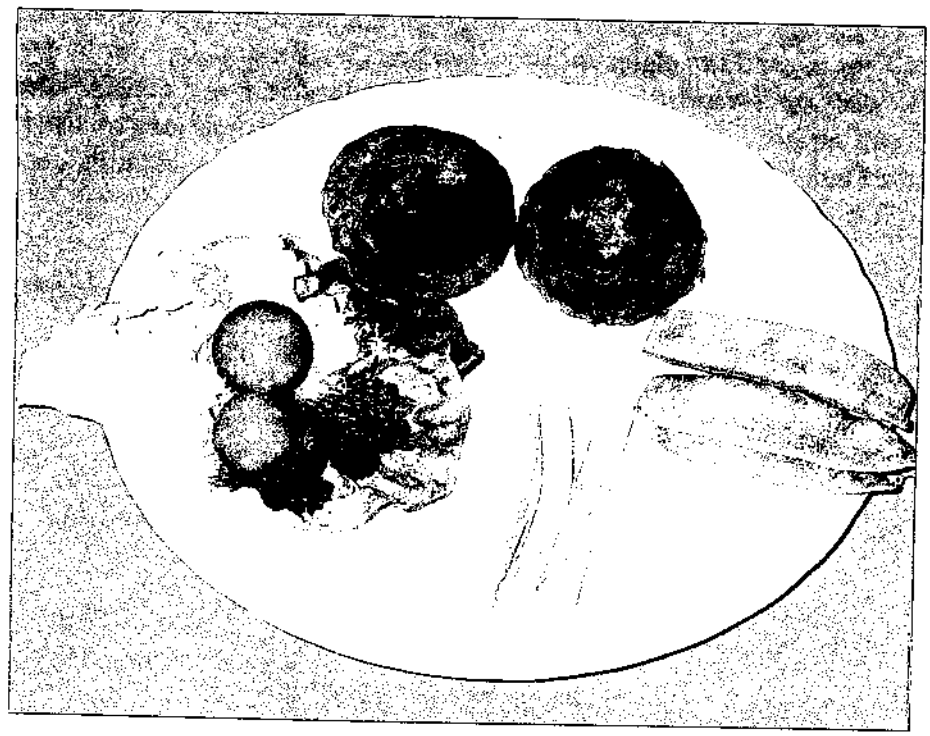


Photo 1: Alginate-bound restructured venison steaks prepared as the meat component in ready-to-eat meals

Pearl F-Bound Roasts (Photo 2)

For the larger pieces of meat in boneless venison forequarters, the best cold-set binder was Pearl F. The method used to manufacture the Pearl F-bound venison logs from whole venison forequarters is shown in Process 2. The surface of boneless venison forequarters was coated with Pearl F by either dusting or dipping the meat into the binder (Process 2; step 2). The coated surfaces were pressed together and the meat rolled using over-wrapping film (Process 2; step 4) to form a log (Process 2; step 5). The product was stored overnight in the chiller (0°C) to allow the bind to form.

Photo 2: Ready-to-eat roast slices produced from Pearl F-bound venison forequarter meat

The restructured venison steaks (Photo 1) and roasts (Photo 2) produced by both cold-set binding processes were evaluated to determine the colour display-life and bind strength of the raw product, and to investigate whether the binders used in the current research produced an unacceptable flavour in the cooked product. In summary, cold-set binder technology was shown to be compatible with venison products, and in some cases actually improved the colour of the product (Table 1). Both steaks and roasts produced in this way were found to be safe to eat and have acceptable quality with no foreign venison flavours. In addition, these products looked similar to whole tissue meat and could compete with higher-value products.

Table 1: The colour stability, raw bind strength, flavour and overall acceptability of cold-set bound venison products

Colour Stability

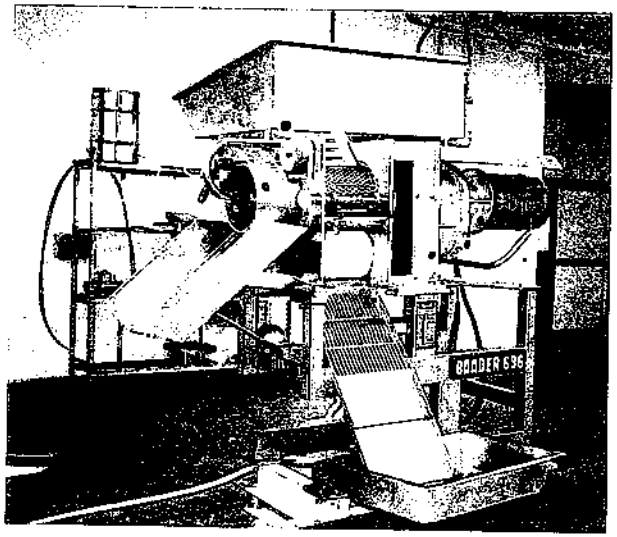
- Whole forequarters bound with Pearl F produced a similar display-life compared to non-bound venison forequarters ($P>0.05$).
- Alginate-bound minced meat produced a significantly better display-life compared to non-bound minced product ($P<0.05$).

Bind Strength

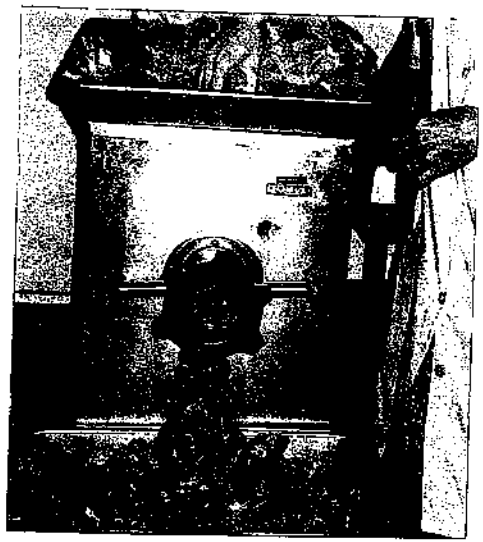
- Alginate and Pearl F binders produced an effective raw and cooked bind on minced trimmings and forequarters, respectively.

Flavour

- There were no significant differences in flavour between the control and the venison meat that was bound with Pearl F or alginate ($P>0.05$).

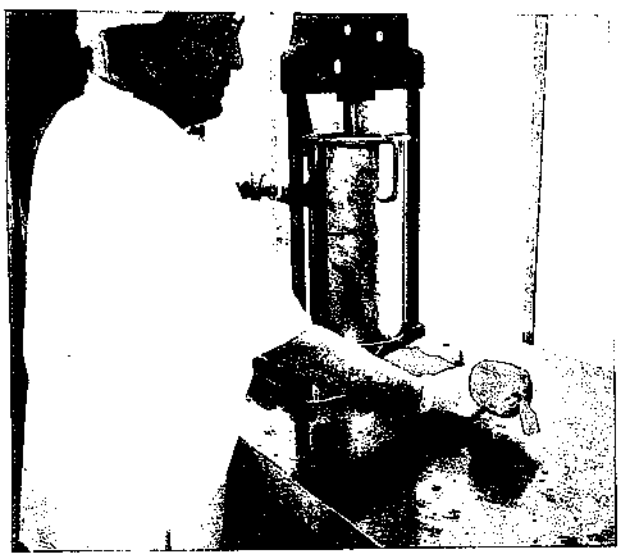


1. Desinewing



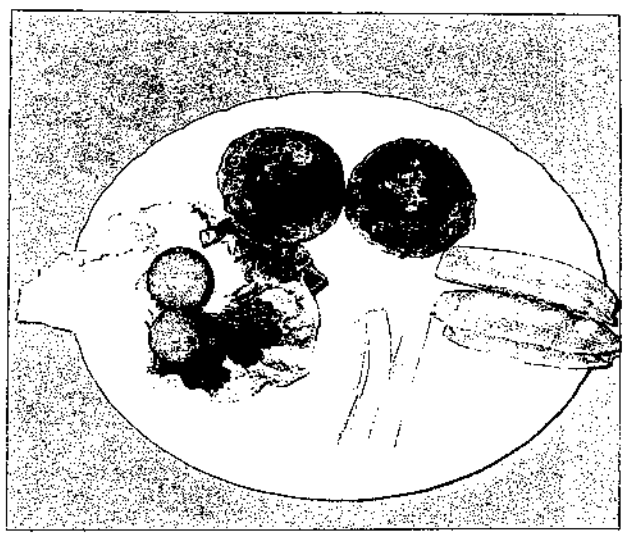
2. Mincing

3. Mixing



4. Filling

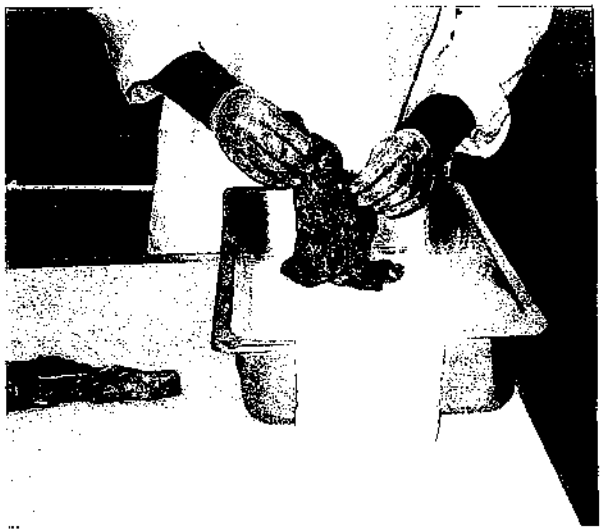
5. Restructured log



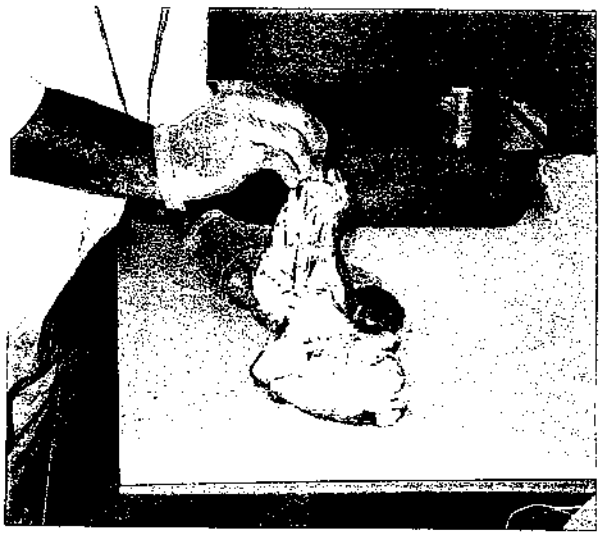
6. Restructured steaks

Process 1: Alginate-binding process used to restructure minced and desinewed venison trimmings

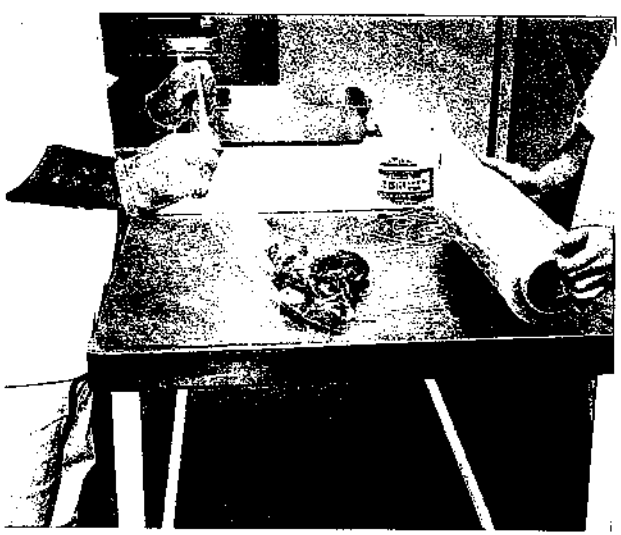
1. Venison forequarter



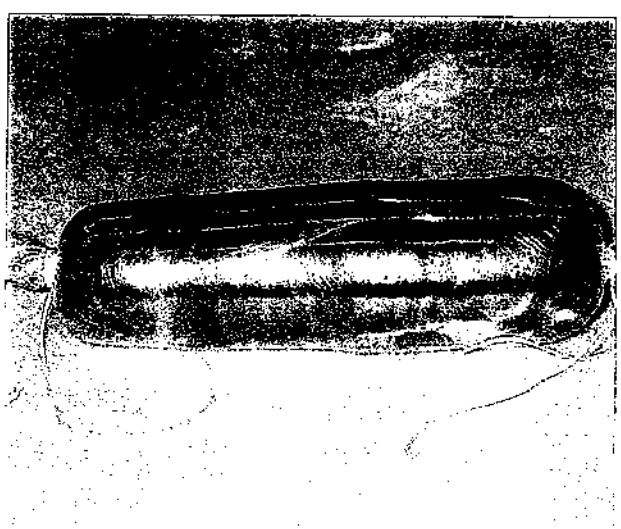
2. Coating with binder



3. Coated forequarter



4. Wrap in film



5. Restructured log

6. Venison roast

Process 2: Pearl F-binding process used to produce rolled, portion-controlled venison forequarters

1. Background To Research

Compared to venison primals, venison forequarters and trimmings are sold at a relatively low price by meat processors. This meat quite often contains high levels of connective tissue and some small pieces of gristle. The low value of venison forequarters and trimmings is a result of the limited commercial uses of this meat in high quality products, which means they are generally in oversupply. Because of the oversupply, the price of venison forequarters and trimmings is maintained at a fairly consistent, low price, irrespective of the current value of live venison in the market. By contrast, venison primals are in high demand and their price reflects the balance between supply and demand; the price varying with the price of live venison.

At present, venison trimmings are commonly used in relatively low-value minced or finely comminuted meat products. An alternative to this is to produce high-value restructured products from this material. During the past decade, considerable attention has been given by the meat processing industry to the manufacture of restructured meat products. Restructured meats have been developed as a means of producing new products and a means of upgrading and utilising meat, which is considered to be of lesser economic value. A major benefit of restructured meat products is that they can be adapted to consumer needs for convenience, portion size, composition and ease of preparation (Mandigo, 1988).

There are two main approaches to manufacturing restructured meat products; hot-set restructured meat products and cold-set restructured meat products. Using hot-set binders is the traditional approach to manufacturing restructured meat products. Typically, this is done by mixing meat pieces with salt and polyphosphates, filling the meat into casings and cooking. The salt and polyphosphates solubilise part of the meat proteins, and these solubilised meat proteins forms a gel when cooked. The gel made of solubilised meat proteins binds the meat pieces together.

While salt and polyphosphates have been used effectively to manufacture a wide range of meat products, there are a number of problems with the technology. Firstly, salt and polyphosphate bound meat products have to be processed and sold when either frozen or pre-cooked because the bind between meat pieces is too weak to withstand handling during processing, packaging or domestic cooking. Secondly, the added salt can accelerate the development of rancidity and discolouration of the product during storage. While manufacture of restructured meats without salt greatly reduces colour deterioration, it has the detrimental effect of reducing the bind between meat pieces (Schwartz & Mandigo, 1976). Thirdly, some consumers wish to limit their Na^+ intake for health reasons, which makes products containing added sodium chloride and sodium polyphosphates unattractive. Finally, polyphosphates are suspected of causing calcium mobilisation and stomach upsets. Because of the limitations of salt and polyphosphate bound restructured meat products, it is desirable to develop restructuring technologies that produce a high quality product with a strong bind.

It is possible to manufacture restructured meat products using binding agents such as casein, egg albumen and wheat proteins. While these binding agents produce an effective bind between meat pieces, they quite often produce problems associated with salt and

polyphosphate. In particular, all of these binding agents must be cooked in order to form a bind between meat pieces. As a result, restructured products manufactured with these binders must be sold frozen or pre-cooked. In conclusion, while alternate hot-set binders avoid some of these problems, they do not completely overcome the drawbacks of the salt and polyphosphates binders.

Another approach to manufacturing restructured meat products is to employ cold-set binding technology. Various research groups have developed a range of cold-set binding technologies. The types of products that these binding technologies are utilised for varies as some cold-set binding technologies are more suitable for restructuring large pieces of meat, while others are suited to restructuring minced meat.

In addition to the advantages associated with conventional hot-set binders, there are numerous advantages associated with the use of cold-set binders to produce raw, unfrozen restructured meat products. Firstly, there is currently a demand in the market for restructured meats that can be marketed in the raw, chilled state. The use of cold-set binders also removes the disadvantages associated with the use of salt and phosphate in restructured meats. Secondly, some cold-set binders have also been shown to stabilise meat colour during frozen storage (Trout, 1989).

The objective of this research project is to develop cold-set binding technologies that will add value to forequarters and trimmings. It is hoped that the cold-set binder technologies will have a wide range of applications in the venison processing industry. The two main types of cold-set binders, alginate and Pearl F, will be studied. The ability of these binders to form an effective bind between minced and whole-tissue products will be determined. Ultimately, it is envisaged that cold-set binders will be used to produce high quality, uniform restructured products that have enhanced colour shelf-life during fresh and frozen storage. This technology will have a wide application to the venison processing industry; eg. cold-set bound meat products could be formed into any shape or size and be sliced, battered, diced, crumbed, or sold chilled in an overwrapped tray.

2. OBJECTIVES OF THE RESEARCH PROJECT

The overall aim of this project was to develop cold-set binding technologies that could be used by the processor to add value to under-utilised venison forequarters and trimmings. The specific objectives of the research were as follows:

- to determine the most suitable cold-set binding systems that were commercially available to produce high-quality venison products from forequarters and trimmings.
- to develop cold-set binder technology that can be used by venison processors to add value to venison forequarters and trimmings.
- to investigate the use of processing procedures (ie. pH of meat, different breeds, temperature, sizes of meat pieces, etc.) to optimise bind strength, product uniformity and colour shelf-life.
- to determine the microbial and display shelf-life of cold-set bound restructured venison products.
- to determine the quality of fresh and frozen cold-set bound venison products.

3. INTRODUCTORY TECHNICAL INFORMATION

Current trends show an increasing consumer demand for primals, from which steaks and chops are fabricated. Only 15-25% of a carcase yields high-value primal cuts. A large part of the carcase is processed into lower-value comminuted products such as minced meat and sausage products. In particular, venison forequarters that are generally in oversupply to the processor produce lower returns, due to their limited commercial application. Also, increased automation and mechanisation of slaughtering and meat cutting technology has further resulted in increased amounts of small pieces and high-quality trimmings of fresh meat which also end up as minced meat products and sausages. From a processor's point of view, there is a need for a technology to increase the utilisation and value of under-utilised forequarters and trimmings.

An alternative to this is to produce high-value restructured products from this material. During the past decade, considerable attention has been given by the meat processing industry to the manufacture of restructured meat products. Restructured meats have been developed as a means of producing new products and a means of upgrading and utilising meat, which is considered to be of lesser economic value. A major benefit of restructured meat products is that they can be adapted to consumer needs for convenience, portion size, composition and ease of preparation (Mandigo, 1988).

There are several binders that are commercially available to Australian meat processors. These binders are categorised into two groups, based on their mechanism of binding (Table 2). The traditional meat restructuring methods used heat-set binders, which depend on cooking the meat for the binder to form a gel. In "hot-set" binding, the meat pieces are tumbled with salt and phosphate to extract muscle proteins, which set when heated. Conventional restructured meat products depend on binding through the extraction of myofibrillar proteins from the combined effect of salt (NaCl), phosphate and mechanical action, and subsequent formation of a heat-set protein gel matrix (Schmidt *et al.*, 1981). The use of salt and phosphate is important in the manufacture of restructured products because of the beneficial effects on the myofibrillar protein extractability and subsequently increase the binding ability (Schnell *et al.*, 1970), yield and flavour (Mandigo *et al.*, 1972; Huffman *et al.*, 1981; Schmidt & Trout, 1982).

While these binders work well, there are a number of problems associated with using these binders. Firstly, most of these products have to be sold frozen; secondly, the salt which is added to retard bacterial growth and bind the meat pieces, causes some undesirable flavour (Huffman & Cordray, 1979; Trout & Schmidt, 1987) and unacceptable colour during storage (Booren & Mandigo, 1981; Chu *et al.*, 1987; Hunt & Kroft, 1987); and finally, addition of salt and certain phosphates is regarded by certain consumers as undesirable for diet/health reasons. While manufacture of restructured meats without salt greatly reduces colour deterioration, it has the detrimental effect of reducing the bind between meat pieces (Schwartz & Mandigo, 1976). It is therefore necessary to use binders that produce a strong bind without the use of salt and retain the value of high quality cuts.

Table 2: Commercially available binders used to produce restructured meat products

Binders	
Cold-Set Binders[a]	**Heat-Set Binders**
Alginate	Salt and Phosphate
ACTIVA	Soy Protein Isolate
Pearl F	Wheat Gluten
Pearl E or Protein Active Meat Binder	Crude Myosin
Pearl MX-30	Blood Plasma
Fibrimex	
Surimi (fish protein)	

There is an increasing awareness of the use of cold-set binders in meat products because of the current demand in the marketplace for restructured meats that can be marketed in the raw, chilled state. The use of cold-set binders also removes the disadvantages associated with the use of salt and phosphate in restructured meats. Some cold-set binders have been shown to stabilise meat colour during frozen storage (Trout, 1989). Also, the use of a natural enzyme system offers a wide range of applications to the fresh and processed meat industries. Several advantages can be obtained from natural meat binders namely: an increase in the economic value of meat trimmings; meat can be moulded into any size, shape or form; natural ingredients labeling; excellent portion control; no salt or phosphate; no comminution of raw meat so the meat structure is retained to an optimum degree; and fresh and processed meat applications.

The use of cold-set binders is currently very limited. Currently, there are only a few Australian meat companies that are commercially using this technology (personal communications). This is possibly due to insufficient knowledge and lack of information on cold-set binding technology. Most people who have heard of this technology do not know enough for them to see the many opportunities that this technology can bring in terms of the many uses and possible meat products that can be made using cold-set binders. Therefore, the aim of this project was to develop cold-set binding processes that can be used by processors to manufacture venison products from lower-grade meats such as venison forequarters and trimmings. It is anticipated that this will offer a wide range of applications to the venison processing industry in the area of restructured meat products.

4. RESEARCH METHODOLOGY

There are several cold-set binders that are commercially available to Australian meat processors (Table 2). In the initial stages of this project, some cold-set binders were evaluated for use in restructured venison products containing forequarters and trimmings. The cold-set binders investigated in the preliminary experiments of this project, along with the suppliers' recommended usage rates in meat products, are listed in Table 3.

Table 3: Cold-set binders that were investigated in the preliminary trials

Cold-Set Binders	Supplier	Usage Rate
Alginate + GDL + $CaCO_3$	Kelco	0.2-0.8%
Alginate + Encap. Calcium Lactate	Kelco	0.2-0.8%
Pearl F	Earlee Products	dusted or sprinkled
Pearl E (Protein Active Meat Binder)	Earlee Products	dusted or sprinkled
ACTIVA	Ajinomoto in Japan	0.5-2%
Fibrimex	Harimex in Netherlands	5-6%

Binders suitable for use in venison products were selected on the basis of their ability to produce an effective raw and cooked bind in restructured steaks and roasts. Each of these binders was trialed at the recommended usage rates on both restructured steaks and whole-tissue roasts (Table 3). Assessments were subjectively made using a small group of panelists. Preliminary trials indicated that alginate and Pearl Meat binders produced effective raw and cooked bind in steaks and roasts at the recommended levels respectively. The alginate-binding systems (alginate-GDL & alginate-ECL) were suitable for the restructured minced product. In particular, this binder was the best binding system for restructured steaks. Pearl F was effective at binding larger pieces of meat, and was best suited for manufacture of whole tissue roasts and steaks. Consequently, a number of trials were carried out using alginate and Pearl F binders. Therefore, methods of adding value to venison forequarters and trimmings were investigated in two products. These products included:

- Alginate-bound restructured venison steaks
- Pearl F-bound whole tissue roasts

The methodology used to develop and evaluate each of these products is described below.

4.1 Alginate-Bound Restructured Venison Steaks

4.1.1 Preliminary Trials

The mechanism by which alginate forms a bind with meat pieces is a sensitive one. Alginate forms a thermo-stable gel by binding water and calcium ions. Gelation of alginate depends on the pH of the solution and the availability of calcium. The pH of the alginate solution does have an impact on its ability to form a gel, but this seems to be less important at the pH range of meat. An excess of H+ ions or Ca++ ions promote the precipitation of the algin molecule, while water in excess dilutes the solution beyond the range useful for

imparting functional properties in solid or semi-solid products. In summary, gelation is a process where calcium ions, alginate and water are bound physically and chemically to form a semi-solid mass. Therefore, a number of preliminary trials were carried out in the initial stages of the project to determine the important food-grade components for the alginate binder to form an effective bind.

Various combinations of calcium ingredients (calcium carbonate, calcium sulphate, granulated calcium lactate, encapsulated calcium lactate, calcium tetrahydrogen diorthophosphate and calcium phosphate [acid]) and slow release acids (glucono-δ-lactone, granulated lactic acid, encapsulated lactic acid, gluconic acid [calcium salt], adipic acid and fumaric acid) were trailed in the initial stages to determine the optimum formulation for the alginate-binding system.

Preliminary results indicated that only two alginate-binding systems produced restructured venison products with effective raw and cooked bind and acceptable meat flavour and colour. The systems that produced acceptable products included; (i) sodium alginate + calcium carbonate + Glucono-δ-lactone (alginate-GDL; Table 5), and (ii) sodium alginate + encapsulated calcium lactate (alginate-ECL; Table 5).

The gelling mechanism for these systems is quite different. In the alginate-GDL system, availability of Ca++ depends on the high solubility of calcium carbonate, and the switch-on mechanism for the reaction depends on the slower release of H+ by the GDL. In contrast, the gelling reaction of the alginate-ECL is initiated by the slow release of Ca++ and H+ as the encapsulated layer degrades when it is added to the meat. Generally speaking, many of the other acids (gluconic, fumaric & adipic acids) trialed in these preliminary experiments produced a rapid drop in pH, which resulted in a gelation of the alginate as the meat was being filled into casings. This rapid gelation of alginate produces an ineffective bind. In addition, many of the calcium ingredients (calcium sulphate, calcium tetrahydrogen diorthophosphate & calcium phosphate) produced unacceptable flavours. Also, some of these calcium ingredients were not sufficiently soluble, and this affected the bind strength.

In support of these findings, there are a number of reported algin/calcium gel systems in the literature. Several previous studies have successfully demonstrated the algin/calcium gel system in restructured meat products (Means & Schmidt, 1986; Means *et al.*, 1987). While the alginate-binding system has yet to be demonstrated for venison, alginate-binding has been demonstrated previously with various concentrations of sodium alginate, calcium carbonate and GDL. Furthermore, the patented alginate system by Kelco uses sodium alginate in combination with encapsulated calcium lactate. In this system, calcium and acid are slowly released as the fat-encapsulated layer breaks down when it comes in to contact with the meat. Both systems will be investigated in the current research to determine their ability to form an effective bind in restructured venison products.

In summary, two alginate-binding systems were investigated over a range of concentrations to determine optimum binding conditions for these binders. The two alginate-binding systems that were investigated included:

- Sodium alginate + Glucono-δ-lactone + Calcium carbonate (alginate – GDL)
- Sodium alginate + Encapsulated calcium lactate (alginate – ECL)

4.1.2 Raw Material

Venison trimmings that were used to manufacture the alginate-bound products were supplied by Mountain Valley Venison of Crows Nest in Qld. Rusa, Chittle and Red deer were slaughtered at Swickers Kingaroy Bacon Factory Pty Ltd. Venison trimmings were removed from the carcases 24h post-slaughter. The meat was delivered to Salm's Continental Butcher in Brisbane where it was picked-up and transported in an AQIS approved esky to the laboratory. The meat was stored chilled in the carton (< 72 h) at 0°C until processing.

The ability of alginate to bind venison forequarters together was determined over a range of deer breeds. The effect of using Red, Rusa and Chittle breeds on the bind strength of alginate-bound venison products was determined on venison trimmings. The quality of venison meat from each of the different breeds was measured once the meat had been delivered to the laboratory (ie. 72h post-slaughter); normal muscles had pH values between 5.6 and 5.7 (Trout, 1992, Myler, 1996). The meat was delivered to the laboratory and stored chilled in the carton at 0°C until processing (< 24h).

Photo 3: A typical 20 kg batch of venison trimmings obtained from Red Deer

Photo 4: Sorting of venison trimmings to separate meat containing high levels of connective tissue. This high connective tissue was recommended to be denuded prior to being processed in cold-set bound products.

4.1.3 Product Ingredients

A list of the suppliers and a brief description of the ingredients required for the two alginate-binding systems are listed in Table 4.

Table 4: Suppliers and description of ingredients used to manufacture alginate-bound venison steaks

Ingredients	Supplier	Description
Alginate	Links Trading	Seaweed gum
Calcium Carbonate	Swift & Company Ltd.	Highly soluble calcium ions
Glucono-δ-lactone (GDL)	Lesnies	Slow release acid
Calcium Lactate (encapsulated)	Links Trading	Slow release of calcium ions
Sodium Erythorbate	Mauri Foods	Antioxidant
Rosemary Extract	Mauri Foods	Antioxidant

4.1.4 Product Formulation

The formulations of the alginate-bound venison products that were manufactured using the two alginate-binding systems are tabulated in Table 5.

Table 5: Product formulations used to manufacture alginate-bound venison products

Product Formulation	Alginate - GDL	Alginate - ECL
Venison trimmings [a]	2 kg	2 kg
Alginate	0.25-2%	0.2-0.8%
Glucono-δ-lactone	0.25-2%	-
CalciumCarbonate	0.15%	-
Calcium Lactate (encapsulated)	0.2-0.8%	0.2-0.8%
Water	0-6%	0-6%

[a] Formulations were calculated based on the weight of meat.

4.1.5 Manufacture of Alginate-Bound Venison Steaks

A summary of the process of manufacturing alginate-bound venison steaks is described previously in Process 1. Each of these processing steps are described in more detail below:

4.1.5.1 Meat Preparation

Venison trimmings were sorted into meat containing high levels of connective tissue and meat containing small amounts of connective tissue (Photo 5). Cartilage was removed during the sorting process. Venison trimmings containing high levels of connective tissue were desinewed; trimmings containing little obvious signs of connective tissue were minced through a kidney plate. Large pieces of trimmings used for mincing were sliced such that the meat pieces were small enough to pass through the mincer. A blend of desinewed (30%) and minced (70%) meat was required to form the meat component of the formulation. Sorted and trimmed meat was stored at 0°C until being minced or desinewed (< 1h).

Photo 5: Sorting and slicing venison trimmings in preparation for mincing

4.1.5.2 Desinewing

Trimmings were denuded of connective tissue, tendons and cartilage using the "Baader 696" (Photo 6). The effect of using a range of mincing drums (8mm; 20mm) was investigated to determine the best mincing drum to use to produce alginate-bound products with acceptable eating quality. Preliminary trials indicated that the best mincing drum to use for venison trimmings was 8mm. When meat obtained from the 20mm mincing drum was used as the meat component in alginate-bound products, there were unacceptable levels of visible fat and connective tissue. Thus, the recommended mincing drum for trimmings containing high levels of connective tissue was 8mm. Desinewed trimmings were stored at 0°C until processing (< 2h).

The following is a brief description of how trimmings were denuded of connective tissue. Firstly, the raw material was fed in via the feed hopper (Photo 7). Tendons, skin and cartilage leave the machine separately. This machine processes the raw material on a continuous basis. A belt then feeds material to the thick-walled perforated drum. The meat was then pressed through the holes of the perforated drum into its interior while solid parts remain on the external shell of the perforated drum and was removed by a knife. The processed meat is then discharged from the interior of the perforated drum. The fibre structure of desinewed meat was retained because the raw material was neither chopped, crushed nor ground. Moreover, this process does not increase the temperature of the material.

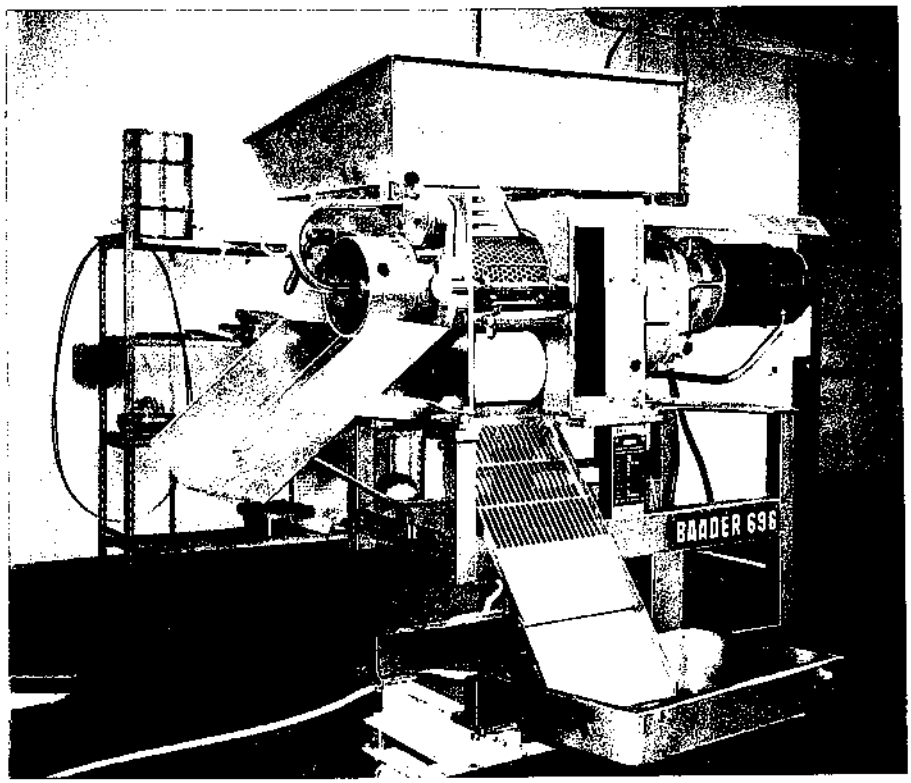


Photo 6: Desinewing venison trimmings using the "Baader 696" machine

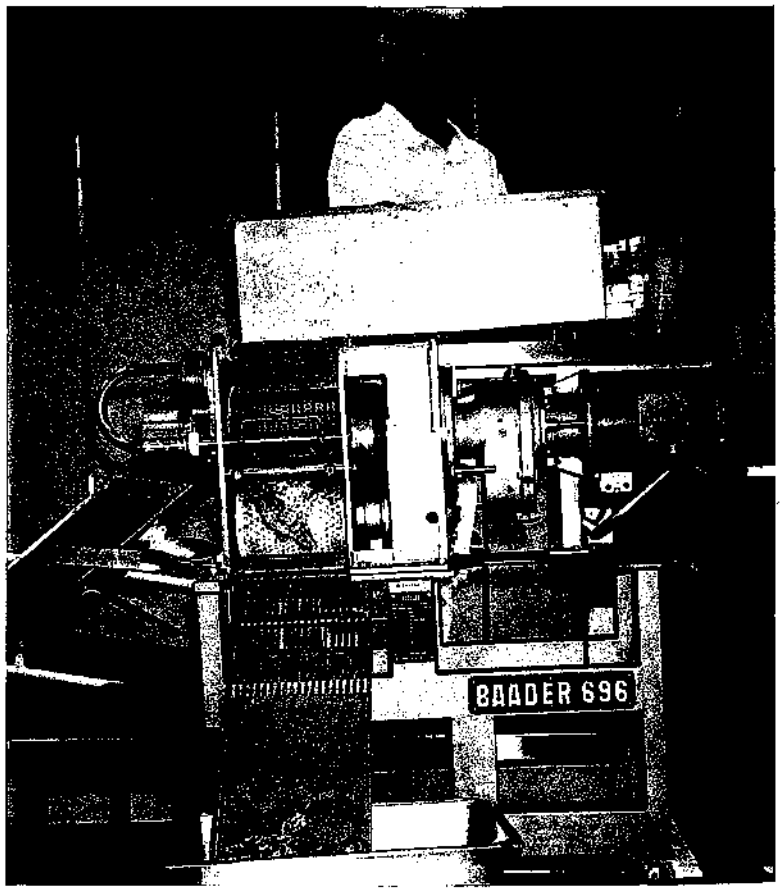


Photo 7: Trimmings containing high levels of connective tissue were fed into the hopper of the Baader machine

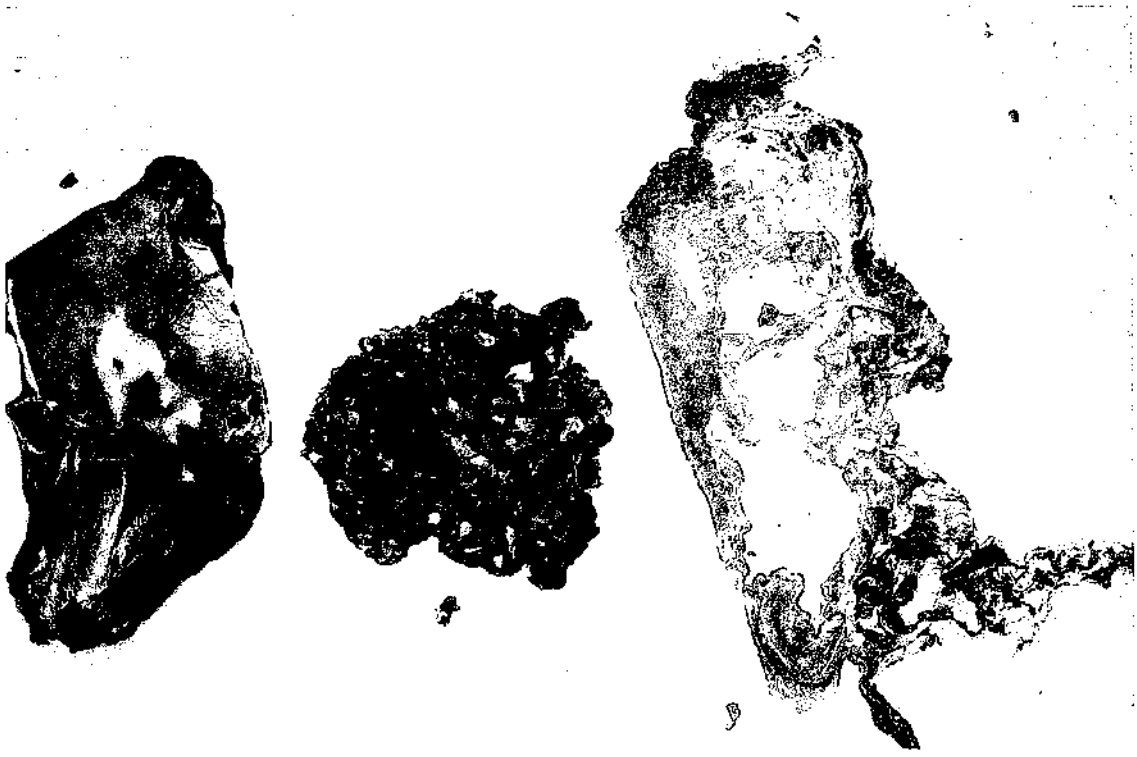


Photo 8: Separation of a) desinewed meat [middle] and b) connective tissue [right] from venison trimmings [left] using the Baader machine

4.1.5.3 Mincing

Venison trimmings were minced using the Schaub mincer (Photo 9). Various mincing plates were used to determine the effect of using different meat particle sizes on the bind strength and colour of alginate-bound venison steaks. The ability of alginate to bind venison trimmings together was determined over a range of meat particle sizes (13 mm, kidney, 13 mm + kidney mincing plates; diced by hand into 2 cm cubes). Minced trimmings were stored at 0°C until processing (< 2h).

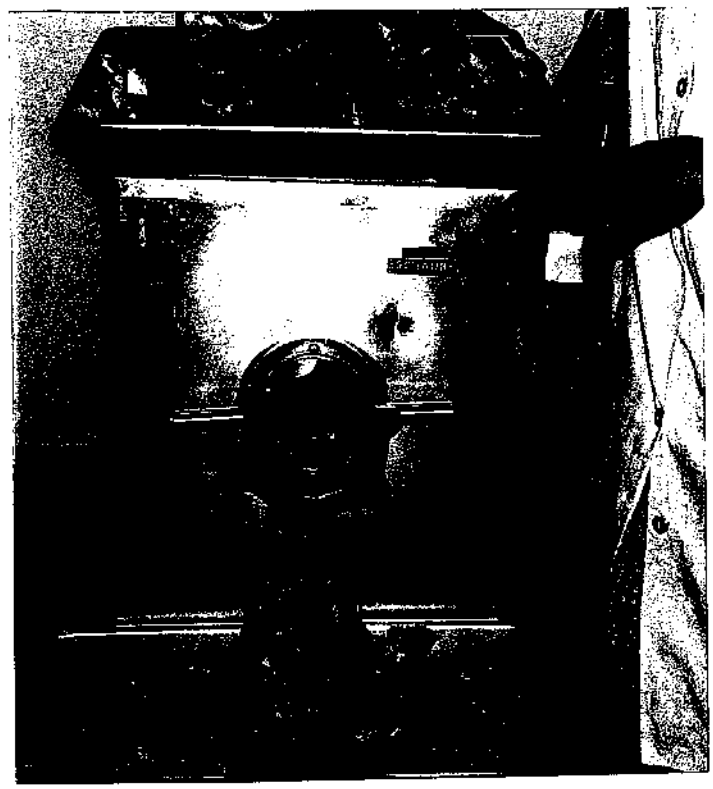


Photo 9: Schaub mincer containing kidney mincing plate used to mince trimmings for manufacture of alginate-bound venison steaks

4.1.5.4 Mixing

The degree of mixing and whether the alginate is introduced pre-hydrated or not are both likely to have some bearing on how far the alginate penetrates into the meat structure. Preliminary trials indicated that optimum bind was produced when alginate was initially added in powdered form. Therefore, this was used as the standard mixing procedure throughout the project.

The standard mixing method used to manufacture alginate-bound venison products was as follows. Minced meat was mixed for 1 minute in a Hobart Mixer at medium speed (setting of 2) using the dough hook mixing attachment (Photo 10). Sodium alginate powder (Manugel DJX, Germantown, Botany) was added to the meat and mixed for 1 minute (ie. amount as per Table 5). With the alginate-GDL system, calcium carbonate ($CaC0_3$), was dispersed in water and then added to the meat, and the meat was mixed at medium speed for 1 minute. Similarly, other calcium derivatives were added and mixed with the meat in the same way. Finally, GDL was added and mixed for a further 1 minute. Similarly, other acids were added to the meat in the same way.

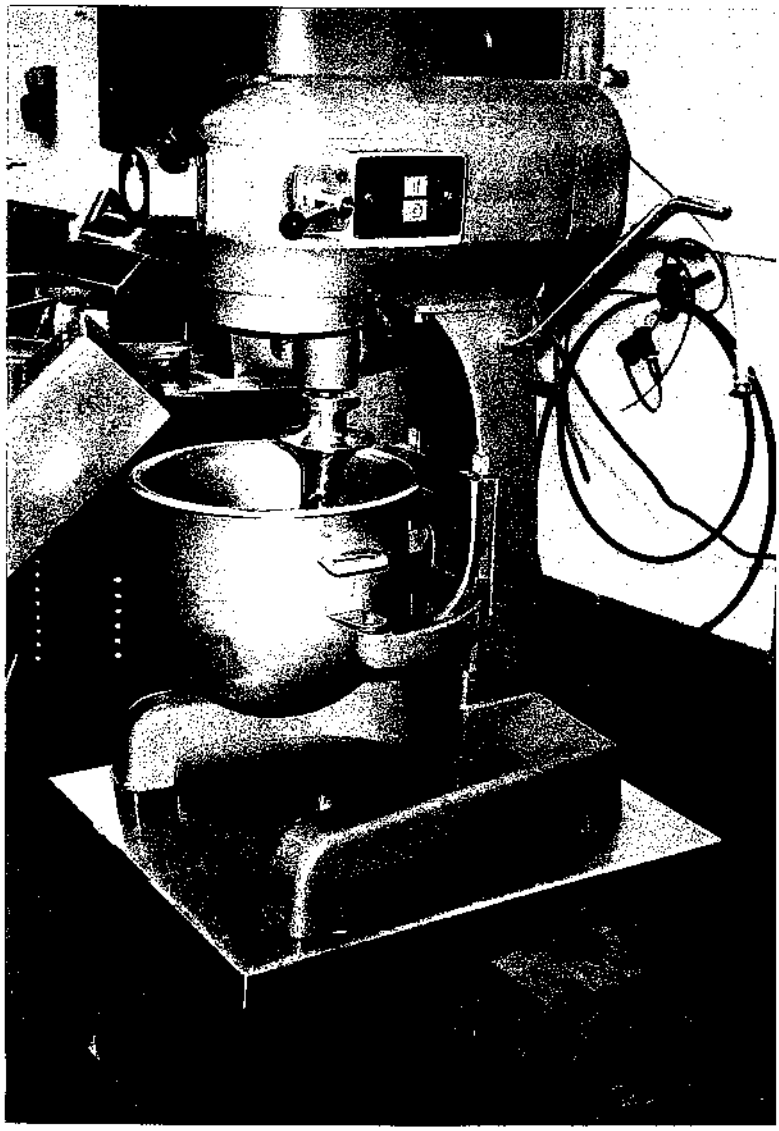


Photo 10: Hobart bowl mixer with hook-mixing attachment

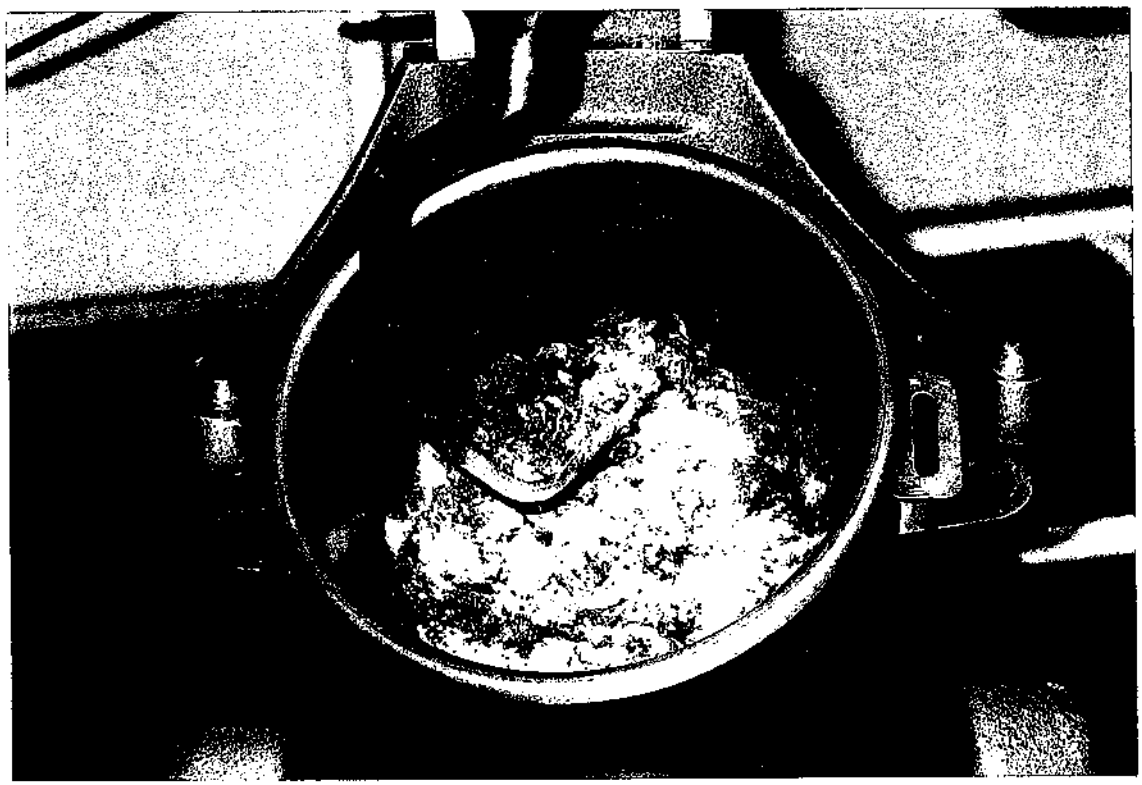


Photo 11: Addition of alginate ingredients for mixing

4.1.5.5 Filling

Immediately after mixing (< 20 minutes), the meat containing the binder was filled into 60mm diameter casings (< 80 cm long) using a hand sausage stuffer (Photo 12). Prior to filling, one end of the casing was stapled using a hand clipper. Once product was filled into the casing, pressure was applied to the chub by hand, and the ends were clipped (Photo 13).

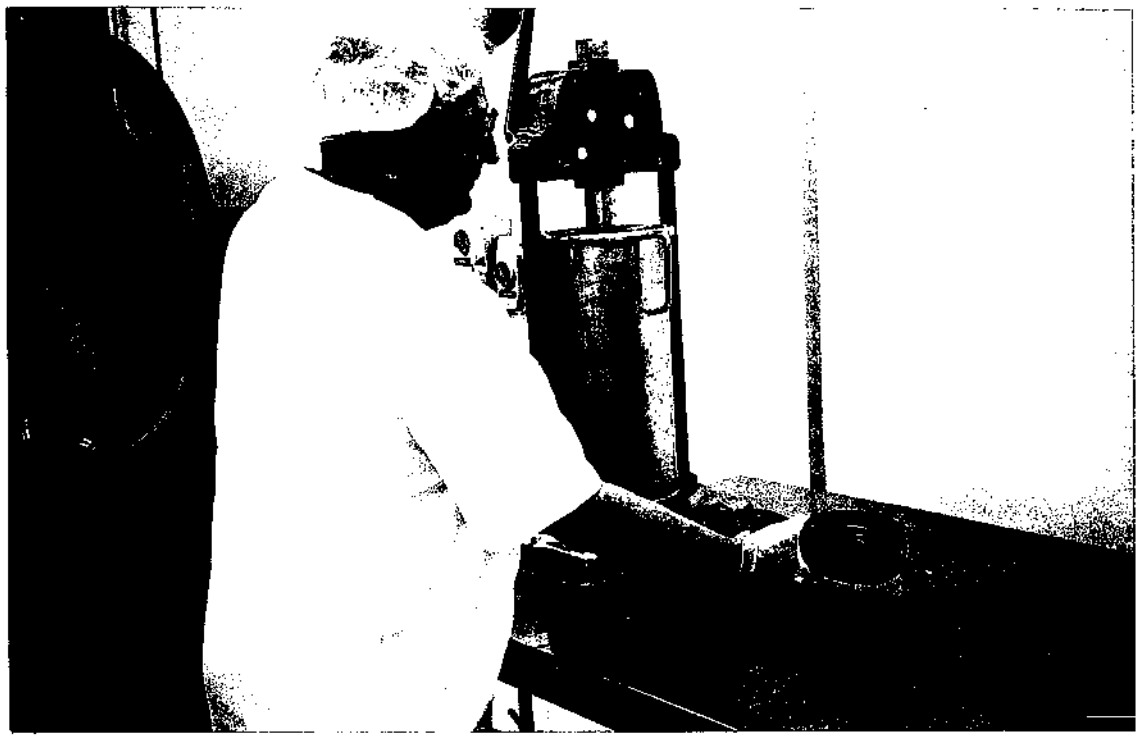


Photo 12: Filling of product containing the alginate binder into casings

4.1.5.6 Storage

Chubs containing alginate-bound product were stored overnight in the chiller (0°C) to allow the bind to form. The time required for a cold-set binding system to form a bind between meat pieces that is strong enough to allow handling of the meat, without the product falling apart, is an important practical consideration. In addition to the storage time, the storage temperature could also affect the rate of raw bind development. The two binding systems use different approaches to controlling the solubilisation of Ca^{2+}, which controls the formation of the Ca^{2+} alginate gel that binds meat pieces together. The storage temperatures (0°C and 5°C) used in this experiment were selected as they represent the extremes of storage temperatures likely to be used commercially. In addition, the effect of freezing the chubs immediately after being made was investigated on the bind strength of alginate steaks upon thawing.

4.1.5.7 Slicing of Steaks

Steaks of uniform size and shape were prepared from the restructured logs. On the day after the meat pieces were filled into the casings, the casings were removed from each of the products, and the bound, restructured logs were sliced by hand into steaks of similar thickness (ie. 15mm thick). In contrast, frozen logs were sliced to the required thickness (ie. 15mm thick) using a band saw.

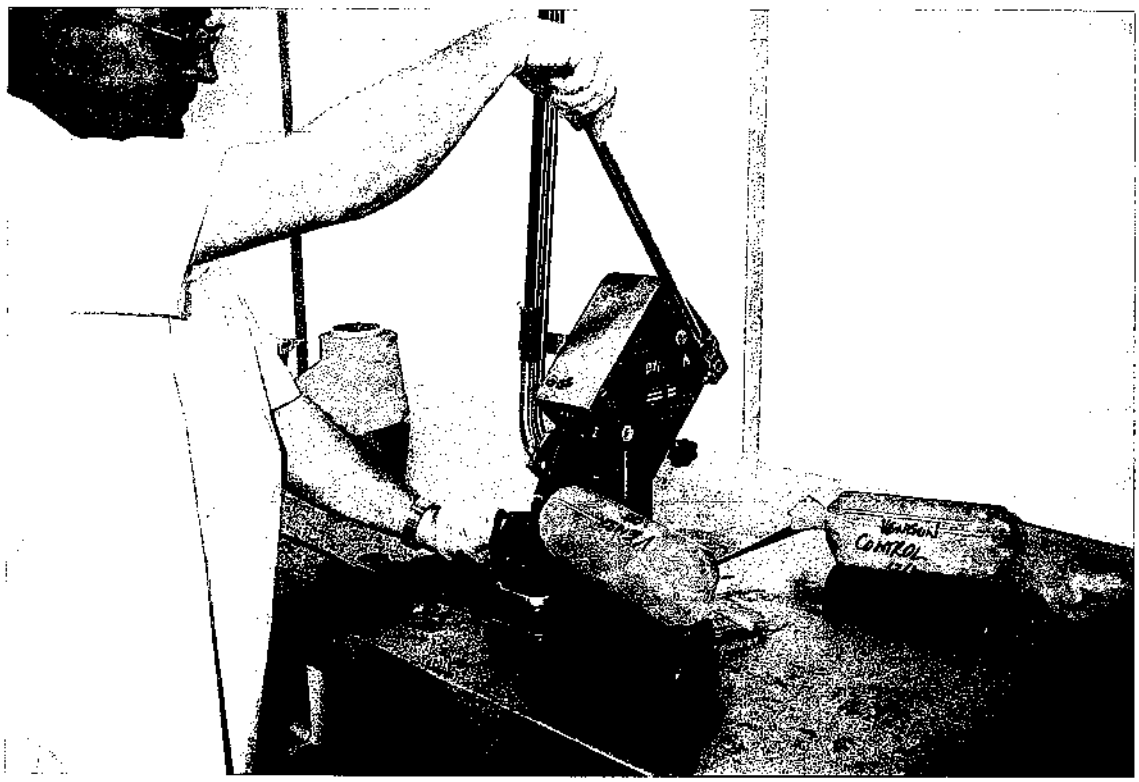


Photo 13: Clipping the casing ends using a hand clipper

Photo 14: Alginate-bound chub produced from venison trimmings

4.1.6 Cooking of Steaks

Two steaks were fully cooked using an electric griller (T-1, Silex Elektrogerate GmbH, Germany) which was initially preheated to approximately 180°C and sprayed with Pure and Simple (Samuel Taylor, Ermington, NSW). Two steaks (ie. 15mm thick) from each treatment were grill-cooked for four minutes each side, to give a total cooking time of eight minutes. The steaks were weighed before and after the cooking procedure to determine the cooking losses. Internal temperatures of the steaks were measured using a temperature probe (Thermister Thermometer, Cole-Parmer Instrument Co.) immediately after cooking to determine whether steaks were adequately cooked (ie. internal temperature of >70°C).

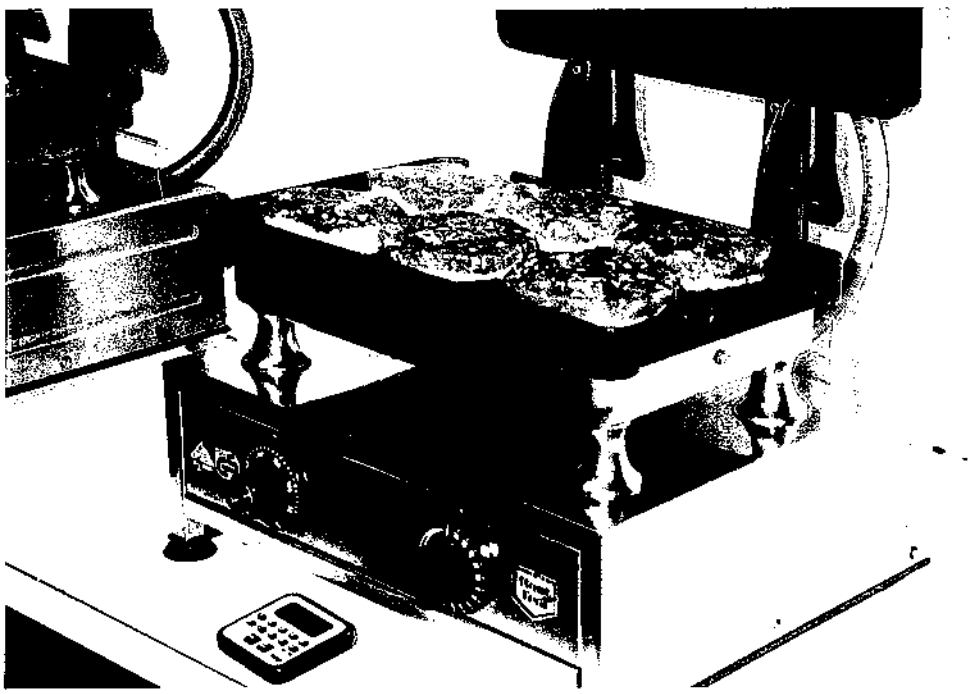


Photo 15: Cooking alginate-bound venison steaks on Silex Griller at moderate temperature (180°C) for a total of 8 minutes

4.1.7 Evaluation of Product

4.1.7.1 pH Measurements

The pH of the venison products was determined using a glass electrode (Phillips C64-1 Combination Glass Electrode, Phillips, South Australia). The pH was measured using the spear electrode technique. In this way, the electrode was stabbed into the meat at several sites throughout the piece of meat. Average pH values were recorded for each steak.

4.1.7.2 Colour Assessment

Display-life of raw steaks

The display-life of raw restructured steaks was determined on steaks (n=2) displayed in white polystyrene trays and over-wrapped with commercial-grade (Van Leer Food Packaging Pty Ltd) polyvinyl chloride (PVC) film (oxygen transmission rate of 11000ml.m^{-2} .24h^{-1} at 20°C and 0% relative humidity). Prior to assessment, steaks were stored in a 0°C chiller for 2 h to allow the steaks to bloom. The colour of the steaks were measured using the Minolta CR200b portable filter colorimeter (Minolta Ltd. Pty., Australia) which had an 8mm optical port and diffuse illumination (D_{65} light source). The display-life of restructured steaks was determined by displaying the steaks in a 5°C refrigerated display cabinet for one week, under Philips 93 Delux fluorescent tubes positioned such that it provided 1000 lux at the surface of the steak. Average CIE L* (Lightness) a* (Redness) b* (Yellowness) values were recorded at three defined locations on the cut, bloomed, surface of each steak at 2h, 6h, 24h and then twice daily for one week after slicing the meat.

Photo 16: Measuring colour of meat using Minolta Colour Meter

Colour of cooked product

Overall meat colour of the cooked product was evaluated on duplicate steaks using a small group of sensory panelists. During these informal evaluation sessions, cooked product was shown to the group and comments were recorded based on the discussion amongst the group. Cooked colour was also determined using the Minolta colour meter. Average CIE L*, a* and b* values were recorded at three selected locations on the cooked surface of each steak immediately after cooking. In particular, the degree of doneness (DD) was determined on each steak using the L* value (or lightness value).

4.1.7.3 Bind Strength

Raw Bind Strength

Raw bind strength of minced products was determined by a single-cycle compression test using a Lloyd LRX instrument (Photo 17). Sixteen 30mm cubes were cut from each restructured meat product, and were compressed at 12 mm / minute, to 50% of their initial height. Average raw bind strength was determined as the maximum compression force detected during the compression test.

Cooked Bind Strength

An electric griller (T-1, Silex Elektrogerate GmbH, Germany) was preheated to approximately 180°C and sprayed with Pure and Simple (Samuel Taylor, Ermington, NSW). Two steaks (15mm thick) from each sample were grill-cooked for four minutes on each side, to give a total cooking time of eight minutes. The steaks were assessed visually for their ability to hold together after being cooked.

Time of Effective Raw Bind (Time versus Temperature)

The time required for a cold-set binding system to form a bind between meat pieces that is strong enough to allow handling of the meat, without the product falling apart, is an important practical consideration. In addition to the storage time, the storage temperature could also affect the rate of raw bind development. The results obtained for raw and cooked bind strength were used to determine the most acceptable formulation, as well as the process, for manufacturing alginate-bound venison steaks. This standard recipe was then evaluated for the time required for an effective raw bind to form. The two binding systems use different mechanisms of releasing Ca^{2+} in to solution, thereby controlling the formation of the Ca^{2+} alginate gel that binds meat pieces together. In preliminary trials, the effect of temperature (0°C & 5°C) on the raw bind strength of restructured meat products was determined for both alginate-binding systems (Table 6). The effect of freezing the chubs was also investigated.

Table 6: The alginate binding systems (alginate and glucono-δ-lactone [GDL], alginate and encapsulated calcium lactate [ECL]) and storage temperatures used in the study of the effect of storage time on raw bind strength.

0°C	5°C
0.4% Alginate + 0.4% GDL	0.4% Alginate + 0.4% GDL
0.5% Alginate + 0.5% ECL	0.5% Alginate + 0.5% ECL

Raw bind strength and pH were measured at seven time intervals (2h, 4h, 6h, 8h, 12h, 24h and 48 h) after filling the product into casings to determine the time required for an effective bind to form between meat pieces. Measurement of the pH of these samples was taken to assess the rate of acidulation. A decrease in pH causes Ca^{2+} solubilisation, and Ca^{2+} solubilisation is a key step in the development of the bind in both the alginate-GDL and alginate-ECL systems.

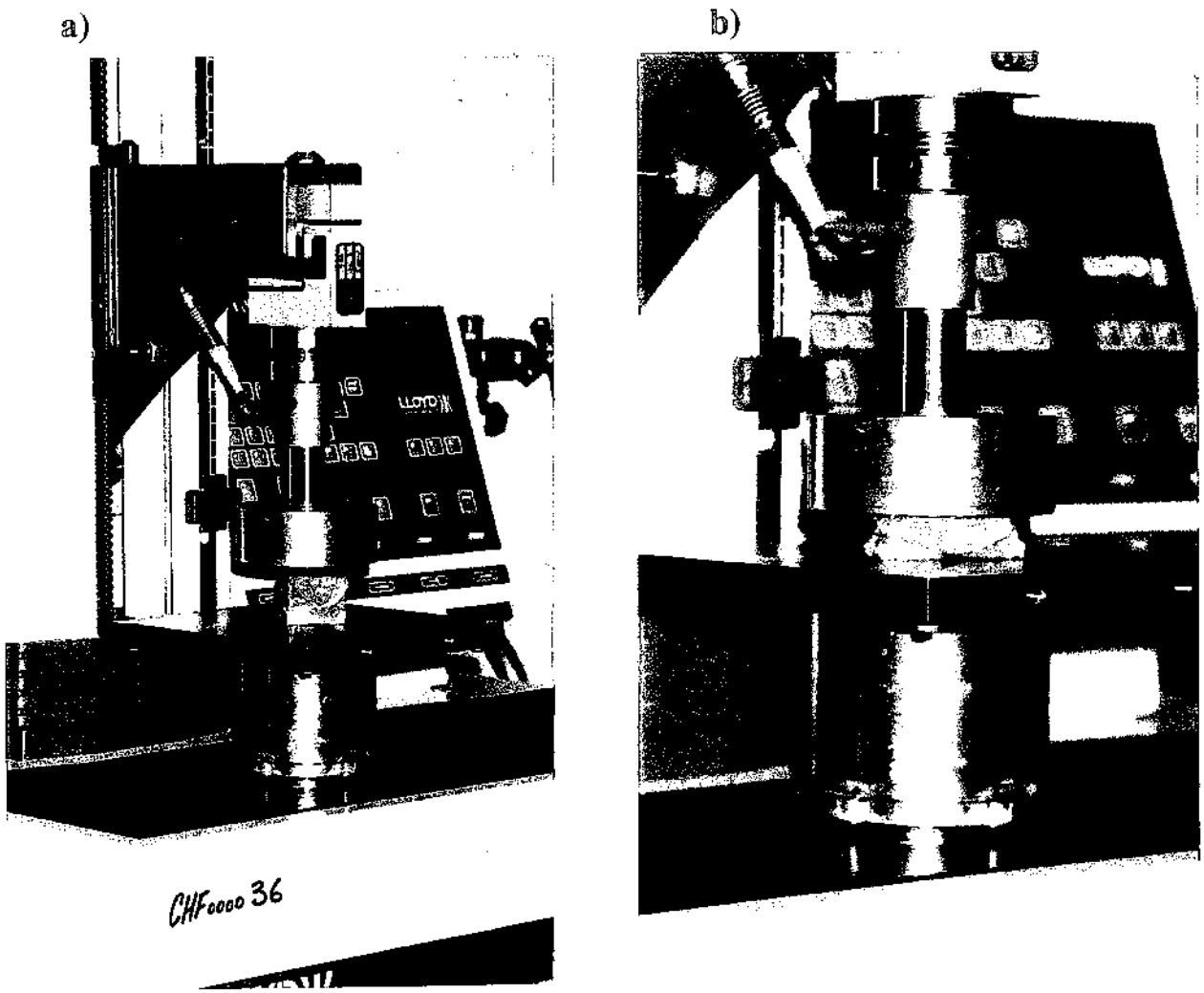


Photo 17: Bind strength test of raw alginate-bound steaks using the Lloyd instrument; a) before compression, b) after compression of samples

Effect of Different Breeds on Bind Strength

The effect of different breeds (ie. Rusa, Chittle & Red Deer) was investigated on the bind strength of alginate-bound venison products. Analysis of bind strength was conducted on restructured venison products made from alginate-binding system (GDL or ECL) using the methods described previously (see section 4.1.5). Raw bind strength of these products was determined by a single-cycle compression test using a Lloyd LRX instrument as described in section 4.1.7.3. Average raw bind strength was determined as the maximum compression force detected during the compression test.

4.1.7.4 Microbiological Analysis of Steaks

The initial microbial load and microbial shelf-life of alginate-bound venison steaks were determined on the standard formulation developed in this research. Various combinations of minced and desinewed meat were mixed as the meat part in the formulation consisting of 0.5% sodium alginate, 0.5% GDL and 0.15% calcium carbonate (Table 7).

Table 7: Treatments used to determine the microbiological status of alginate-bound venison steaks

Treatments No.	Treatments
(1) 100% kidney plate	Venison, diced through a kidney plate, formed and set, frozen then cut into steaks.
(2) 70% KP+30% DN	70% kidney plate meat mixed with 30% denuded meat, formed and set, frozen then cut into steaks.
(3) 100% denuded	Venison, denuded of connective tissue, diced, formed and set, frozen then cut into steaks.

All treatments were stored frozen (-25°C) for 24 hours during freezing, then band sawed into steaks. Steaks were packed into normal retail trays, overwrapped with PVC and displayed for 5 days in a retail display cabinet running at 5°C. Samples were taken for microbiological testing on the day of slicing into steaks (initial), after thawing (Day 0), after 1 and 4 days display (Day 1 and Day 4). Bacterial growth was recorded on all treatments and compared to the controls.

Initial Microbial Counts

To obtain the initial bacterial counts, samples were obtained by coring 10 g from steaks in two retail packs from each treatment tested. Each sample was placed in a sterile stomacher bag (A J Seward Co Ltd, London). To each bag 1.25% NaCl solution was added to a total of 100 g and the samples treated for 1 minute with a Colworth Stomacher, Model 400 (A J Seward Co Ltd, London). Appropriate dilutions were spread-plated on pre-dried plates of Tryptone Soya Agar (Oxoid) supplemented with 0.2% (w/v) yeast extract and 0.2% glucose (TSYG agar); MRS (de Man, Rogosa, Sharpe) Agar (Oxoid); streptomycin thallous acetate, actidione agar (STAA Agar; Gardner, 1966) and Peptone (0.8%, w/v; Oxoid) Agar (PA agar; Grau, 1983). Total aerobic counts were obtained from TYSG plates incubated at 25°C for 3 days. STAA agar plates were incubated at 25°C for 3 days to enumerate *Brochothrix thermosphacta*. Counts of lactic acid bacteria were obtained from MRS agar incubated aerobically at 25°C for 3 days. Peptone agar plates were incubated for 3 days at 25°C to obtain Gram negative counts.

Microbial Shelf-life

Microbial shelf-life of alginate bound steaks was determined on product displayed in a refrigerated cabinet (5°C) under the same conditions as previously used for colour assessment (see section 4.1.7.2). Analyses were carried out on steaks which were withdrawn from the cabinet at 0, 1 and 5 days after thawing of restructured steaks, and then sampled by coring 20g from each steak tested. Microbiology of these samples was determined as described for the initial counts.

4.1.7.5 Preliminary Sensory Evaluation

An informal evaluation of the sensory properties of alginate-bound venison steaks was determined using a small panel. Once these products had been cooked on the electric griller from raw, they were assessed on flavour, juiciness, texture and appearance. Comments on each of these attributes were recorded after being discussed amongst members of the panel. In addition, photographs were taken of raw and cooked steaks.

4.1.7.6 Sensory Evaluation

The purpose of this trial was to determine whether processing methods can be used to improve the quality of meat products produced from venison trimmings. In this trial, the appearance, aroma, flavour and overall quality (ie. acceptability) were assessed with three (3) variations in processing method as shown in Table 8.

Table 8: Product types

No	*Treatment*
1	100% Kidney Plate (KP)
2	100% Baader Denuded (DN)
3	70% Kidney Plate, 30% Baader Denuded

The samples were prepared and kept frozen until ready for tasting. They were then thawed overnight at 5^{O}C. The steaks were cooked on a SILEX Griller (Type T-1). The grills were preheated to approximately 180^{O}C and the samples were cooked for a total of 10 minutes, turned over at 4 and 8 minutes. Two cooks were carried out for each session cooking 18 samples each time, six from each treatment. The reformed steaks were put in to a casserole dish and kept warm in a Bain Marie set at 65 -70^{O}C until ready for serving. Samples were served from the initial cook first for each session. The samples were presented whole, to 12 panelist who have eaten venison before and who are familiar with assessment of the textural properties of meat. Each sample was presented on a white plastic plate in random order with three treatments per session assessed and 3 digit codes used to identify each sample. Samples were presented to panelists under daylight conditions in individual booths. For this work, the 12 member panel was asked to assess each product for nine attributes as shown in Table 8 using a 9 point category scales. The data was recorded directly onto a multi-user computer system.

An analysis of variance was performed on the data to assess for differences between treatments. The SAS System for Windows (SAS, 1989-1996); version 6.12 TS020 was used to analyse the data.

4.1.7.7 Frozen Storage Stability

The stability of frozen product after thawing was determined on alginate-bound steaks. Alginate-bound products were frozen immediately after being rolled using plastic film. Frozen alginate-bound products were thawed at 0°C for 48 h. Upon thawing, product was sliced into steaks and assessed for overall appearance, colour stability and raw bind as

previously described. Percent cooking losses were determined on duplicate steaks cooked on an electric grilling plate (T-1, Silex Elektrogerate GmbH, Germany). Steaks were weighed before and after cooking to determine the percent losses during the cooking process.

4.2 Pearl F-Bound Whole Tissue Venison Roasts

4.2.1 Raw Material

Boneless venison forequarters were used in the current research to manufacture Pearl F-bound venison roasts. Venison forequarters were supplied by Mountain Valley Venison of Crows Nest in Queensland. Rusa, Chittle and Red Deer were slaughtered at Swickers Kingaroy Bacon Factory Pty Ltd. Venison forequarters were excised from the carcases 24h post-slaughter. The meat packaged in 15kg cartons were delivered to Salm's Continental Butcher in Brisbane where they were picked-up and transported in an AQIS approved esky to the laboratory. The meat was stored chilled in the carton (< 72 h) at 0°C until processing.

Photo 18. A typical 20kg batch of venison forequarters obtained from Red Deer

4.2.2 Product Ingredients

Pearl Meat binders were used to manufacture restructured roasts from venison forequarters. In particular, Pearl F and Pearl E (or Protein Activated Meat Binder) binders were trialed in preliminary experiments. Preliminary results indicated that Pearl F and Pearl E both produced effective binds. However, Pearl E was excluded from this research because it is a relatively new binder that is presently awaiting acceptance by the Australian Food regulatory authority. Therefore, Pearl F was utilised as the binder in subsequent trials. Pearl F which is supplied by Earlee Products Limited of Brisbane, is a commercially available binder from Japan (Table 9).

Table 9: Suppliers and description of Pearl Meat binder used to manufacture cold-set bound venison roasts

Ingredients	Supplier	Description
Pearl E (Protein Active Meat Binder)	Earlee Products	Fine white powder mixture of carbohydrate, protein and bone ash.
Pearl F	Earlee Products	Fine white powder, mixture of carbohydrate, protein and bone ash.

4.2.3 Meat Preparation

Boneless venison forequarters were trimmed of excess fat and connective tissue. Meat was stored at 0°C until processing (< 2h).

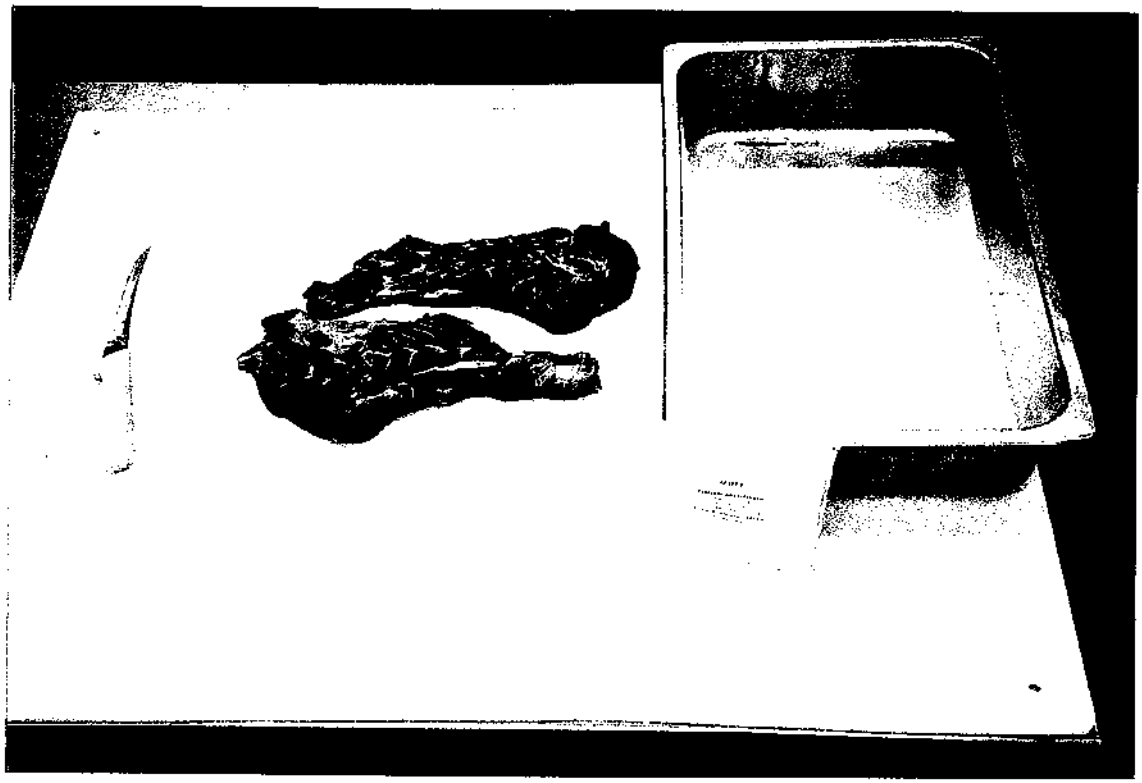


Photo 19: Sorting of venison forequarters for preparation of Pearl-bound venison products

4.2.4 Manufacture of Pearl F-Bound Venison Logs

A summary of the process is shown previously in Process 2. The following section details the manufacture of Pearl F-bound product in more detail.

4.2.4.1 Addition of the Binder

The surface of boneless venison forequarters were coated with Pearl F binder by either dusting or dipping the meat into the binder which is spread out in a tray (Photo 20).

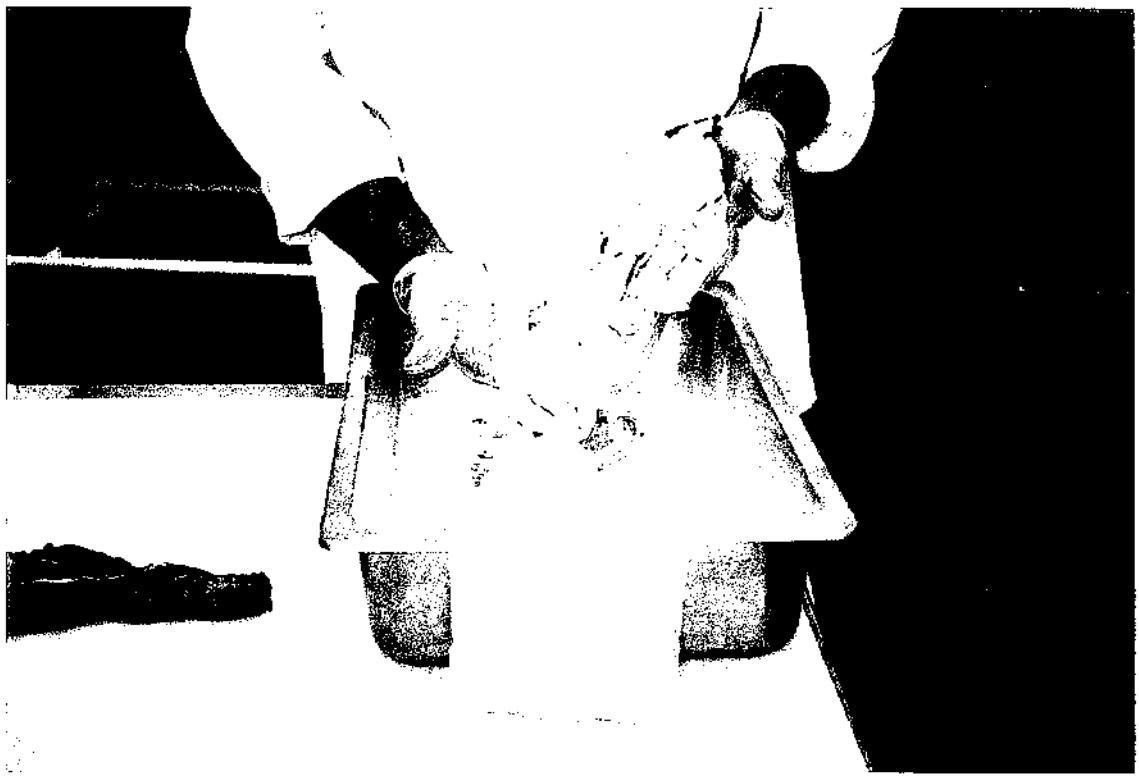


Photo 20: Addition of Pearl F to the surface of meat using the dusting method

4.2.4.2 Forming of Whole Tissue Meat

The coated surfaces were pressed together and pressure was applied either by vacuum-packaging or rolling the meat into commercial-grade film to form a log (Photo 21). It was made sure that there were no spaces between the pressed meat. The product was stored overnight in the chiller (0°C) to allow the bind to form. Some products were frozen immediately after being rolled, and held at -25°C until analyses (< 2 weeks).

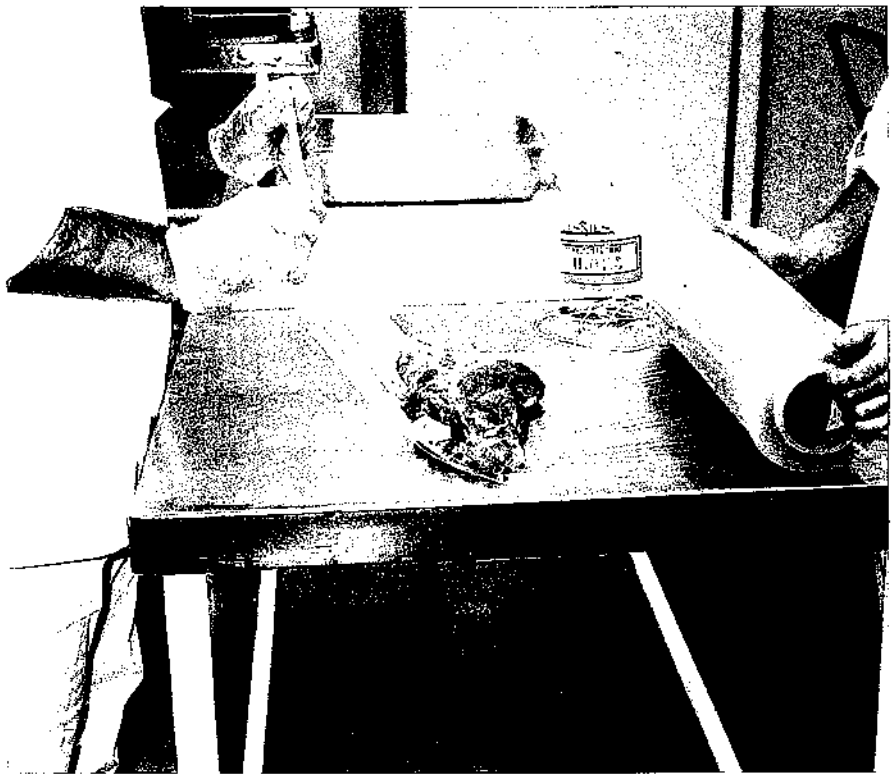


Photo 21: Forming of Pearl F-bound log by hand using plastic film

Photo 22: Forming of Pearl F-bound venison forequarter roasts

4.2.4.3 Storage

The product was stored in the plastic film overnight in the chiller (0°C) to allow the bind to form. The time required for Pearl F to form an effective bind between meat pieces is an important practical consideration. In addition to the storage time, the storage temperature could also affect the rate of raw bind development. The storage temperatures used in this experiment were selected as they represent the extremes of storage temperatures likely to be used commercially. The effect of temperature on the bind strength of Pearl F-bound venison products was investigated at 0°C, 5°C and at frozen (-25°C) temperatures.

4.2.4.4 Preparation of Roasts

After the bind was allowed to form, the plastic film was removed from each of the products, and the bound, restructured logs were trimmed by hand into uniform roasts of similar weights (ie. approximately 1 kg). Prior to analysis of frozen product, frozen logs were thawed at 0°C for 48h.

4.2.4.5 Cooking of Roasts

Roasts (approximately 1 kg) were fully cooked using a fan-forced conventional oven, which was initially preheated to approximately 180°C. Roasts were weighed before and after the cooking procedure to determine the percent cooking losses. Internal temperatures of the roasts were measured using a temperature probe (Thermister Thermometer, Cole-Parmer Instrument Co.) immediately after cooking to determine whether the roasts were adequately cooked (ie. internal product temperature of > 70°C).

4.2.5 Evaluation of Product

4.2.5.1 Colour Assessment

Overall meat colour of the cooked roasts was evaluated using a small group of sensory panelists. During these informal evaluation sessions, cooked product was shown to the group and comments were recorded based on the discussion amongst the group. Cooked colour was also determined using the Minolta Colour Meter. Average CIE L*, a* and b* values were recorded at three locations on the cooked surface of each product immediately after cooking. In particular, the degree of doneness (DD) was determined using the L* value (or lightness value).

4.2.5.2 Bind Strength

Raw Bind Strength

Raw bind strength of whole-tissue products was determined by a single-cycle tension test using a Lloyd LRX instrument. Sixteen strips of each product were cut from a template such that the bind was located at the centre of the strip. Samples were pulled apart at 12 mm / minute to a height at which the sample was fractured. Average raw bind strength was determined as the maximum force detected during the tension test.

Cooked Bind Strength

Samples were cooked in a cook-in-bag immersed in water (80°C) until an internal temperature of > 70°C. Sixteen strips of each product were cut from a template such that the bind was located at the centre of the strip. Samples were pulled apart at 12 mm / minute to a

height at which the sample was fractured. Average raw bind strength was determined as the maximum force detected during the tension test.

4.2.5.3 Microbiological Analysis

The initial microbial load and microbial shelf-life of Pearl F-bound venison roasts were determined on the standard formulation developed in this research. The treatments that were investigated are shown in Table 10.

Table 10: Treatments used to determine the microbiological status of Pearl F-bound venison steaks

Treat. No	Treatments
Control	venison primal rolled with no additive, frozen then cut into steaks.
Pearl	venison primal dusted with Pearl-F, rolled and set, frozen then cut into steaks.

All treatments were allowed to set over 24 hours during freezing, then band sawed into steaks. Steaks were packed into normal retail trays, overwrapped with PVC and displayed for 5 days in a retail display cabinet running at 5°C. Samples were taken for microbiological testing on the day of slicing into steaks (initial), after thawing (Day 0), after 1 and 4 days display (Day 1 and Day 4). Bacterial growth was recorded on all treatments and compared to the controls.

Initial Microbial Counts

To obtain the initial bacterial counts, samples were obtained by coring 10 g from steaks in two retail packs from each treatment tested. Each sample was placed in a sterile stomacher bag (A J Seward Co Ltd, London). To each bag 1.25% NaCl solution was added to a total of 100 g and the samples treated for 1 minute with a Colworth Stomacher, Model 400 (A J Seward Co Ltd, London). Appropriate dilutions were spread-plated on pre-dried plates of Tryptone Soya Agar (Oxoid) supplemented with 0.2% (w/v) yeast extract and 0.2% glucose (TSYG agar); MRS (de Man, Rogosa, Sharpe) Agar (Oxoid); streptomycin thallous acetate, actidione agar (STAA Agar; Gardner, 1966) and Peptone (0.8%, w/v; Oxoid) Agar (PA agar; Grau, 1983). Total aerobic counts were obtained from TYSG plates incubated at 25□C for 3 days. STAA agar plates were incubated at 25°C for 3 days to enumerate *Brochothrix thermosphacta*. Counts of lactic acid bacteria were obtained from MRS agar incubated aerobically at 25°C for 3 days. Peptone agar plates were incubated for 3 days at 25°C to obtain Gram negative counts.

Microbial Shelf-life

Microbial shelf-life of Pearl F-bound roasts was determined on product displayed in a refrigerated cabinet (5°C) under the same conditions as previously used for colour assessment (see section 4.1.7.2). Analyses were carried out on roasts that were withdrawn from the cabinet at 1, 2, 3, 6 and 7 days after preparation of restructured roasts, and then sampled by coring 20g from each roast tested. Microbiology of these samples was determined as described for the initial counts.

4.2.5.4 Preliminary Sensory Evaluation

An informal evaluation of the sensory properties of Pearl F-bound venison roasts was determined using a small panel. Once these products had been cooked in the convention oven from raw, they were assessed on flavour, juiciness, texture and appearance. Comments on each of these attributes were recorded after being discussed amongst members of the panel. In addition, photographs were taken of raw and cooked roasts.

4.2.5.5 Sensory Evaluation

Flavour differences can be imparted into meat products when certain binders are used. A duo/trio test procedure was used to assess if there was a flavour difference due to using Pearl F as a meat binder. The samples treated with Pearl F were used as the control or reference samples with the different sample having no binder. This was due to the quantity of samples available. The samples were presented to 18 panelists who have eaten venison before and who are familiar with assessment of the textural properties of meat. The sensory evaluation was carried out under red light to disguise differences due to colour.

The samples were prepared and kept frozen until ready for tasting. The samples were then thawed overnight at 5°C. The patties were cooked on a SILEX Griller (Type T-1). The grills were preheated to approximately 180°C and the samples were cooked for 4 minutes each side. The lid was lowered for the second four minute period as the patty edges curled up, raising the sample outer portion significantly above the hot plate surface. By lowering the upper hot plate the samples were held flat for the remainder of the cooking period. Each reformed steak was quartered and put in a casserole dish and kept warm in a Bain Marie set at 65 -70°C until ready for serving.

4.2.5.6 Frozen Storage Stability

The stability of frozen product after thawing was determined on Pearl F-bound steaks. Pearl F-bound products were frozen immediately after being rolled using plastic film. Frozen Pearl F-bound products were thawed at 0°C for 48h. Upon thawing, products were sliced into steaks and assessed for overall appearance, colour stability and raw bind as previously described. In addition, Pearl F-bound steaks were assessed for cooking losses. Percent cook losses were determined on duplicate steaks cooked on an electric grilling plate (T-1, Silex Elektrogerate GmbH, Germany). Steaks were weighed before and after cooking to determine losses during the cooking process.

5. DISCUSSION OF RESULTS

5.1 Alginate-bound Venison Steaks

5.1.1 Effect of Size of Meat Pieces

The four different meat particle sizes that were investigated in a preliminary experiment to determine the optimum mincing plate for venison trimmings, to produce alginate-bound steaks, are shown in Table 11.

Table 11: Different meat particle sizes that were investigated in preliminary trials

Treatment[a]	Alginate	$CaCO_3$	GDL	Water	Particle Size
1	0.5	0.15	0.5	3.0	13 mm plate
2	0.5	0.15	0.5	3.0	Kidney plate (KP)
3	0.5	0.15	0.5	3.0	Diced (2cm cubes)
4	0.5	0.15	0.5	3.0	50% KP + 50% 13mm

[a] Note that the levels of alginate, calcium carbonate, GDL and water used in the initial product formulation were recommended by suppliers of the alginate binder.

Table 12: The effect of different meat particle sizes on raw pH, bind strength, colour stability, and cooking losses of alginate-bound venison

Treat	Raw		Colour (a*-value)				Cook Losses	Appearance of Cooked Product
	pH	Bind[x]	4 h	24 h	30 h	48 h		
1	5.84	127.4	16.38	11.70	9.90	6.67	25.4	Poor
2	5.74	141.8	14.99	14.86	13.17	11.35	29.6	Good
3	5.54	350.9	16.69	15.17	14.54	11.78	28.0	Poor
4	5.73	178.7	14.67	11.17	10.73	7.73	21.3	Good

[x] Bind strength of raw products was determined as the hardness values (N)

Table 12 shows that meat particle sizes had an effect on bind strength, initial colour (4h) colour stability (ie. rate of change in the a*-value), and the appearance of the cooked product. Generally, the smaller the meat pieces, the poorer the product bind. This is probably due to the increased surface area of smaller meat pieces that subsequently require more binder to produce the same bind strength as the large meat pieces. The results in Table 12 show that diced product (ie. treatment 3 with the smallest surface area) required 2-3 fold the force to break the bind between the meat pieces as was required for 13mm minced treatment (ie. Treatment 1 with the largest surface area). Similarly, meat particle sizes had an impact on the appearance (visual bind) of cooked products. The treatment containing kidney plate minced meat (Treatments 2 and Treatment 4) had a good bind after cooking.

This is because there is an ideal amount of small and large meat particles in kidney plate minced meat, which stabilises the meat matrix.

Finally, there were large differences between the different treatments in the initial colours and loss of colour (colour stability) indicated by a reduction in the a*-value over 48 hours. The important result is that the larger meat pieces have significant better colour shelf-life compared to the smaller meat pieces. This is likely to be attributed to the increased surface area of smaller meat pieces.

In conclusion, the size of the meat pieces used to produce alginate-bound venison products affects the quality of the final product. While the diced product had the best colour shelf-life, it did not hold together as well as the kidney plate treatment upon cooking. Therefore, it appears from this preliminary experiment that it is best to pass trimmings through a kidney mincing plate prior to adding the alginate binder. Therefore, in the remainder of the trials either kidney plate minced meat, or a combination of kidney plate minced meat and 13mm minced meat was used.

5.1.2 Different Breeds (Chittle, Red and Rusa)

The effect of meat from different breeds was also investigated. There was large variations in the initial pH between trimmings from Rusa, Chittle and Red Deer (Table 15).

Table 13: The effect of different breeds (Rusa, Chittle and Red Deer) on raw pH, bind strength, colour stability, and cooking losses of alginate-bound venison steaks produced from venison trimmings.

Treat	Raw		Colour (a*-value)				Cook Losses	Appearance of Cooked Product
	pH	Bind[x]	4 h	24 h	30 h	48 h		
Rusa	5.74	141.8	14.99	14.86	13.17	11.35	29.6	Good
Chittle	6.24	60.55	15.34	13.89	12.55	10.98	19.0	Very Poor
Red	5.69	168.7	10.48	9.85	8.35	6.91	21.7	Good

[x] Bind strength of raw products was determined as the hardness values (N)

The high pH (6.24) of Chittle deer resulted in poor bind in both raw and cooked product. These results indicate that the alginate binder produces a stronger bind at pH well below 6.24. Rusa and Red deer, with a pH of 5.74 and 5.69 respectively, resulted in restructured steaks with good raw and cooked bind.

In conclusion, different breeds of deer have different ultimate pH. Chittle has significantly higher pH than Rusa and Red deer. Therefore, the pH of the meat should be measured prior to using the meat in an alginate binding system, as high pH meat results in poor bind in the product. Further work was carried out with Chittle deer with different levels of GDL, to reduce the pH of the meat to obtain an acceptable bind.

5.1.3 GDL Concentration

Since the pH of Chittle deer was high (6.24), varying concentration of GDL was added to the meat to reduce the pH of the meat matrix. The purpose of this trial was to determine if the reduction in pH resulted in a stronger bind in the product.

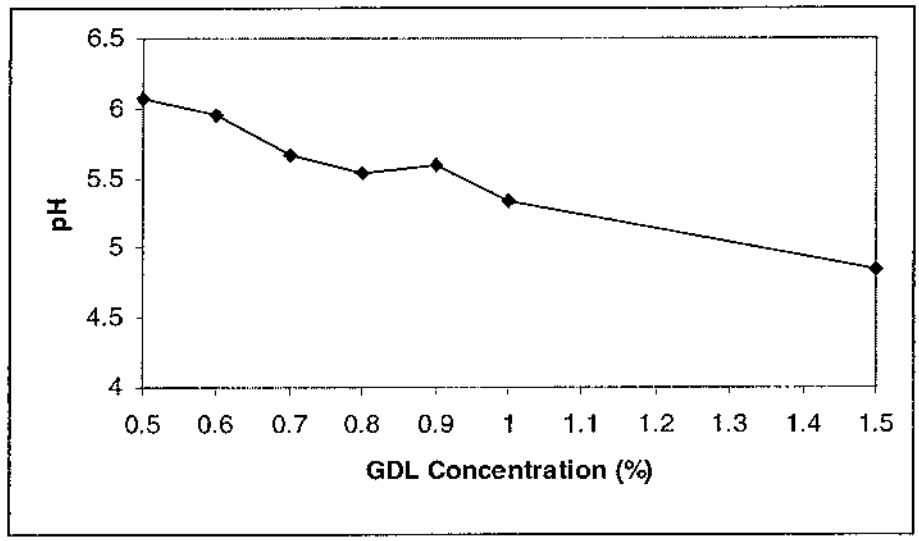


Figure 2: The effect of GDL concentration on the pH of alginate-bound venison products from Chittle deer.

Figure 2 shows that increasing the concentration of GDL (a slow release acid), resulted in gradual reduction of the pH of the meat (between 0.5 – 1.5% GDL).

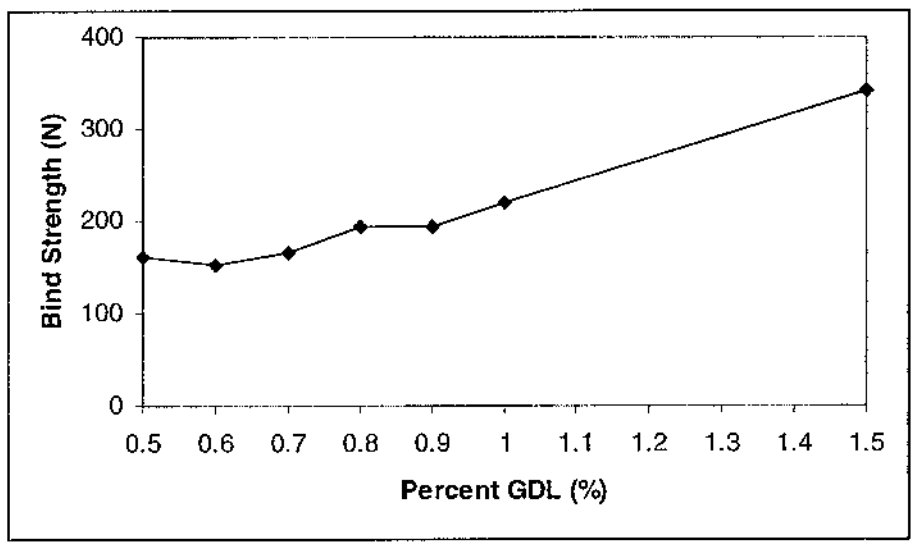


Figure 3: The effect of GDL concentration on the bind strength of alginate-bound venison products from Chittle deer.

Figure 3 shows that as the concentration of the GDL increased, the raw bind strength of the product also increased. This result can be explained by the reduced pH of the meat matrix, which results in the increased solubility of calcium carbonate. At the lower pH, sodium alginate is more readily converted to calcium alginate (due to the higher solubility of calcium carbonate) resulting in a crosslinking reaction between the meat particles covered in alginate. This crosslinking between the meat particles resulted in the increase in the bind strength.

Although the bind strength increased with increasing levels of GDL, the flavour of the steaks were affected by high GDL concentrations. Therefore it is recommended that the pH of the meat should be measured, especially if the meat is from Chittle deer, and the 0.5 – 0.8% GDL added to achieve a venison steak with an acceptable bind and flavour.

5.1.4 Storage Temperature/Time Required for Bind Formation

Storage temperature between 0°C and 5°C did not affect the raw bind strength and pH fall in the alginate-GDL binding system. The alginate-GDL binding system showed a steady increase in bind strength throughout the 48 hour storage time, and this was not affected by the storage temperature (Fig. 4). Similar rates of increase in raw bind strength are probably a result of storage temperature having no effect on the decline in meat pH (Fig. 5). By contrast, storage temperature had a large effect on the raw bind strength development and pH fall of the alginate-ECL binding system. The alginate-ECL samples stored at 0°C showed a more rapid increase in raw bind strength and decrease in pH (Figs. 4 and 5). The alginate-ECL samples stored at 0°C also had higher ultimate bind strength than the samples stored at 5°C. The most likely explanation for the storage temperature effect is that the lower temperature (0°C) produces fractures in the surface of the ECL particles, resulting in a more rapid acid release.

Freezing alginate-bound product immediately after being filled out did not affect the raw or cooked bind strength of the thawed steaks. According to the discussion with processors at the workshop, some processors actually preferred to store product frozen rather than storing the product chilled while the bind set.

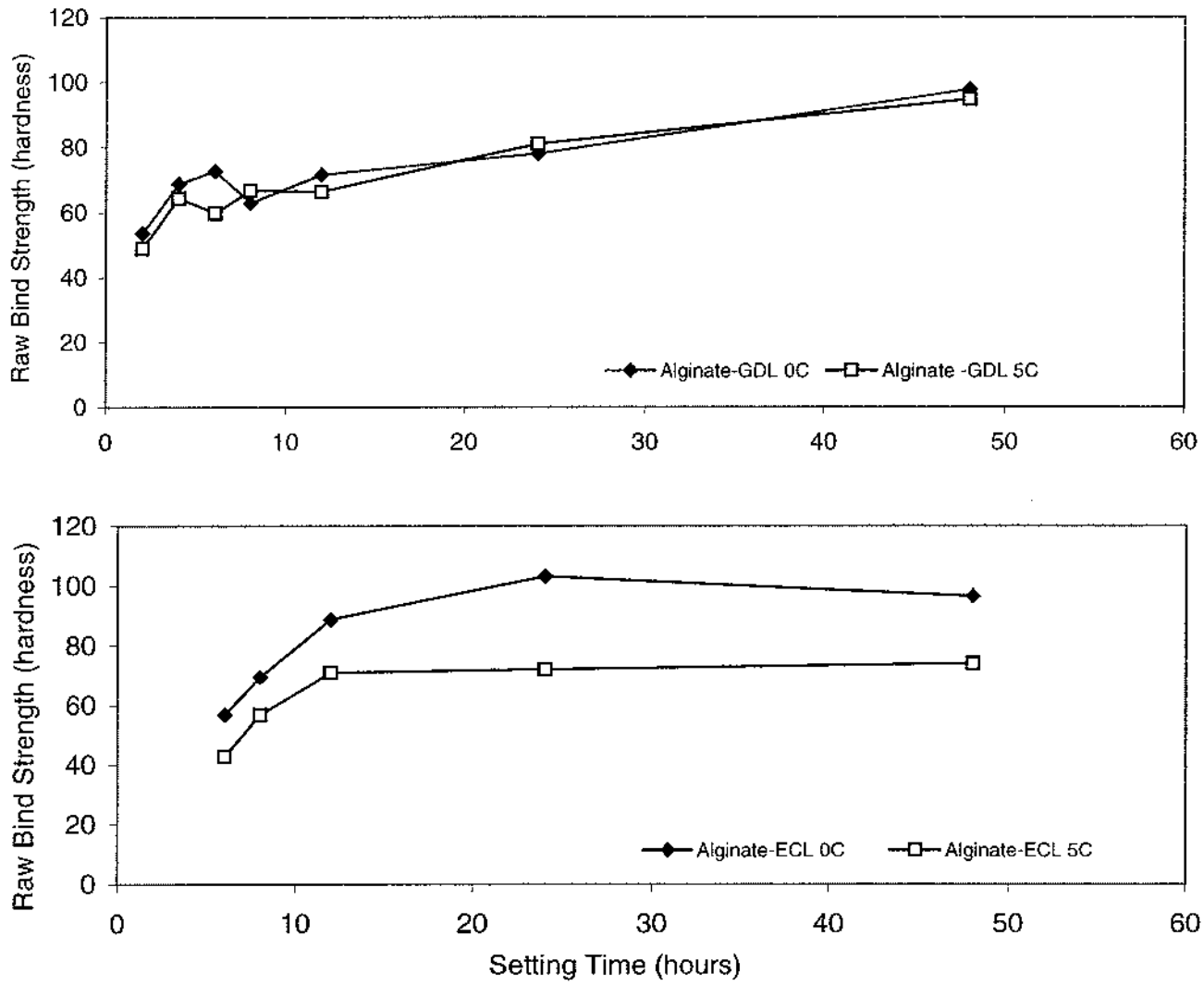


Figure 4: The effect of temperature (0-5°C) and acid release on the raw bind strength, as measured by hardness, of restructured venison products produced from two alginate-binding systems

The setting properties of the alginate-GDL and the alginate-ECL binding systems differ from each other. The alginate-ECL at 5°C treatment had the weakest raw bind strength of any of the samples studied. In particular, the 48 hour bind strength of the alginate-ECL at 5°C treatment was much lower than any of the other treatments after 48 hours. The raw bind strength of the alginate-ECL at 0°C treatment reached its maximum raw bind strength more rapidly than the alginate-GDL treatment (Fig. 4). The raw bind strength of the alginate-GDL treatment increased throughout the storage time studied, while the alginate-ECL at 0°C treatment had reached its maximum after 24 hours storage time.

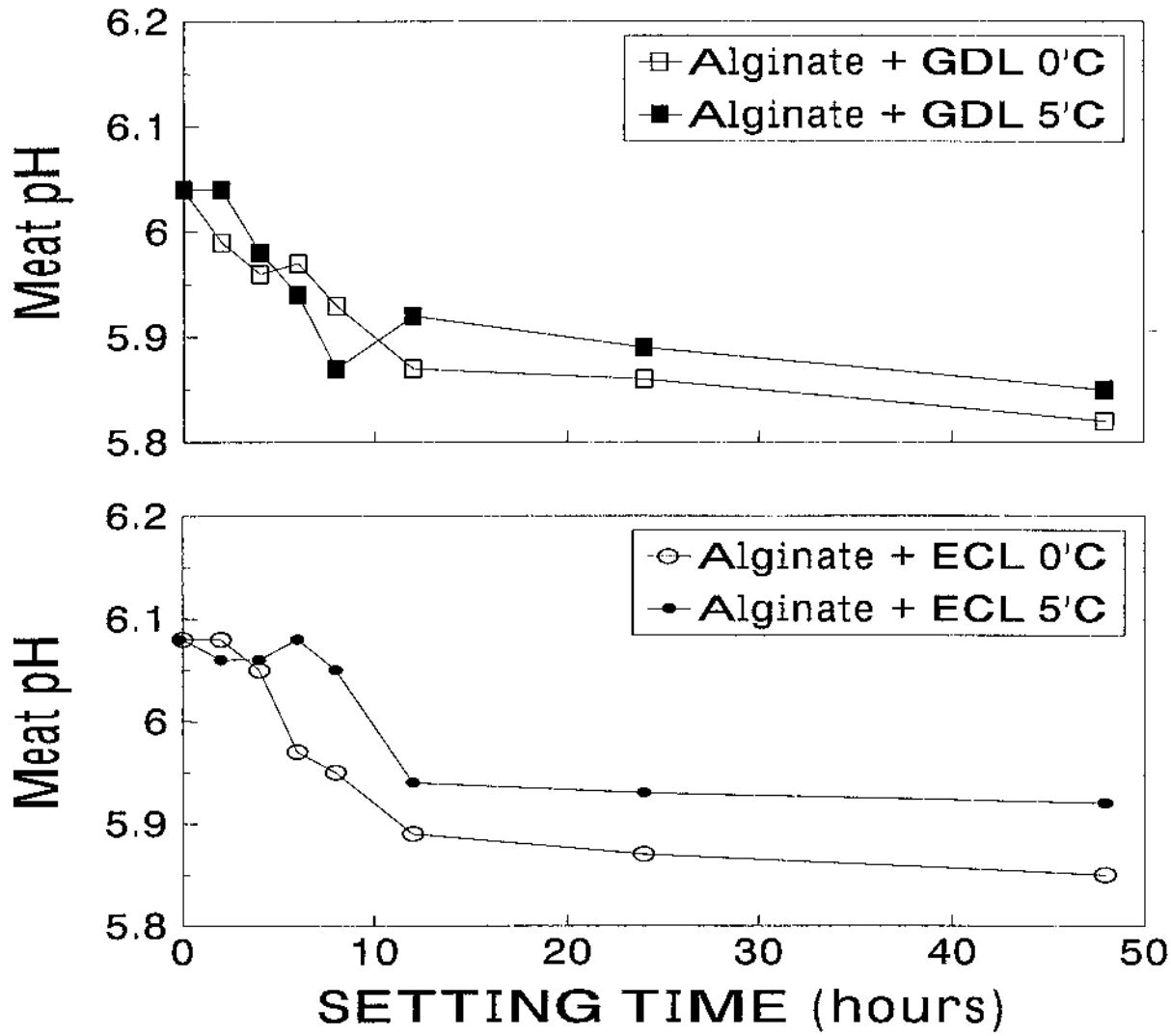


Figure 5: The pH of restructured venison products bound with either alginate-ECL or alginate-GDL stored for up to 48 hours at 0°C and 5°C

In conclusion, the results of this trial show that alginate-GDL and alginate-ECL binding systems were capable of forming an acceptable bind with venison forequarters. However, the alginate-ECL samples stored at 5°C had a relatively weak, unacceptable, raw bind strength. The alginate-GDL samples stored at 0°C and 5°C, and alginate-ECL samples stored at 0°C all had relatively strong, acceptable, raw bind strengths. The alginate-ECL at 0°C was the most rapid at forming a raw bind. The remainder of the trials were conducted with alginate-GDL because ECL produced unacceptable white specks in bound products.

5.1.5 Cominbations of Minced and Desinewed Meat

Table 14: Different combination of kidney plate and denuded material that was investigated.

Treatment	Alginate	CaCO3	GDL	Water	Particle Size %	
					KP [a]	Dn [b]
1	0.5	0.15	0.5	3.0	50 %	50 %
2	0.5	0.15	0.5	3.0	70 %	30 %
3	0.5	0.15	0.5	3.0	80 %	20 %
4	0.5	0.15	0.5	3.0	90 %	10 %
5	0.5	0.15	0.5	3.0	0 %	100 %

[a] :- material has been minced through kidney plate mincer.
[b] :- material has been denuded through the Baader '696'.

Table 15: Raw bind strength, colour stability, cooking losses and appearance of alginate-bound venison steaks produced from different meat particle sizes.

Treatment		Bind (Raw)	Colour (a*-value)				Cook Losses	Appearance of Cooked Product
KP[a]	Dn[b]		4h	30h	48h	72h		
50%	50%	220.5	14.85	11.55	9.72	7.69	23.21	Poorly bound
70%	30%	223.7	14.6	11.42	8.87	7.16	29.11	Well bound
80%	20%	227.7	15.83	10.44	9.81	7.71	27.82	Very well bound
90%	10%	248.8	14.14	11.75	8.47	7.5	22.51	Well bound
0%	100%	226.6	14.42	10.96	9.15	7.27	25.28	Very well bound

[a] :- material has been minced through kidney plate mincer.
[b] :- material has been denuded through the Baader '696'.

The results in Table 15 show that except for the 50%KP and 50% Dn, all other combinations of kidney plate meat and denuded meat resulted in acceptable cooked product, that is, well bound product.

Although 100% denuded material had an acceptable cooked bind, it had a poor texture due to the smaller particle size of the denuded material.

The various combinations of meat particle sizes did not seem to have a significant effect on cooking loss, colour stability (a*-values) or raw bind strength (hardness).

In conclusion, any combination of 70%-90% kidney plate material and 10-30% denuded material would result in an acceptable product with good cooked bind and texture.

5.1.6 Effect of Antioxidants

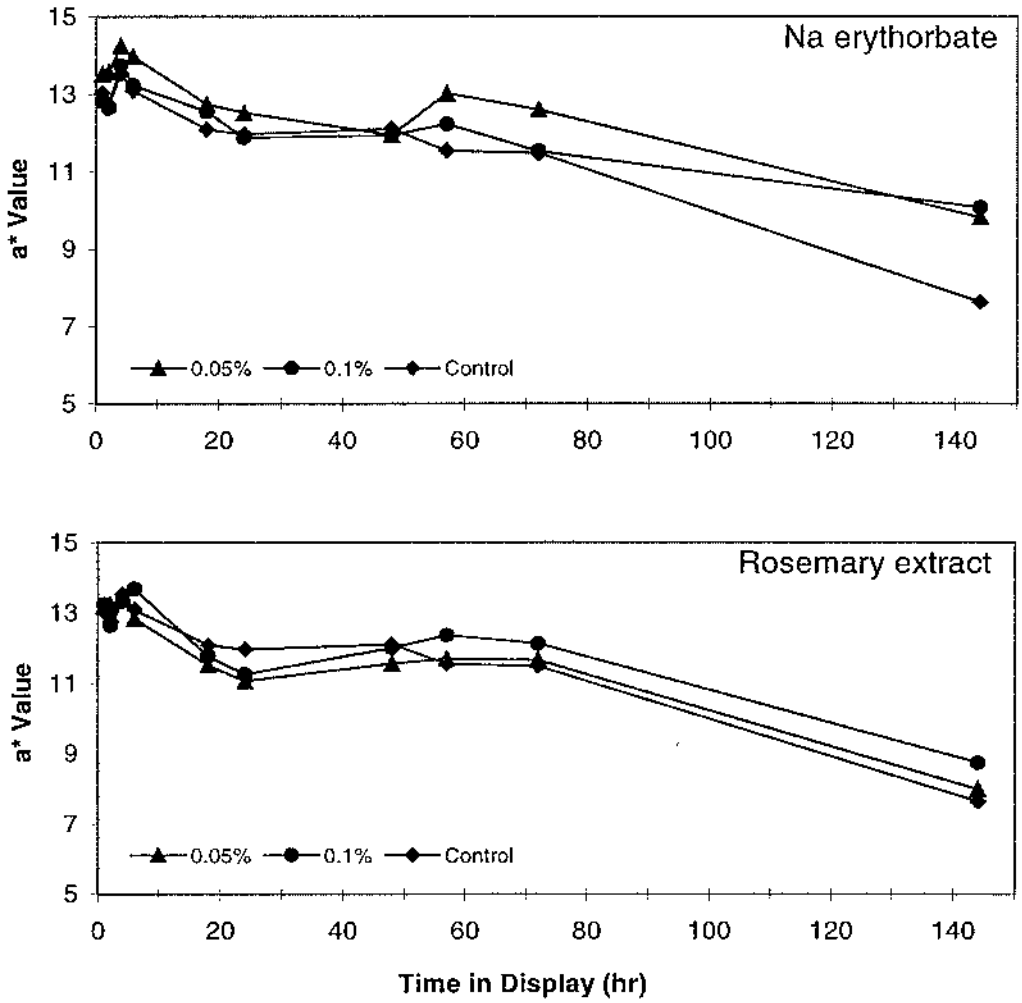


Figure 6: The effect of sodium erythorbate and rosemary extract on alginate-bound venison steak

Venison tends to have poor colour stability, therefore antioxidants - sodium erythorbate and rosemary extract, were trialed to improve colour and colour stability of alginate-bound venison steaks. Neither of the antioxidants had a significant effect on the colour stability of alginate-bound venison steaks. Rosemary extract has a very strong flavour and even at concentrations as low as 0.05%, a strong flavour could be detected in the venison steaks. Sodium erythorbate is only permitted in meat products that come under the "manufactured meat" category. Therefore, if erythorbate was used, the alginate-bound venison steaks would have to be labelled as manufactured meat.

In conclusion neither of these antioxidants are recommended to be used to improve colour stability of alginate-bound venison steaks.

5.1.7 Sensory Evaluation

The least squares means (LSMeans) for the sensory analysis are shown in Table 16 and plotted in Fig. 7 for overall appearance and quality, aroma, flavour and textural attributes.

Of the nine attributes assessed, five sensory aspects were similar ($p>0.05$) when assessed for treatment effects. The results indicated that there were no differences between each of the treatments for venison aroma and flavour, other aroma and flavour and also overall quality.

The venison aroma was rated as being moderate with a slight other aroma and flavour. The venison flavour for the 100% Baader denuded samples had a lower venison flavour and higher other flavour but it was not significantly different from the other treatments. Overall quality was rated as moderate to good, with the 100 % Baader denuded treatment rated slightly higher than the other treatments.

Table 16: LSMeans for venison sensory evaluation

ATTRIBUTE	100% KP	100% Baad DN	70% KP, 30% DN	Std Err LSMEAN	P value
Overall Appearance	3.39	5.37	3.96	0.16	P<0.01
Venison Aroma	5.00	5.24	5.10	0.16	NSD
Other Aroma	2.58	2.77	2.65	0.08	NSD
Venison Flavour	5.31	4.80	5.10	0.17	NSD
Other Flavour	3.00	3.42	2.98	0.14	NSD
Texture	6.89	4.81	6.23	0.17	P<0.01
Cohesiveness	7.06	5.64	6.61	0.04	P<0.0001
Juiciness	5.88	6.32	5.51	0.10	P<0.05
Overall Quality	5.69	5.95	5.75	0.13	NSD

Significant differences were found for overall appearance and the three textural properties evaluated. Overall appearance was significant ($p<0.01$) with the 100% Baader denuded (DN) treatment being rated significantly more patty like than the 100% kidney plate (KP) treatment ($p=0.0008$) and also the 70%KP, 30% DN treatments ($p=0.0.0028$). There was no significant difference between the two treatments processed through the kidney plate for overall appearance.

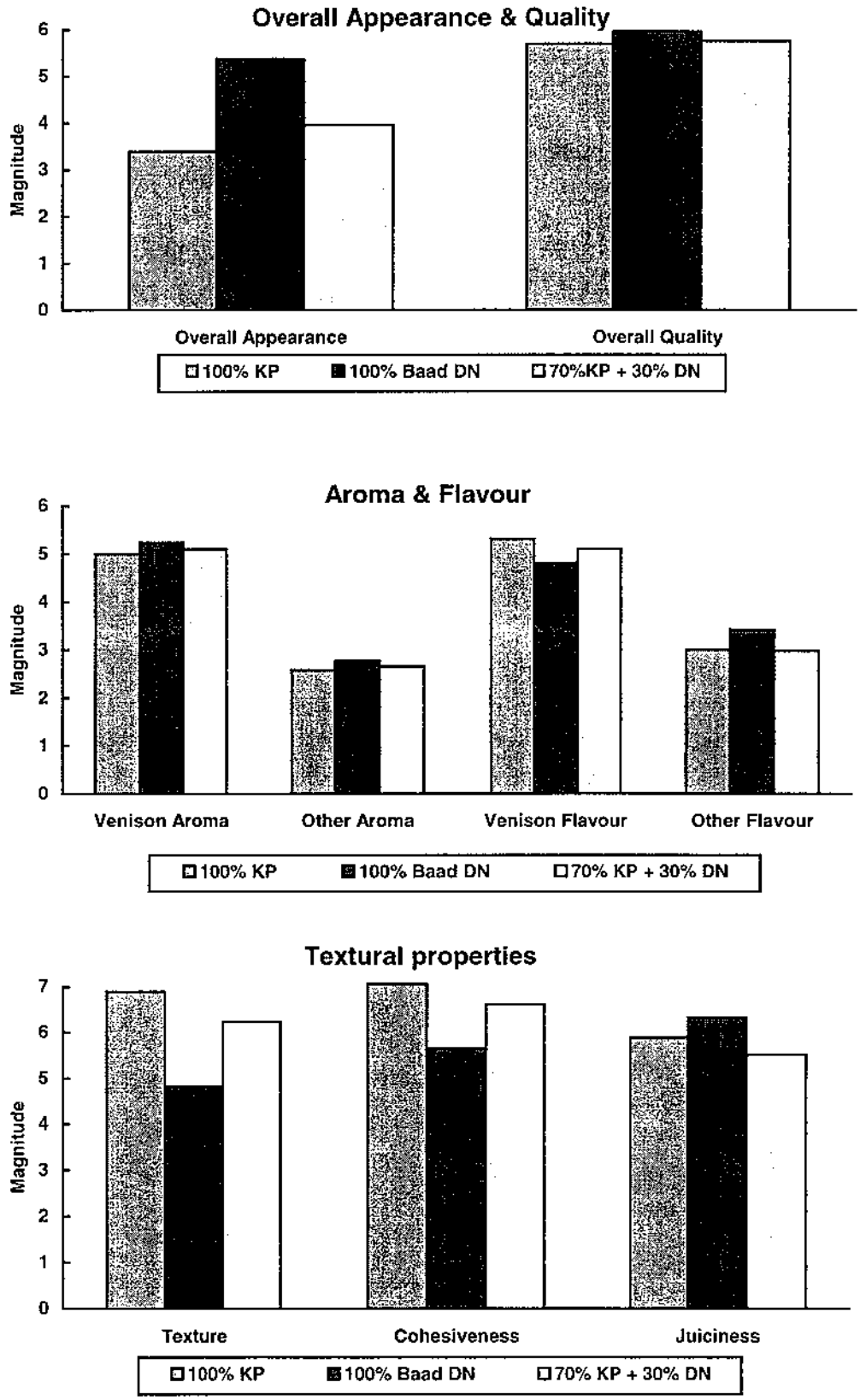


Figure 7: LS Means of consensus profile for cold-set bound venison products

The 100%KP treatment was rated as having a firm texture, which was significantly higher than the 70%KP + 30% DN treatment ($p<0.05$) and also the 100% Baader denuded treatment ($p=0.001$) which was rated as being moderate firmness. The 70%KP + 30% DN treatment was also significantly higher than the 100% Baader denuded treatment ($p=0.004$). A similar result was obtained for the cohesiveness attribute with the 100% Baader denuded treatment being rated significantly lower ($p<0.0001$) than the other treatments. It was rated as being moderate to cohesive on the nine point category scale with the 100% KP sample cohesive and significantly more cohesive ($p=0.0012$) than the 70%KP +30% DN treatment.

Juiciness was also significant ($p=0.013$), with the 100% Baader denuded treatment rated as juicy and significantly more juicy than the 100% KP and 70%KP+30%DN treatments, p=0.0.034,0.0039 respectively. The 100% KP treatment was also significantly more juicy than the 70%KP+30%DN treatment ($p=0.0475$).

Panelists had the opportunity to record descriptive comments about any other aromas and flavours detected. The main comments made by the panelists were that the 100% Baader denuded treatment had a slight acidy, fatty flavour and that there was gristle in the 100% kidney plate treatment. There was some cartilage fragments in the 100% baader denuded treatment.

The results showed that there were differences in the overall appearance and textural properties between the different samples. These attributes impacted on the overall quality assessments for each treatment by the panelists. The effect of denuding the venison meant that it was rated as more patty-like. The cohesiveness and textural properties were reduced but with a subsequent improvement in juiciness. This in turn impacted on the overall quality of this treatment to allow it to have a slightly higher rating than the other treatments.

5.1.8 Microbiology

The initial total counts on alginate-bound venison products made from various blends of minced and desinewed meat were > 8.0×10^5 cfu / g. There was no difference between treatments (Table 17). Of those bacterial groups tested, there was no dominant group. The counts were considered to be high for meat that had been vacuum packed, processed and tested 7 days after slaughter.

Table 17: Initial bacterial counts (cfu per cm^2) on alginate-bound venison steaks produced from minced and desinewed trimmings

Treatment	Count / cm^2			
	Total count	Lactic acid bacteria	Gram negative bacteria	*Brochothrix thermosphacta*
100% KP	5.6×10^5	1.6×10^5	3.4×10^5	3.0×10^4
70% KP	4.0×10^5	3.0×10^4	3.4×10^5	3.0×10^4
100% denuded	8.0×10^5	2.5×10^5	5.6×10^5	3.0×10^4

* = count per cm^2

Table 18: Bacterial counts (cfu per cm^2) on alginate-bound venison steaks produced from minced and desinewed trimmings during retail display

Treatments	Day	Count / cm^2			
		Total count	Lactic acid bacteria	Gram negative bacteria	*Brochothrix thermosphacta*
100% KP	0	5.0×10^5	4.4×10^5	2.9×10^5	2.5×10^4
70% KP	0	4.9×10^5	3.9×10^5	3.0×10^5	2.9×10^4
100% denuded	0	6.7×10^5	2.1×10^5	3.5×10^5	3.4×10^4
100% KP	1	7.0×10^6	6.5×10^6	3.1×10^5	7.5×10^4
70% KP	1	1.0×10^7	9.5×10^6	4.0×10^5	1.7×10^5
100% denuded	1	6.3×10^6	5.5×10^6	7.1×10^5	2.7×10^5
100% KP	4	5.9×10^7	5.3×10^7	6.0×10^6	2.0×10^6
70% KP	4	5.9×10^8	1.7×10^8	4.6×10^8	$<5.0 \times 10^7$
100% denuded	4	1.2×10^9	8.0×10^7	1.1×10^9	1.0×10^7

Numbers of bacteria recorded on samples taken after thawing (Day 0) were not different from the initial counts. Numbers of bacteria recorded on samples on Day 1 had increased, but were still below spoilage levels (1×10^7 cfu/ g in aerobic storage). After 4 days display all treatments recorded bacterial numbers > 5.9×10^7 cfu/ g and were considered microbiologically spoiled. The dominant groups of bacteria were lactic acid bacteria and Gram negative bacteria. Off, sour odours were observed on the denuded and the 70% KP samples.

The counts on the diced products show that using alginate has no effect on the growth rate of bacteria in venison products displayed in a retail cabinet at 5°C. However, it should be noted that the total bacteria counts recorded on the initial samples were higher than expected. The lactic acid bacteria and *Brochothrix thermosphacta* counts were typical of vacuum packaged meat stored chilled for several weeks, not for 6 days as in the case of this trial. Under the operating conditions in which the tested products were processed, bacterial numbers should not have increased significantly. Therefore these high counts may be due to high temperatures encountered by the venison primals prior to being further processed at Food Science Australia.

The microbiological retail shelf-life of the venison products was only one or two days after the steaks were placed into the display cabinet. This short shelf-life was possibly due to the initial high bacterial counts.

The results of this trial indicate that alginate, used as cold set binders for venison products, will have no adverse effect on the microbiological status of the retail product.

5.2 Pearl F-Bound Venison Roasts

5.2.1 Sensory Evaluation

There was no significant difference found between the sensory properties of Pearl F-bound forequarters compared with rolled forequarters containing no binder (ie. control sample). These results indicate that the Pearl F used at the level required to bind forequarter meat does not impart any foreign venison flavours.

5.2.2 Microbiology

The total counts of bacteria recorded on initial samples from all treatments were > 1.1×10^5 cfu / g. There was no difference between treatments (Table 19). Of those bacterial groups tested, there was no dominant group. The counts were considered to be high for meat that had been vacuum packed, processed and tested 7 days after slaughter.

Table 19: Initial bacterial counts (cfu per cm^2) on Pearl F-bound venison steaks produced from forequarters

Treatment	Count / cm^2			
	Total count	Lactic acid bacteria	Gram negative bacteria	*Brochothrix thermosphacta*
Control	5.8×10^5	2.2×10^5	4.1×10^5	5.5×10^4
Pearl-bound	1.1×10^5	9.1×10^4	4.3×10^4	5.5×10^3

* = count per cm^2

Table 20: Bacterial counts (cfu per cm^2) of Pearl F-bound venison produced from forequarters after retail display

Treatments	Day	Count / cm^2			
		Total count	Lactic acid bacteria	Gram negative bacteria	*Brochothrix thermosphacta*
Control	0	1.2×10^6	6.0×10^5	4.5×10^5	5.1×10^4
Pearl-bound	0	1.3×10^5	5.2×10^4	5.5×10^4	1.5×10^4
Control	1	6.2×10^6	1.7×10^6	4.3×10^5	1.0×10^4
Pearl-bound	1	1.7×10^6	6.3×10^5	6.6×10^4	7.1×10^4
Control	4	1.3×10^8	5.1×10^7	6.6×10^7	4.0×10^6
Pearl-bound	4	2.3×10^8	2.2×10^8	2.4×10^7	1.0×10^6

Numbers of bacteria recorded on samples taken after thawing (Day 0) were not different from the initial counts (Table 20). Numbers of bacteria recorded on samples on Day 1 had increased, but were still below spoilage levels (1×10^7 cfu/ g in aerobic storage). After 4 days display all treatments recorded bacterial numbers > 5.9×10^7 cfu/ g and were considered microbiologically spoiled. The dominant groups of bacteria were lactic acid bacteria and Gram negative bacteria. Off, sour odours were observed on the DN and the 70% KP samples.

The bacterial counts indicate that the addition of Pearl-F does not have any affect on the growth rate of bacteria on venison displayed at 5°C.

It should be noted that the total bacteria counts recorded on the initial samples were higher than expected. The lactic acid bacteria and *Brochothrix thermosphacta* counts were typical of vacuum packaged meat stored chilled for several weeks, not for 6 days as in the case of this trial. Under the operating conditions in which the tested products were processed, bacterial numbers should not have increased significantly. Therefore, these high counts may be due to high temperatures encountered by the venison primals prior to being further processed at Food Science Australia.

The microbiological retail shelf-life of the venison products was only one or two days after the steaks were placed into the display cabinet. This short shelf-life was possibly due to the initial high bacterial counts. In conclusion, this trial indicates that the use of Pearl-F or alginate, as cold-set binders, will not affect the bacterial growth rate of venison products displayed at 5°C.

6. CONCLUSIONS

In summary, the microbiology and sensory results of this trial indicate that Pearl-F or alginate, used as cold-set binders for venison products, will have no adverse effect on the microbiological status or sensory properties of the retail product.

7. IMPLICATIONS AND RECOMMENDATIONS

7.1 Implications

The results from these trials indicated that two different binding processes were required. The best cold-set binding technology for venison trimmings used alginate as the binder. In this process, minced venison trimmings were mixed with alginate and other ingredients, filled into casings, then chilled overnight to bind the alginate-bound product (process shown in Process 1). For the larger pieces of meat in boneless venison forequarters, the best cold-set binder was Pearl F. Pearl F was dusted onto the cut surface of venison forequarters. The dusted surfaces of the meat were joined together, and then the meat was wrapped in PVC film, and chilled overnight to allow the bind to form (process shown in Process 2).

This research proposed the development of an alternative that will be used to add value to lower-grade meats and will offer a wide range of applications to the venison processing industry in the area of restructured meat products. Ultimately it is envisaged that cold-set binders will be used to produce high quality, uniform restructured products that have enhanced colour shelf-life during fresh and frozen storage. This technology will have diverse applications in the venison processing industry; ie. these products may compete with higher value cuts such as fillet steaks, or with other processed meats such as cooked, crumbed or battered products.

7.2 Recommendations

The binder that is best used for your purpose will depend on the raw material characteristics, the desired product attributes, the market, and other factors (see Table 21). Contact the Value-Added Group of Food Science Australia for advice on how to use any of these binders.

Table 21: Overview of commercially available cold-set binding systems for venison shoulder meat

Binding System	Works well with	Manufacturer
Alginate	Both comminuted and diced meat	Kelco
Glucono-δ-lactone	"	Earlee Products
ECL	"	Kelco
Pearl F	Large meat pieces	Earlee Products
Pearl E	"	Earlee Products
Pearl MX-30	"	Earlee Products
Fibrimex	Small meat pieces, small muscles	Harimex
Surimi	Both comminuted and diced meat	Several

8. INTELLECTUAL PROPERTY

While the technology developed in this research is commercially significant, it is unlikely that any patents will arise from this work. There are currently no patents, or are there likely at this time to be any intellectual property generating from this research. Methods used to develop high quality cold-set bound restructured steaks and roasts were innovative; however, a number of individual technologies used such as the patented alginate binding system, are well established. It may be quite difficult to seek recognition for some aspects of the developed processes that are already well adopted. It would be unwise to apply for a patent on technology that was developed in this project for cold-set bound venison steaks and roasts since some aspects of the process may be similar. Therefore, Food Science Australia does not wish to apply for a patent on the processes at this time.

9. COMMUNICATIONS STRATEGY

The technology developed in this project will be transferred to the industry via media releases and personal communications. It is possible to demonstrate these methods to processors here at the laboratory.

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APPENDIX 1: Microbiology Report

FOOD SCIENCE AUSTRALIA
A JOINT VENTURE OF CSIRO AND AFISC

Microbiological Report of Venison Products using Cold Set Binders

Project : CSS-1A

Prepared for
Dean Gutzke

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Background
The Food Safety and Quality Group evaluated the microbiological status of cold-set bound venison.

Methods
Five products were produced and evaluated (Table A1.1).

Table A1.1: Treatments used to determine the microbiological status of alginate-bound venison steaks

Treatments No.	Treatments
(1) Control	venison primal rolled and set with no additive, frozen then cut into steaks.
(2) Pearl	venison primal was dusted with Pearl-F, rolled and set, frozen then cut into steaks.
(3) 100% kidney plate	venison, diced through a kidney plate, formed and set, frozen then cut into steaks.
(4) 70% KP+30% Dn	venison, diced through a kidney plate, mixed to 70%, formed and set, frozen then cut into steaks.
(5) 100% denuded	Venison, denuded of connective tissue, diced, formed and set, frozen then cut into steaks.

All treatments were allowed to set over 24 hours during freezing, then band sawed into steaks. Steaks were packed into normal retail trays, overwrapped with PVC and displayed for 5 days in a retail display cabinet running at 5°C. Samples were taken for microbiological testing on the day of slicing into steaks (initial), after thawing (Day 0), after 1 and 4 days display (Day 1 and Day 4). Bacterial growth was recorded on all treatments and compared to the controls.

Microbiological analysis
Samples were obtained by coring 10 g from steaks in two retail packs from each treatment tested. Each sample was placed in a sterile stomacher bag (A J Seward Co Ltd, London). To each bag 1.25% NaCl solution was added to a total of 100 g and the samples treated for 1 minute with a Colworth Stomacher, Model 400 (A J Seward Co Ltd, London). Appropriate dilutions were spread-plated on pre-dried plates of Tryptone Soya Agar (Oxoid) supplemented with 0.2% (w/v) yeast extract and 0.2% glucose (TSYG agar); MRS (de Man, Rogosa, Sharpe) Agar (Oxoid); streptomycin thallous acetate, actidione agar (STAA Agar; Gardner, 1966) and Peptone (0.8%, w/v; Oxoid) Agar (PA agar; Grau, 1983). Total aerobic counts were obtained from TYSG plates incubated at 25°C for 3 days. STAA agar plates were incubated at 25□C for 3 days to enumerate *Brochothrix thermosphacta*. Counts of lactic acid bacteria were obtained from MRS agar incubated aerobically at 25°C for 3 days. Peptone agar plates were incubated for 3 days at 25°C to obtain Gram negative counts.

Results

The microbiological results for the initial processed products and after retail display are shown in Table A1.2. These counts are shown as cfu /g.

Table A1.2: Bacterial counts (cfu/g) on processed products prepared from venison

Treatment	Day	Count cfu/ g			
		Total count	**Lactic acid bacteria**	**Gram negative bacteria**	***Brochothrix thermosphacta***
Control	initial	5.8×10^5	2.2×10^5	4.1×10^5	5.5×10^4
Pearl	"	1.1×10^5	9.1×10^4	4.3×10^4	5.5×10^3
100% KP	"	5.6×10^5	1.6×10^5	3.4×10^5	3.0×10^4
70% KP	"	4.0×10^5	3.0×10^4	3.4×10^5	3.0×10^4
100% denuded	"	8.0×10^5	2.5×10^5	5.6×10^5	3.0×10^4
Control	Day 0	1.2×10^6	6.0×10^5	4.5×10^5	5.1×10^4
Pearl	"	1.3×10^5	5.2×10^4	5.5×10^4	1.5×10^4
100% KP	"	5.0×10^5	4.4×10^5	2.9×10^5	2.5×10^4
70% KP	"	4.9×10^5	3.9×10^5	3.0×10^5	2.9×10^4
100% denuded	"	6.7×10^5	2.1×10^5	3.5×10^5	3.4×10^4
Control	Day 1	6.2×10^6	1.7×10^6	4.3×10^5	1.0×10^4
Pearl	"	1.7×10^6	6.3×10^5	6.6×10^4	7.1×10^4
100% KP	"	7.0×10^6	6.5×10^6	3.1×10^5	7.5×10^4
70% KP	"	1.0×10^7	9.5×10^6	4.0×10^5	1.7×10^5
100% denuded	"	6.3×10^6	5.5×10^6	7.1×10^5	2.7×10^5
Control	Day 4	1.3×10^8	5.1×10^7	6.6×10^7	4.0×10^6
Pearl	"	2.3×10^8	2.2×10^8	2.4×10^7	1.0×10^6
100% KP	"	5.9×10^7	5.3×10^7	6.0×10^6	2.0×10^6
70% KP	"	5.9×10^8	1.7×10^8	4.6×10^8	$<5.0 \times 10^7$
100% denuded	"	1.2×10^9	8.0×10^7	1.1×10^9	1.0×10^7

The total counts of bacteria recorded on initial samples from all treatments were > 1.1×10^5 cfu / g. There was no difference between treatments. Of those bacterial groups tested, there was no dominant group. The counts were considered to be high for meat that had been vacuum packed, processed and tested 7 days after slaughter.

Numbers of bacteria recorded on samples taken after thawing (Day 0) were not different from the initial counts. Numbers of bacteria recorded on samples on Day 1 had increased, but were still below spoilage levels (1×10^7 cfu/ g in aerobic storage). After 4 days display all treatments recorded bacterial numbers > 5.9×10^7 cfu/ g and were considered

microbiologically spoiled. The dominant groups of bacteria were lactic acid bacteria and Gram negative bacteria. Off, sour odours were observed on the denuded and the 70% samples.

Discussion

The bacterial counts indicate that the addition of Pearl-F does not have any affect on the growth rate of bacteria on venison displayed at 5°C. Similarly the counts on the diced products show that using alginate has no effect on the growth rate of bacteria in venison products displayed in a retail cabinet at 5°C.

It should be noted that the total bacteria counts recorded on the initial samples were higher than expected. The lactic acid bacteria and *Brochothrix thermosphacta* counts were typical of vacuum packaged meat stored chilled for several weeks, not for 6 days as in the case of this trial. Under the operating conditions in which the tested products were processed, bacterial numbers should not have increased significantly. Therefore these high counts may be due to high temperatures encountered by the venison primals prior to being further processed at Food Science Australia.

The microbiological retail shelf-life of the venison products was only one or two days after the steaks were placed into the display cabinet. This short shelf-life was possibly due to the initial high bacterial counts.

In summary this trial indicates that the use of Pearl-F or alginate, as cold set binders, will not affect the bacterial growth rate of venison products displayed at 5°C.

Conclusion

The results of this trial indicate that Pearl-F or alginate, used as cold set binders for venison products will have no adverse effect on the microbiological status of the retail product.

APPENDIX 2: Sensory Report

FOOD SCIENCE AUSTRALIA
A JOINT VENTURE OF CSIRO AND AFISC

Sensory Evaluation Report of Venison Products using Cold-Set Binders
Project : CSS-1A

Prepared for
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Summary
The main aim of the first study was to determine whether processing methods can be used improve the quality of meat products produced from venison trim.

The major finding was the differences in the overall appearance and textural properties of the samples. These attributes impacted on the overall quality assessments for each treatment by the panelist. The effect of denuding the venison meant that it was rated as more patty-like. The cohesiveness and textural properties were reduced but with a subsequent improvement in juiciness. This in turn impacted on the overall quality of this treatment to allow it to have a slightly higher rating than the other treatments.

In the second study to determine the impact of using Pearl F as a binder for venison, no significant difference found between the control (Pearl F) and the different sample.

Sensory Panel Evaluation of Venison Products

The purpose of this trial was to determine whether processing methods can be used to improve the quality of meat products produced from venison trim. In this trial the appearance, aroma, flavour and overall quality (ie. acceptability) was assessed with three (3) variation in processing method as shown in Table A2.1.

Table A2.1: Product types

No	*Treatment*
1	100% Kidney Plate (KP)
2	100% Baader Denuded (DN)
3	70% Kidney Plate, 30% Baader Denuded

Preparation Method
The samples were prepared and kept frozen until ready for tasting. They were then thawed overnight at 5°C. The patties were cooked on SILEX Grillers (Type T-1). The grillers were preheated to approximately 180°C and the samples were cooked for a total of 10 minutes, turned over at 4 and 8 minutes. Two cooks were carried out for each session cooking 18 samples each time, six from each treatment. The reformed steaks were put in a casserole dish and kept warm in a Bain Marie set at 65 -70°C until ready for serving. Samples were served from the initial cook first for each session. The samples were presented whole, to 12 panelist who have eaten venison before and who are familiar with assessment of the textural properties of meat. Each sample was presented on a white plastic plate in random order with three treatments per session assessed and 3 digit codes used to identify each sample. Samples were presented to panelists under daylight conditions in individual booths. For this work, the 12 member panel was asked to assess each product for nine attributes as shown in

Table A3 using a 9 point category scales. The data was recorded directly onto a multi-user computer system.

Statistical Analysis

An analysis of variance was performed on the data to assess for differences between treatments. The SAS System for Windows (SAS, 1989-1996); version 6.12 TS020 was used to analyse the data.

Table A2.2: Venison Profile

No	Sensory attribute	End labels	Interpretation
	Appearance		
1.	Overall Appearance	Meat like – Patty like	Overall impression of appearance
	Aroma & Flavour		
2.	Venison Aroma	None – Very strong	Strength of venison aroma
3.	Other Aroma	None – Very Strong	Strength of aromas other than venison
4.	Venison Flavour	None – Very Strong	Strength of venison flavour
5.	Other Flavour	None – Very Strong	Strength of flavours other than venison
	Textural Properties		
6.	Texture	Very soft – Very firm	Initial sensation on biting
7.	Cohesiveness	Very mushy – Very cohesive	Nature and ease of initial breakdown on chewing
8.	Juiciness	Very dry – Very juicy	Degree of juiciness
9.	Overall quality	Very poor – Very good	The overall impression of the product quality

Results

The least squares means (LSMeans) for the sensory analysis are shown in Table A2.3 and plotted in Fig. A1 for overall appearance and quality, aroma, flavour and textural attributes.

Of the nine attributes assessed, five were not significantly different when assessed for treatment effects. These were venison aroma and flavour, other aroma and flavour and also overall quality.

The venison aroma was rated as being moderate with a slight other aroma and flavour. The venison flavour for the 100% Baader denuded samples had a lower venison flavour and higher other flavour but it was not significantly different from the other treatments. Overall quality was rated as moderate to good, with the 100 % Baader denuded treatment rated slightly higher than the other treatments.

Table A2.3: LSMeans for Venison sensory evaluation

ATTRIBUTE	!00% KP	100% Baad DN	70% KP, 30% DN	Std Err LSMEAN	P value
Overall Appearance	3.39	5.37	3.96	0.16	P<0.01
Venison Aroma	5.00	5.24	5.10	0.16	NSD
Other Aroma	2.58	2.77	2.65	0.08	NSD
Venison Flavour	5.31	4.80	5.10	0.17	NSD
Other Flavour	3.00	3.42	2.98	0.14	NSD
Texture	6.89	4.81	6.23	0.17	P<0.01
Cohesiveness	7.06	5.64	6.61	0.04	P<0.0001
Juiciness	5.88	6.32	5.51	0.10	P<0.05
Overall Quality	5.69	5.95	5.75	0.13	NSD

Significant differences were found for overall appearance and the three textural properties evaluated. Overall appearance was significant (p<0.01) with the 100% Baader denuded (DN) treatment being rated significantly more patty like than the 100% kidney plate (KP) treatment (p=0.0008) and also the 70%KP, 30% DN treatments (p=0.0.0028). There was no significant difference between the two treatments processed through the kidney plate for overall appearance.

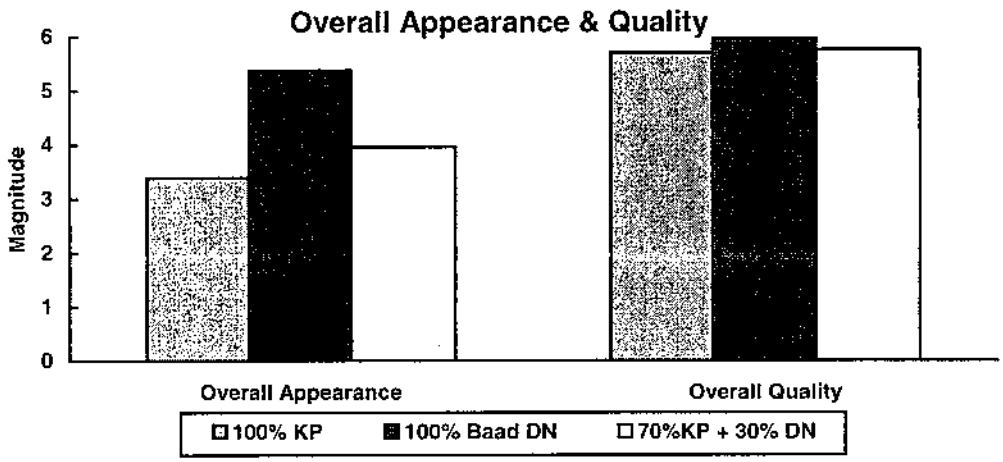
The 100%KP treatment was rated as having a firm texture, which was significantly higher than the 70%KP + 30% DN treatment (p<0.05) and also the 100% Baader denuded treatment (p=0.001) which was rated as being moderate firmness. The 70%KP + 30% DN treatment was also significantly higher than the 100% Baader denuded treatment (p=0.004). A similar result was obtained for the cohesiveness attribute with the 100% Baader denuded treatment being rated highly significantly lower (p<0.0001) than the other treatments. It was rated as being moderate to cohesive on the nine point category scale with the 100% KP sample cohesive and significantly more cohesive (p=0.0012) than the 70%KP +30% DN treatment.

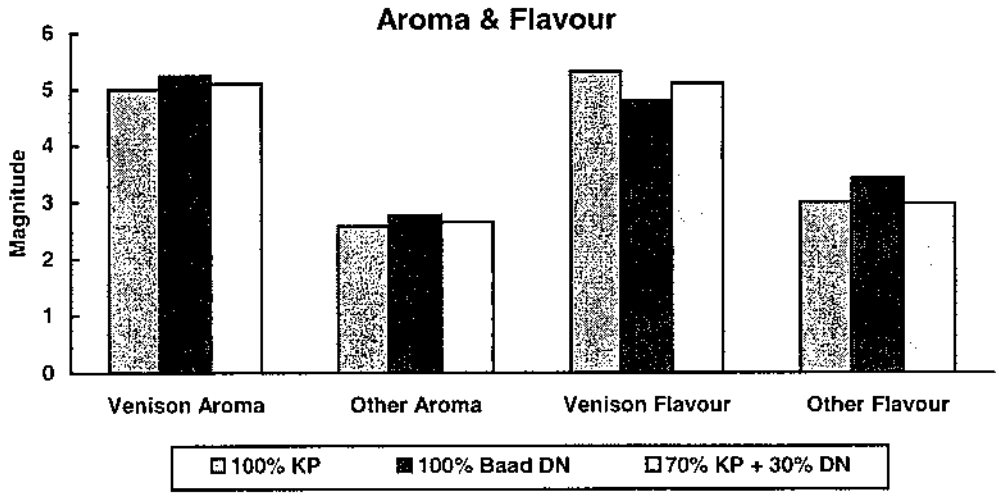
Juiciness was also significant (p=0.013), with the 100% Baader denuded treatment rated as juicy and significantly more juicy than the 100% KP and 70%KP+30%DN treatments, p=0.0.034,0.0039 respectively. The 100% KP treatment was also significantly more juicy than the 70%KP+30%DN treatment (p=0.0475).

Panelist had the opportunity to record descriptive comments about any other aromas and flavours detected. The main comment were that the 100% Baader denuded treatment had a slight acidy, fatty flavour and that there was gristle in the 100% kidney plate treatment. There was some bone fragments in the 100% baader denuded treatment.

Conclusion

The major finding was the differences in the overall appearance and textural properties of the samples. These attributes impacted on the overall quality assessments for each treatment by the panelist. The effect of denuding the venison meant that it was rated as more patty-like. The cohesiveness and textural properties were reduced but with a subsequent improvement in juiciness. This in turn impacted on the overall quality of this treatment to allow it to have a slightly higher rating than the other treatments.





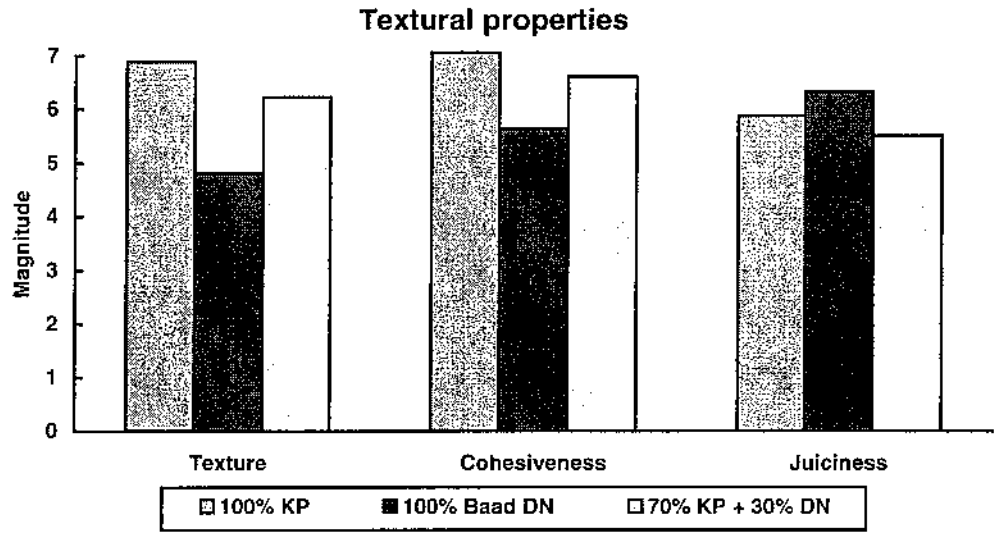


Figure A2.1: LS Means of consensus profile for cold-set bound venison products

Experiment 2
Sensory panel evaluation of Venison products treated with Pearl F.

Flavour differences can be imparted into meat products when certain binders are used. A duo/trio test procedure was used to assess if there was a flavour difference due to using Pearl F as a meat binder. The samples treated with Pearl F were used as the control or reference samples with the different sample having no binder. This was due to the quantity of samples available. The samples were presented to 18 panelist who have eaten venison before and who are familiar with assessment of the textural properties of meat. The sensory evaluation was carried out under red light to disguise differences due to colour.

Preparation Method

The samples were prepared and kept frozen until ready for tasting. The samples were then thawed overnight at 5^{O}C. The patties were cooked on SILEX Grillers (Type T-1). The grills were preheated to approximately 180^{O}C and the samples were cooked for 4 minutes each side. The lid was lowered for the second four minute period as the patty edges curled up, raising the sample outer portion significantly above the hot plate surface. By lowering the upper hot plate the samples were held flat for the remainder of the cooking period. Each reformed steak was quartered and put in a casserole dish and kept warm in a Bain Marie set at 65 -70^{O}C until ready for serving.

Results

There was no significant difference found between the control (Pearl F) and the different sample.

APPENDIX 3: Meal Solutions for Cold-set Bound Venison Products

A range of cold-set bound venison products including roasts, slices and steaks were developed in this research. The following are some of the products that were developed in this project. Some of these products were not discussed in depth in the report. A significant amount of work is needed to commercialise these products.

Photo 23: Pearl F-bound roast meat prepared from venison forequarter meat

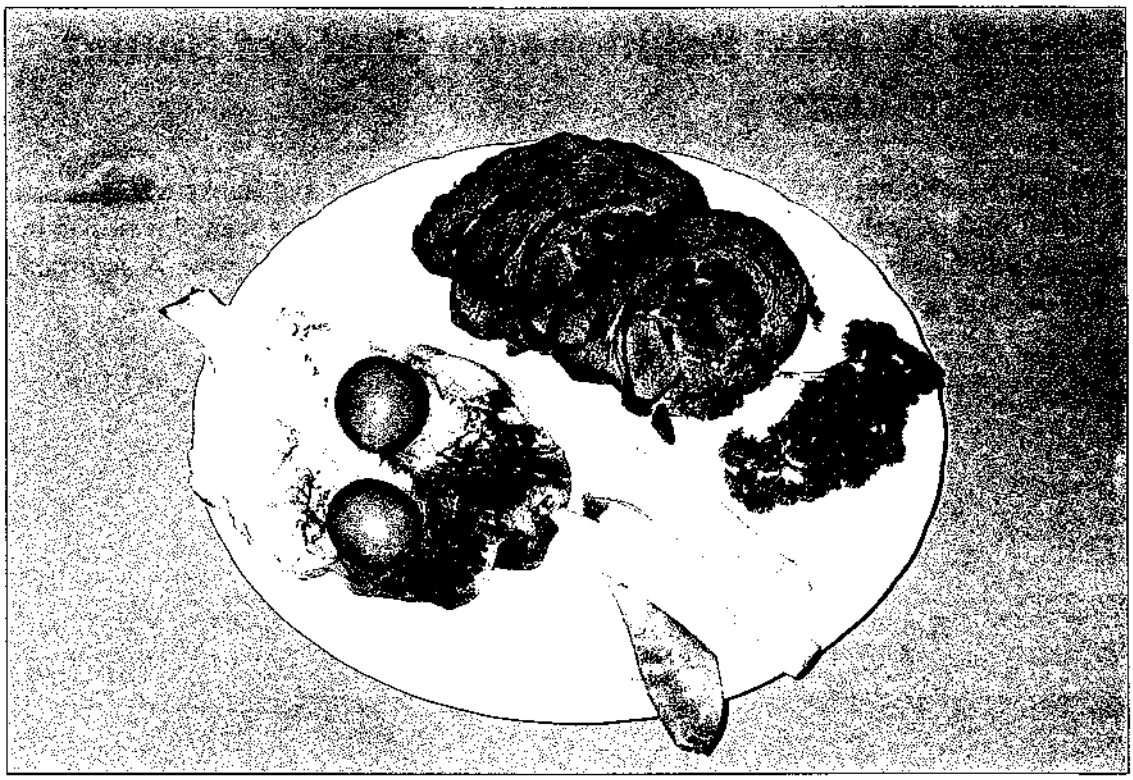
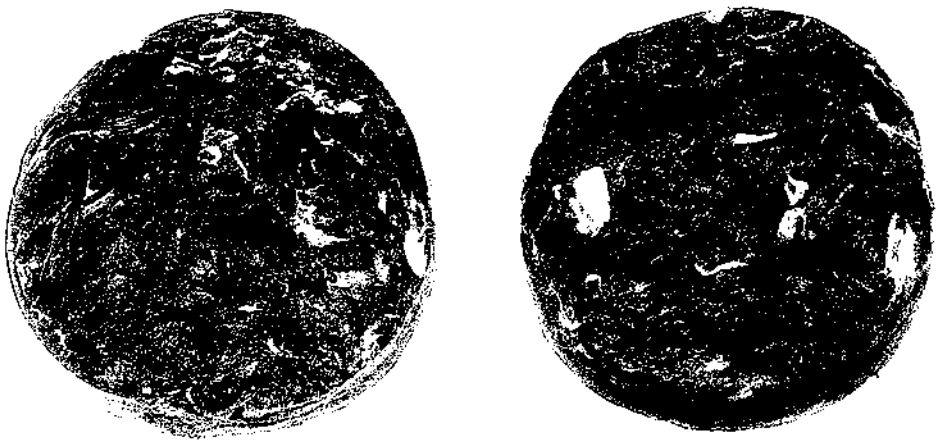


Photo 24: Sliced Venison forequarter roast made using Pearl F



Alginate-Bound Venison Steaks
(minced Forequarter-kidney plate)

Photo 25: Raw alginate-bound venison steaks manufactured from venison forequarter kidney plate material

Photo 26: Steaks produced from venison forequarter meat using Pearl F as the binder

Cold-set bound Venison Steaks
(Pearl F)

Photo 27: Cooked Pearl F-bound venison forequarter steaks

Photo 28: Surface roasted, water-bath cooked Pearl F-bound venison forequarter meat

Photo 29: Sliced roast meat produced from surface roasted, water-bath cooked Pearl F-bound venison forequarter meat

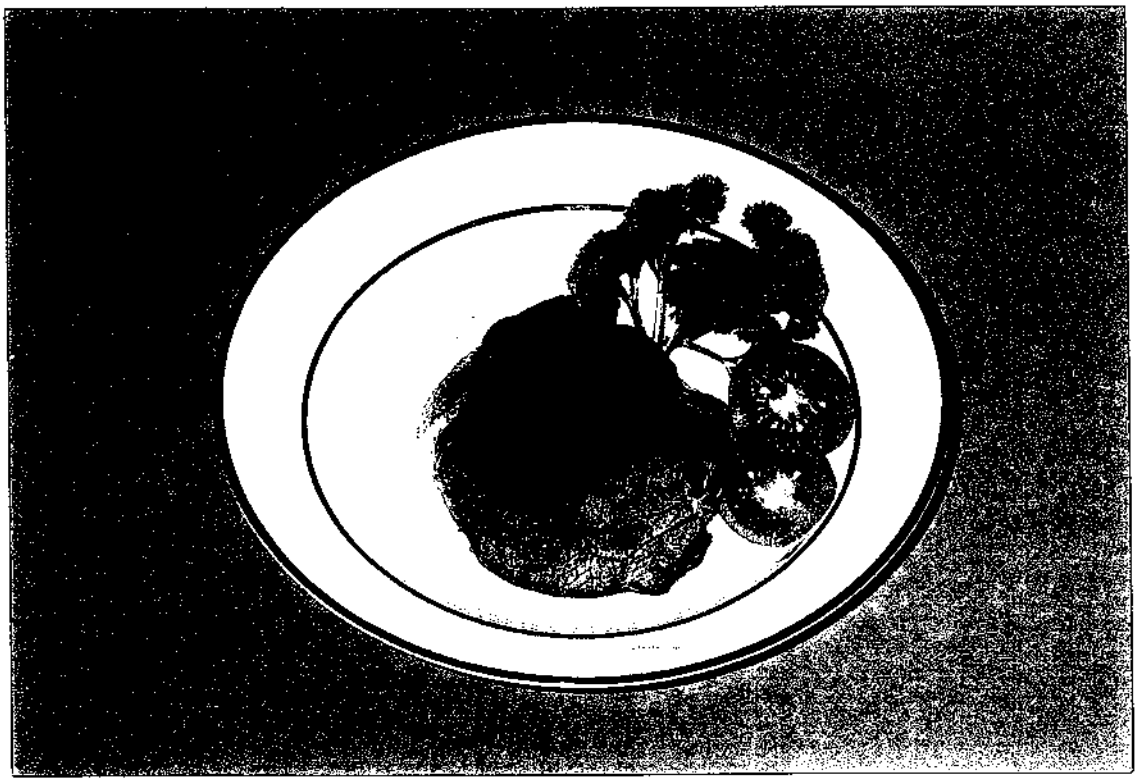


Photo 30: Cooked Pearl F-bound venison forequarter steak

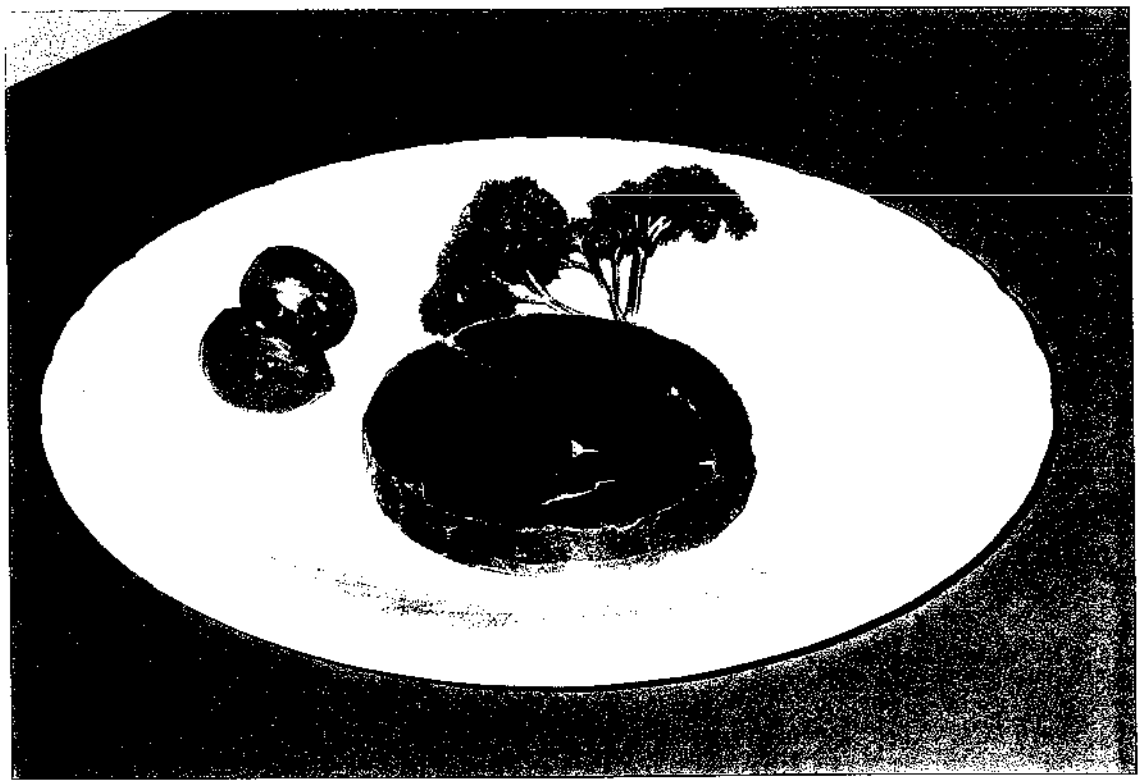


Photo 31: Cold-set bound steak produced from venison forequarter meat

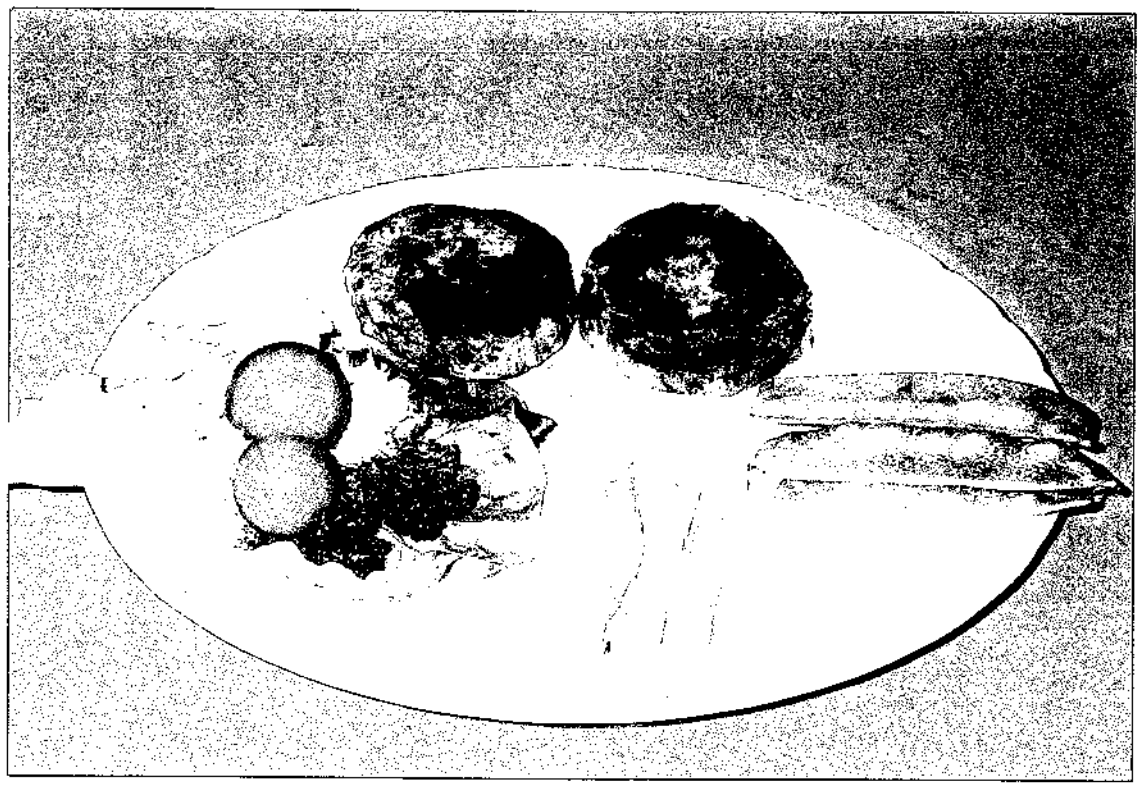


Photo 32: Cooked alginate-bound venison forequarter steaks produced from kidney plate material

Photo 33: Sliced roast meat produced from Pearl F-bound venison forequarters

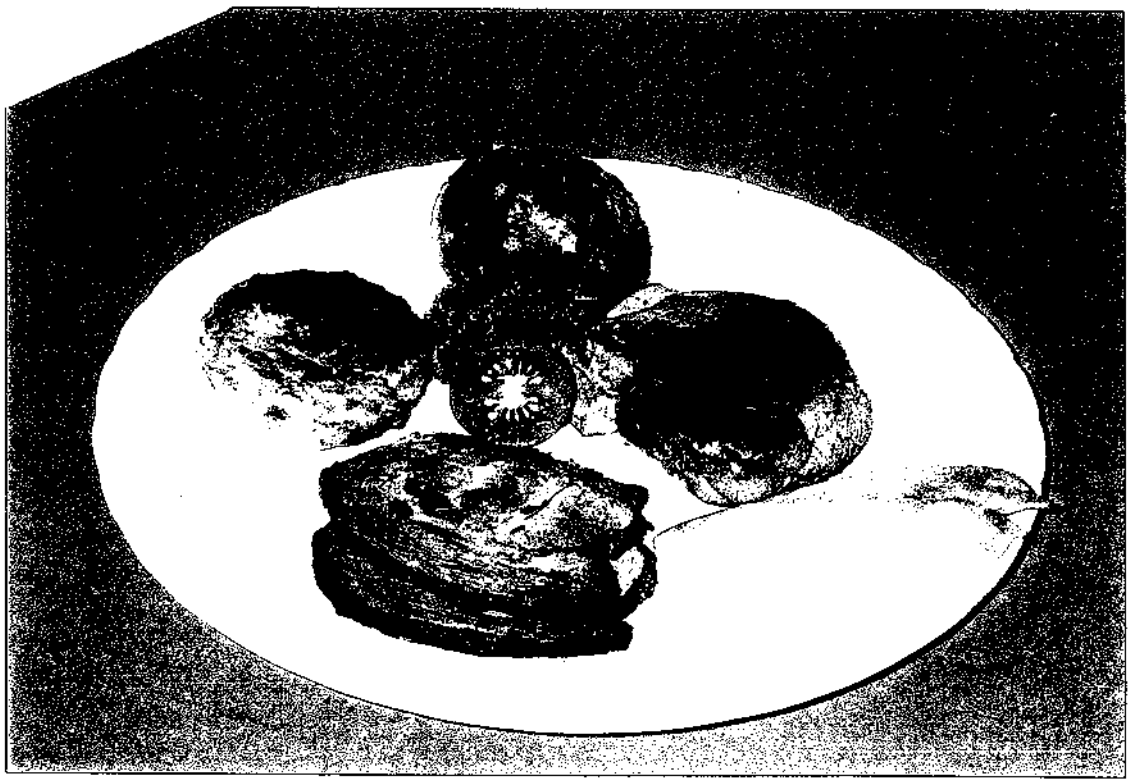


Photo 34: Cold-set bound venison products made from forequarter meat and trim