RESEARCH FUNDAMENTALS SERIES

Advanced Techniques in Meat Cookery

WINSTON INDUSTRIES

I N T R O D U C T I O N

This issue of the research Fundamental Series was taken from papers and lectures given by Mr. Leo Loeb, Foodservice Research Consultant for Winston Industries in Louisville, Kentucky. Mr. Loeb's research in food chemistry is critical to the development of equipment for the rapidly expanding technological needs of the foodservice industry.

In preparing this paper, Mr. Loeb made wide use of a large number of investigators from food processing and appropriate industries. This paper and other activities by Mr. Loeb assists the company in developing equipment with improved food processing capabilities that require fewer human disciplines.

Advanced Techniques in Meat Cookery

The Role of the CVap® Vapor Oven with Microprocessor Controls

Numerous chemical and physical changes occur in meats during the cooking process. The nature of these changes are discussed in this paper to provide a framework for better understanding of the capabilities inherent in the CVap Vapor Oven coupled with programmable electronic controls.

Before considering the changes brought about during cooking, it is desirable to establish a baseline understanding of the composition and structure of raw meats. Figure 1 gives a simplified summary on meat composition. It will be noted that water is the single largest component of lean muscle. The conservation of this water component during cooking is of key importance in determining tenderness, texture, juiciness, and yield. As will be shown, the CVap Vapor Oven offers some unique opportunities in the proper management of this water phase.

Protein is the second largest component and the key constituent in regard to changes which occurs during cooking. It will be necessary to consider protein structure in greater detail in order to understand changes which take place in meats during heating.

Fat, the third most abundant component, is of importance in its effects on flavor, texture, and yield. The fat content of muscle varies greatly depending on its source as is indicated in Figure 1. Water, protein, and fat taken together constitute approximately 96% of the weight of a lean muscle portion in the raw state. The remaining 4% include a miscellany of minor constituents which are of little concern in cooking.

MUSCLE COMPOSITION (LEAN PORTION)

CONSTITUENT	AVERAGE	RANGE
WATER	75%	65-80%
PROTEIN	18%	16-22%
FAT	3%	1.5-13%

Figure 1

Protein chemistry and structure must now be considered in more detail. For the present purpose, proteins can be visualized as long-chain filament-like molecules with numerous chemically reactive groups spaced out along the length of the chains. Because of these reactive groups the molecular chains interact strongly with each other and form themselves into organized fibrils, fibers, and cables which make up a network extending throughout the whole muscle. In addition to interacting strongly with adjacent chains, protein molecules interact strongly with water. In raw meat the whole of the 75% water content can be considered as bound to or tied up with the protein molecules. At a simplistic level, meat can be considered as a highly extended protein network with a large amount of bound water. The high water binding capacity of native protein is the reason why there is little or no water seepage or leakage when raw meat is cut or ground.

Figure 2 depicts how a muscle is built up from the molecular level through the various intermediate structural elements to the full intact muscle which is considered meat.

It was previously shown in Figure 1 that lean muscle contains about 18% protein. The protein component is organized structurally into several distinct forms for the various functions of the muscle in the living animal. Figure 3 describes two protein fractions which are of importance in edible meat since they govern the quality, cost, and cooking procedures for the various meat cuts. The fibrous connective tissue mentioned in Figure 3 is widely distributed in muscle. In particular, it makes up a large part of the tendons which function to transmit the mechanical action of the contractile muscle fibers to the animal's bone structure.

The level of connective tissue or collagen protein in a meat cut largely determines its quality and consequent cost. When the consumer pays $4 to $6 per pound for a prime rib roast or a tenderloin, he or she is paying for freedom from connective tissue. Such prime cuts can be cooked lightly and served rare with excellent tenderness and other quality attributes. On the other hand, cuts with high levels of connective tissue such as chuck roasts or brisket are inherently more tough, and must be processed at higher temperatures in the presence of water to breakdown connective tissue. This is called hydrothermal cooking; the common names

MUSCLE STRUCTURAL COMPONENTS

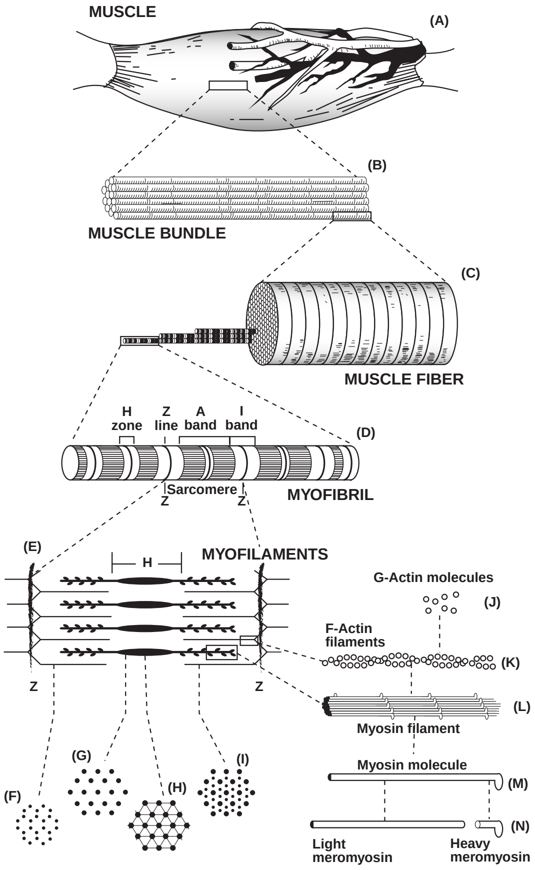

Figure 2

associated with hydrothermal cooking are stewing, braising, boiling, etc.

Figure 4, taken from material provided by the National LiveStock and Meat Board, delineates the various retail cuts of beef, and their recommended cooking methods.

As given in the figure, the braise, cook in liquid method has been recommended for the cuts higher in connective tissue. The roast, broil, panbroil, panfry method has been recommended for the quality cuts having lower levels of connective tissue.

In the foregoing paragraphs, the importance of connective tissue on meat texture and required cooking method has been emphasized. Some published consumer survey data on quality attributes of cooked meat are given in Figure 5. Tenderness, or the lack thereof, is seen to be the dominant attribute of consumer concern.

At the commercial level these responses must be coupled with the important requirement of high yield, i.e., low weight loss during cooking. As will be shown, in respect to both high yield and tenderness the CVap Vapor Oven can make significant contributions.

ORGANIZATIONS OF PROTEIN IN MUSCLE

Total Protein	18%
Protein in Contractile muscle fiber (Myofibrillar Proteins)	–10%
Protein in connective tissues (Collagen Protein)	–2%

Figure 3

Utilizing the background information presented on the chemistry of native muscle, the reader should now be well prepared to consider the changes brought about by cooking to various levels of doneness. Most of the documented information on effects of heating have been developed for beef since it can be eaten at any stage of doneness from very rare to well done depending on the consumer's preference. For reasons specific to the products, poultry and pork are usually cooked to the well done state; poultry to an internal temperature of 180-185˚F, pork at an internal temperature of 170˚F or higher.

Figure 6 summarizes the results of numerous published studies on the changes occurring in beef as the internal temperature is realized; and relates these change to the generally accepted doneness levels. The figure illustrates that for high quality beef cuts, essentially free from connective tissue, cooking up to an internal temperate of 140˚F should produce maximum tenderness, juiciness, and yield. For such cuts cooking to higher temperatures only leads to increased compaction of the contractile fibers with

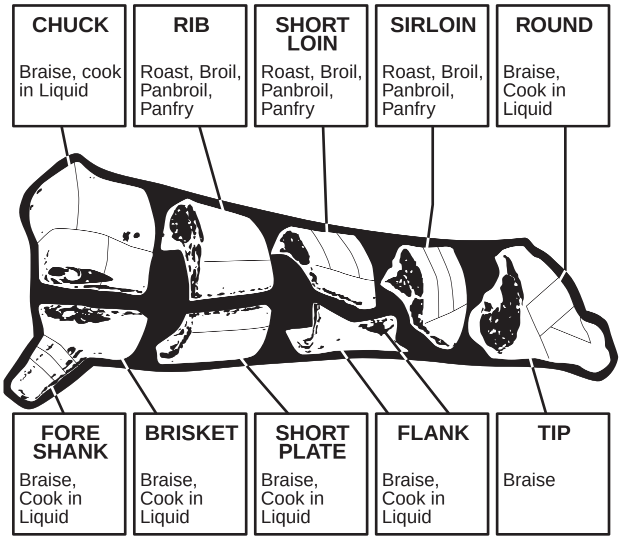

Figure 4

CONSUMER QUALITY ATTRIBUTES FOR COOKED MEATS

QUESTION
What is Eating Characteristic of Greatest Consequence in Meat?

Characteristic	% of Responses
TENDERNESS	57
FLAVOR	30
JUICINESS	8
FAT	5

QUESTION
What Attribute Produces the Greatest Dissatisfaction with Cooked Meat?

Characteristic	% of Responses
TENDERNESS	72
FLAVOR	18
JUICINESS	10

Figure 5

attendant toughening and drying. The Collagen Shrink Temperature (Ts), shown as occurring slightly above 140˚F for beef, is very critical to yield. As meat is heated through this zone, the collagen fibers undergo considerable rearrangement and shrinkage. This contraction squeezes out much of the water previously liberated from attachment to the protein molecules by the heating process. Thus a roast cooked to an internal temperature of 140˚F or less may be expected to have a much higher yield than one taken through the Ts zone to higher internal temperature.

For lesser quality cuts requiring collagen conversion, hydrothermal cooking to at least the medium well done state will usually be necessary to obtain sufficient tendering of the connective tissue. For meat cuts taken to these higher internal temperatures, one must expect considerable water expulsion and poorer yields, as well as some compaction, toughening, and drying of the base muscle fibers. However, to render such cuts edible the primary concern must be to achieve breakdown and conversion of the connective tissue. Hence the lower yields and some toughening of the base muscle fibers have to be tolerated.

The role of the CVap Vapor Oven within the general scheme of meat cookery can now be considered. A schematic of the CVap Oven is shown in Figure 7. The uniqueness of the vapor oven lies in its dual control system which provides independent temperature control for an integral water evaporator and for matched air heaters. This dual control capability allows both the wet bulb and dry bulb temperatures to be independently set, thus providing an oven environment matched to the specific needs of the food load being held or processed. Food moisture loss or gain can thus be controlled, and food temperature and textural quality attributes can be maintained at optimum levels.

CHANGES OCCURRING IN BEEF DURING COOKING

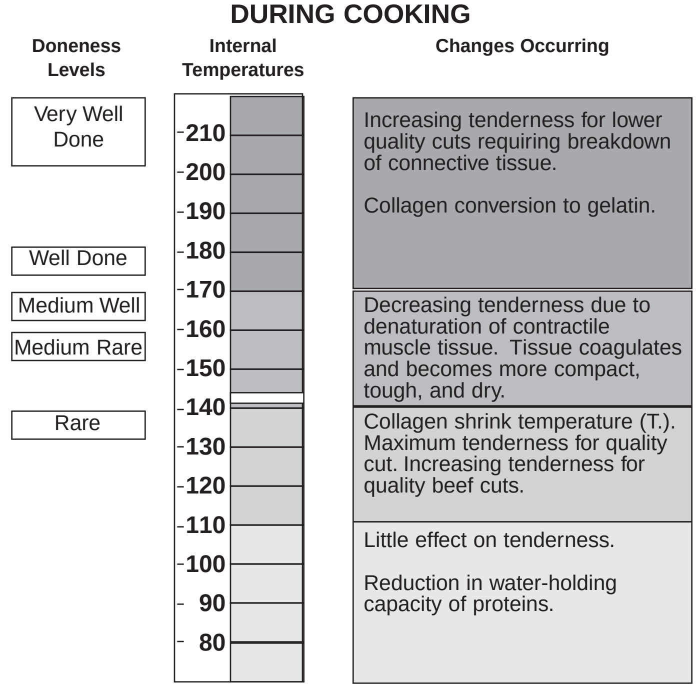

Figure 6

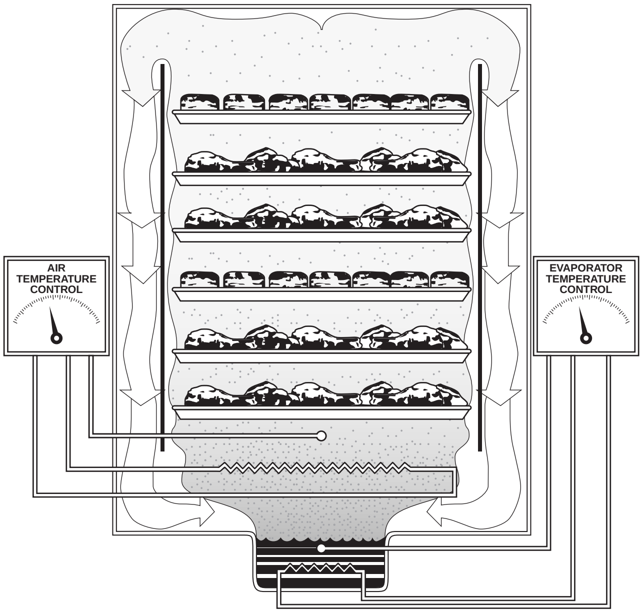

Figure 7

The dual control scheme discussed above allows the CVap Vapor Oven to function effectively in a broad spectrum of foodservice applications, including proofing of bakery products, holding of hot foods over a range of water activity values, low pressure steaming of frozen or fresh products, and low temperature meat cooking. Applications of the CVap Vapor Oven for meat cookery will be emphasized in the remainder of this paper; discussion of the other applications will be covered in separate issues under the RESEARCH FUNDAMENTALS SERIES.

WINSTON PRODUCTS COMPANY produces the CVap Vapor Oven over a range of sizes and in two basic control formats. The electromechanical format utilizes the dual control concept with two independently set thermostats controlling evaporator and air heaters. The more recently developed electronic model conforms to the same basic wet bulb – dry bulb concept with all temperature and time variables under control of a fully programmable microprocessor. Further the electronic model has an integral temperature sensing probe which can be used either to give a digital readout of internal temperature or to control the cooking process at pre-programmed temperature levels. The value of this informational and control feature will be obvious to those who have experienced the vagaries of large scale meat cooking.

While both the electromechanical and electronic model can be operated to give excellent and equivalent meat cooking performance, the programmable model can do this more precisely and with a much lower level of required human intervention. Throughout the remainder of this paper the results cited and the conclusions given will be taken from meat cook test runs in the microprocessor-controlled CVap Vapor Oven. The following generalizations have been determined:

(a) The Evaporator Temperature is dominant in control of both cooking time and yield losses. One set of data for prime rib roasts illustrating the dominant effect of evaporator temperature on yield is given in Figure 8. From this and other meat cook tests an evaporator temperature of 180-190˚F has been recommended to obtain the slow cooking necessary to assure a maximum yield weight (less than 10% loss) and to assure maximum tenderness and juiciness of the product.

(b) The Air Temperature is less critical, but best results as regards to flavor and external appearance have been obtained when the air setting was 30˚ to 40˚F higher than the evaporator setting.

(c) Surface browning of the meat, which is important in some foodservice applications, is favored by a profiled cycle in which the roast is finished to its final cooking end point with air heat only at an air heater setting of about 250˚F. A special browning cycle has been incorporated in the microprocessor control logic; this option will be discussed below in relations to the programming capabilities.

The full value of the microprocessor control lies in its ability for total front-end programming of meat cooking processes including cycles such as COOK & HOLD, or COOK, BROWN, & HOLD. Four such processes specifically devoted to meat cookery are presently available; these may be described as follows:

- Cook and Hold Control by Batch Timer. (PROCESS #3)

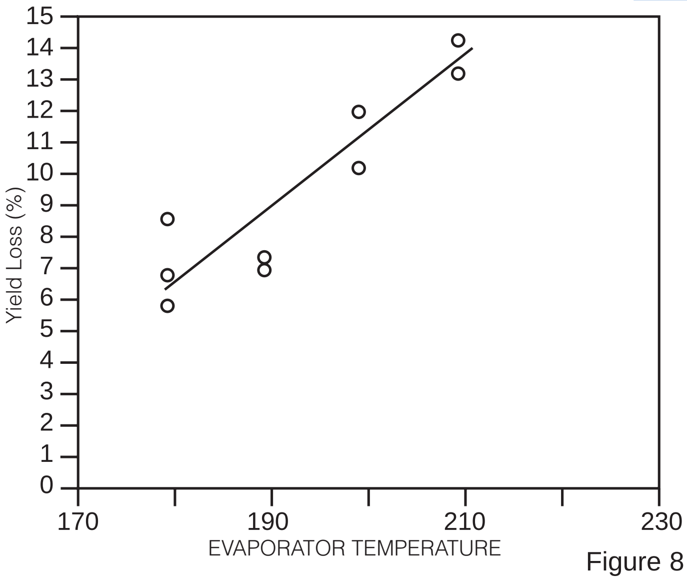

Figure 8

- Cook and Hold with Control by Internal Temperature. (PROCESS #4)
- Cook, Brown, & Hold with Control by Batch Timer. (PROCESS #5)
- Cook, Brown & Hold with Control by Internal Temperature. (PROCESS #6)

Further, all of these processes can be programmed for delayed start to facilitate unattended "middle of the night" cooking. If cooking is done with personnel present, the software provides on-demand digital read-out of all pertinent temperatures including AIR, EVAPORATOR, FOOD, and TIME remaining on timer controlled process. Figure 9 delineates the programming required to set up the four meat cooking cycles previously discussed together with typical values for the variable involved in each cycle. Once the process of choice is selected, the software guides the user through setting of the pertinent variables. The whole system has been designed to be user friendly and set up of any process requires only a few seconds.

Figure 10 gives time-temperature plots for a bottom round roast load cooked in a six bun pan microprocessor-controlled CVap Vapor Oven. The load consisted of two 11 pound roasts–one at Shelf Position #1 and the other at Shelf Position #4. The cycle was under total control of the temperature sensing probe inserted into the roast on Shelf #4. Variable settings for the Process run were as follows:

C1 190˚F
A1 220˚F
F1 130˚F (Initiation of Browning Phase)

A2 250˚F
F2 150˚F (Completion of Cooking; initiation of Holding Phase)

C3 140˚F
A3 150˚F

CVap VAPOR OVEN PROGRAMMABLE MEAT COOKING PROCESS

PROCESS PHASE	VARIABLE NAME		DISPLAY CODE	------------PROCESS NUMBER AND TYPE------------			
				3 COOK & HOLD	4 COOK & HOLD	5 COOK, BROWN &HOLD	6 COOK, BROWN & HOLD
	CONTROL MODE			TIMER	PROBE	TIMER	PROBE
COOK	CVAP	1	C1	180	180	180	180
	AIR	1	A1	220	220	220	220
	TIME	1	T1	4:00	--	4:00	--
	FOOD	1	F1	--	125	--	105
BROWN	AIR	2	A2	--	--	250	250
	TIME	2	T2	--	--	:30	--
	FOOD	2	F2	--	--	--	125
HOLD	CVAP	3	C3	140	140	140	140
	AIR	3	A3	150	150	150	150

NOTE: Times and Temperatures given are for illustration only.

Figure 9

Both of the transitions, to browning and to holding, occurred exactly when the probe reached the preprogrammed F1 and F2 settings. Thus the whole of this sequentialized process functioned exactly as programmed and without any attention, i.e., labor, required after entering the roasts into the preheated CVap Oven. The programming capability here illustrated for meat cookery is also available for other cycles benefiting from sequentialized processing.

Based on the experimental results at hand, the CVap Vapor Oven would appear to have an important new role within the general scheme of meat cookery. This new cooking concept with its dual controls for both wet bulb and dry bulb temperatures offers a simple and safe means for cooking meat with low yield loss and with a full complement of related quality attributes.

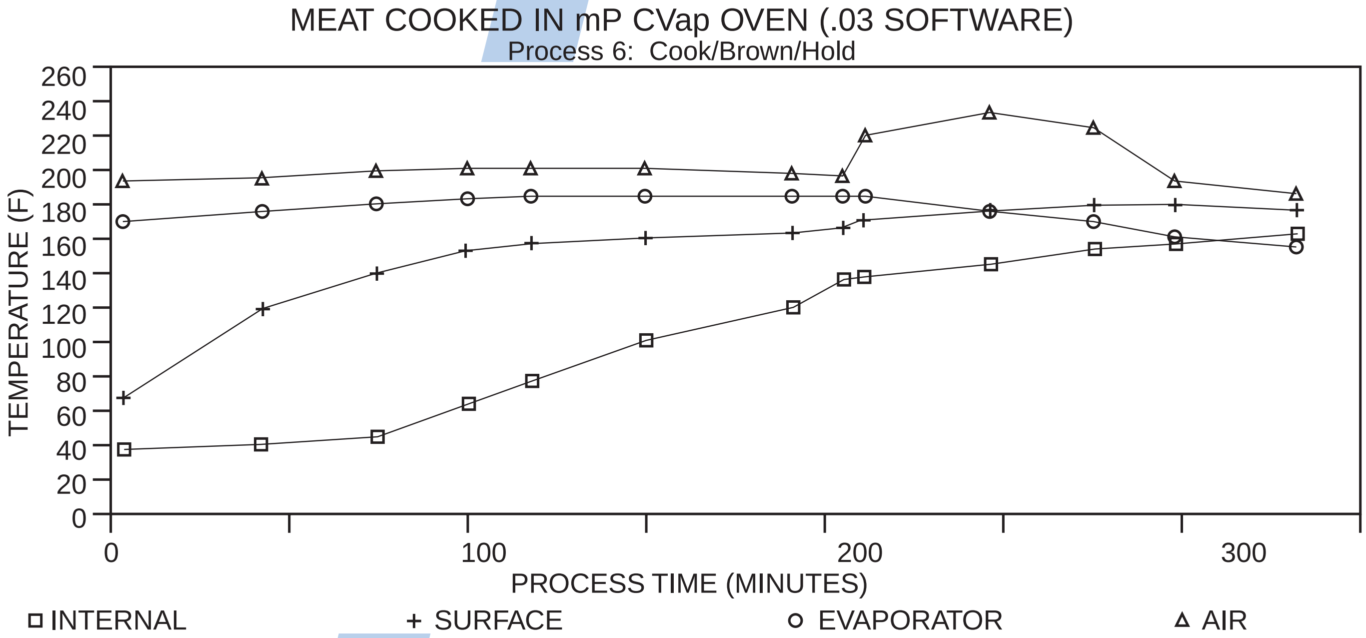

Figure 10

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