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Sampling of Cartoned Meat and Preparation for Chemical Lean Determination

To accurately estimate the chemical lean (CL) of a production run of boneless meat from samples taken from the production, it is necessary to ensure that:

i. samples taken from a carton are representative of the carton;

ii. cartons chosen for sampling are representative of the production;

iii. samples are prepared and homogenised so that subsamples for testing accurately represent the CL of that sample; and

iv. testing procedures are accurate within the limits of the test.

This Information Brochure contains guidelines for sampling plans that can be used to sample meat from different types of production and, procedures for taking core samples, preparing and testing them. The Information Brochure is based on the Manual "Sampling, Preparation and Testing for Chemical Lean Determination" prepared by W F Spooncer and P M Husband in June 1993.

Number of Cartons Sampled

If cartons of boneless meat could be produced to the same precise CL specification, the samples taken from one carton from a production run would accurately represent the whole production. However, there is bound to be variation in CL between cartons in a production and several cartons have to be sampled to obtain a range of samples whose average CL reflects the average CL of the production. The more the CL varies between cartons, the more cartons should be sampled to give a good chance that the average CL of the samples matches the average CL of the production.

The variability in CL from carton to carton can be measured mathematically by calculating the carton-to-carton standard deviation (SD). (For calculation of SD see Appendix 1). From this measurement of variability, it is possible to calculate the likelihood of a certain number of samples representing a production lot within certain limits of accuracy.

Even in the best circumstances, variation between cartons is inevitable. The extent of the variation is determined by several factors. Some factors, such as close control of the packing operation, and proper training of the operators, are under the control of management. One other factor is the actual CL of the product. Variation in CL between

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cartons is greater for low CL product than for high CL product.

Before the required number of samples from any production lot can be determined, management must decide on the degree of accuracy required for the product concerned.

Degree of accuracy is defined in terms of:

a. Sample accuracy

b. Confidence limit.

For CL determination, it is appropriate to define sample accuracy with confidence limits of 90%. This means that on 90% of occasions when a sample is drawn at random from a production, the sample CLs will agree with the chosen accuracy range. There is a 90% chance that a sample of the same size taken by a customer in the same way will agree with the supplier's test result within the chosen accuracy range. This can be interpreted to mean that there is a 90% chance that the average CL of the whole production will fall within the chosen accuracy range of the test results.

Tables 1, 2 and 3 show the numbers of cartons that should be sampled from production lots of different sizes, in order to achieve sample accuracy of ±0.5%, ±1.0% and ±2.0% respectively with 90% confidence.

Table 1 Number of cartons to be sampled to achieve accuracy of ±0.5% (based on 10 cores per carton with 90% confidence)

Number of Cartons in the Production	Standard Deviation (carton-to-carton)								
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
10	8	9	9	9	9	10	10	10	10
20	14	15	17	17	18	19	19	19	19
30	18	21	23	24	26	26	27	27	28
40	21	25	28	31	32	34	35	36	36
50	23	29	33	36	39	41	42	43	44
60	25	32	37	41	45	47	49	51	52
70	27	34	41	46	50	53	56	58	59
80	28	37	44	50	55	59	62	64	66
90	29	39	47	54	59	64	68	71	73
100	30	40	49	57	63	69	73	77	80
200	36	50	65	80	93	104	115	124	132
300	38	55	73	92	110	126	142	156	169
400	39	58	78	99	121	141	161	180	197
500	40	59	81	105	128	152	175	198	219
1000	41	63	89	117	147	179	213	246	280
3000	43	66	94	127	163	204	248	295	344

Table 2 **Number of cartons to be sampled to achieve accuracy of ±1.0% (based on 10 cores per carton with 90% confidence)**

Number of Cartons in the Production	Standard Deviation (carton-to-carton)								
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
10	5	6	7	8	8	8	9	9	9
20	7	9	11	12	14	15	15	16	17
30	8	11	13	16	18	19	21	22	23
40	9	12	15	18	21	23	25	27	28
50	9	13	16	20	23	26	29	31	33
60	9	13	17	21	25	29	32	35	37
70	9	14	18	22	27	31	34	38	41
80	10	14	19	23	28	32	37	40	44
90	10	14	19	24	29	34	39	43	47
100	10	14	20	25	30	35	40	45	49
200	10	16	22	28	36	43	50	58	65
300	10	16	22	30	38	46	55	64	73
400	11	16	23	31	39	48	58	68	78
500	11	16	23	31	40	49	59	70	81
1000	11	17	24	32	41	52	63	76	89
3000	11	17	24	33	43	54	66	80	94

The greater the accuracy required, the more samples are necessary from a production lot. Similarly, the greater the carton variability (standard deviation), i.e. the lower the CL, the more samples are necessary from a production lot.

Note that the recommended number of cartons to be sampled applies to fresh meat during production or frozen meat in storage. For fresh meat, it is convenient to consider the number of cartons in the production as one day's production. However, if cartons in a production are produced from groups of carcases of different fatness, the cartons produced from the different groups of carcases should be regarded as separate productions. In reality, only carcase lots that are sufficiently different in fatness to make accurate pre-trimming difficult need to be separated into different production lots for the purpose of CL testing. For frozen meat, the number of cartons in the production could mean any group of cartons, but it would be convenient to consider the number of cartons in a shipping lot.

Despite differences between boning rooms in respect of carton variability (standard deviation), experience has shown that a reasonably accurate estimate of carton variability, in an "average" boning room, can be made as follows:

CL Specification	Carton-to-carton Standard Deviation
90% - 100%	2.0
75% - 89%	3.5
Less than 74%	4.5

If a +1% sample accuracy is chosen for a production run of 600 cartons of 85 CL product and the above standard deviation figures are accepted, the number of cartons that would need to be sampled is 32 (refer Table 2).

If, on the other hand, the variability of the 85 CL product had been determined and it was found to have a carton-to-carton standard deviation of 3.0, the number of samples needed to give the same +1% accuracy would be 24 (refer Table 2). Where the production lot size lies between two figures in the table, the higher sample number should be chosen.

Once the carton variability of all products has been determined, a decision needs to be made as to what degree of accuracy is appropriate for each product type.

The most commonly accepted sample accuracy is +1%. Most manufacturing meat is packed to a specification of 80 CL or above. Assuming an average, or better than average, carton variability, the number of cartons that need to be sampled (and cored) to achieve a result within +1% accuracy can be handled with little difficulty during normal production (refer Table 2).

If a higher degree of accuracy, i.e. +0.5%, is desired, then this is feasible provided the carton variability is low enough. In general terms, this would be practical for high CL product only (refer Table1).

It is not practical to aim for too high a sample accuracy for low CL product. Low CL product will inevitably yield a higher degree of variability and, therefore, a higher carton-to-carton standard deviation than high CL product. As well, low CL product represents a smaller proportion of overall production than high CL product. Therefore, in order to maintain a constant +1% sample accuracy, it would be necessary to sample more cartons from a 100 carton run of 70 CL product (assuming SD=4.5) than from a 100 carton run of 85 CL product (assuming SD = 3.5) – 35 cartons and 32 cartons respectively (refer Table 2).

To overcome the above problem, it is appropriate for management to choose to accept a sample accuracy lower than +1% for low CL product. This does not mean that fat claims need be a problem. In choosing a lower sample accuracy, say +2.0%, management is simply acknowledging that the actual CL of the production will be somewhere within the range of 2.0% (rather than 1.0%) above or below the test result. It is then up to management to judge how close the test result should be to the prescribed CL specification of the production lot before action needs to be taken to re-specify the CL.

In any decision regarding accuracy, management has to taken into account the sampling procedure and tolerance allowed for by the client. The discussion in this manual relates to production lots, contract lots or shipment lots; not individual cartons being to be specified CL.

The need to review required sample accuracy becomes even more apparent with very low CL products, namely those lower than 60 CL. In these cases, it is not practical to aim for a sample accuracy greater than +2% (refer Table 3).

Notwithstanding the acceptability of a lower sample accuracy, there is still merit in knowing the carton variation so that the appropriate number of samples can be selected using Table 3.

A good estimate of standard deviation can be made with twenty test results from a single production run, for each product type.

Table 3 **Number of cartons to be sampled to achieve accuracy of +2.0% (based on 10 cores per carton with 90% confidence)**

Number of CartonsI in the Production	Standard Deviation (carton-to-carton)								
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
10	2	3	4	5	5	6	6	7	7
20	2	3	5	6	7	8	9	10	11
30	2	4	5	6	8	9	11	12	13
40	3	4	5	7	9	10	12	14	15
50	3	4	5	7	9	11	13	14	16
60	3	4	6	7	9	11	13	15	17
70	3	4	6	7	9	11	14	16	18
80	3	4	6	7	10	12	14	16	19
90	3	4	6	8	10	12	14	17	19
100	3	4	6	8	10	12	14	17	20
200	3	4	6	8	10	13	16	19	22
300	3	4	6	8	10	13	16	19	22
400	3	4	6	8	11	13	16	19	23
500	3	4	6	8	11	13	16	20	23
1000	3	4	6	8	11	13	17	20	24
3000	3	4	6	8	11	14	17	20	24

Selecting Cartons to Sample

Once the number of cartons to sample has been established, a procedure to collect the cartons so that they are drawn randomly from the production can be devised.

If a day's production is considered to be a production lot i.e. the day's production is from carcases of similar fatness, it is convenient to divide the production into three periods (start-up to morning tea, morning tea to lunch and lunch to finish) and apportion the samples to be collected to each of the three periods. Cartons should be sampled at random throughout the work period and the samples from one work period may be pooled together for a single analysis. An example of how samples from a production of 300 cartons of 85% CL product (with SD=3.5) can be collected and tested is shown in Table 4. Thirty cartons should be sampled from this production.

Samples may be analysed more frequently than suggested in Table 4 in order to monitor the CL of product during production. However, results from a small number of samples will not give a good representation of the average CL of the production. For example, from the example shown in Table 4, if the samples from the first five cartons sampled were pooled and analysed, the result would only represent the production so far (50 cartons). The accuracy would be +2.4% CL at 90% confidence.

This is still a good guide to production, however, and there is merit in having results of

Table 4 **Minimum sampling program for collecting samples from a production of 300 cartons of 85% CL product (SD=3.5)**

Work Period	Number of Cartons Sampled and Pooled	Number of Cores for Testing	Number of Analyses in Duplicate
Start-up to morning tea	10	100	1
Morning tea to lunch	10	100	1
Lunch to finish	10	100	1
TOTAL	30	300	3

ongoing tests relayed to the boning room throughout production. Analyses on single cartons, or even pairs of cartons, are of limited value as a guide to production; however, blended core samples from five or six cartons will yield a useful result. This is consistent with a practical sampling and testing program.

The Five-percent Sample

The practice of sampling a standard five percent of cartons, irrespective of lot size or SD, will not always result in an accurate assessment of CL for the production lot. When large production lots, particularly of high-CL products, are sampled at a rate of 5%, the accuracy of the results obtained are well in excess of the necessary level of accuracy. On the other hand, smaller production runs will yield results that are inadequate in terms of sample accuracy.

The extent of variability of sample accuracy is illustrated in Table 5. Table 5 lists the sample accuracies that will be achieved (with 90% confidence) if production lots of difference sizes are sampled at a rate of 5%. Accuracies are listed for three different carton-to-carton standard deviations, to further illustrate the effect with different CL products (lower-CL products having a higher SD).

Sampling Program Example

The following sample program outline is an illustration of practical sampling scenario designed to adequately monitor the product during production and to properly specify the final product. The actual number of samples taken needs to be consistent with the number required according to the carton-to-carton standard deviation of each product line.

Cartons sampled as follows:

> Ten (10) cores are taken from cartons selected at random from each production lot. A minimum 180 g sample is recovered from each 10 cores.

Samples bulked as follows:

> Cores from six (6) cartons are bulked together to yield one sample for grinding and analysis.

This method yields a CL result of sufficient accuracy to be used by the Boning Room Manager to monitor production. As well, the sample turnaround is sufficiently fast to enable appropriate production adjustments to be made.

The sampling system for each product description is structured according to the overall importance of each product in terms of production volume and accuracy requirements.

90 CL product is sampled at regular intervals throughout production. This procedure may yield more samples than are necessary to achieve an overall statistically accurate result for any one production day. This is done to ensure a constant flow of information to the Boning Room Manager, given that 90 CL is a high-volume, high-value product requiring accurate testing.

85 CL product is sampled constantly throughout the production period. Sampling is similar to that for 90 CL product, in terms of information feedback to the Boning Room Manager.

Table 5 Accuracy (±%) of a 5% sample (based on 10 cores per carton with 90% confidence)

Number of Cartons in the Production	Number of Cartons Sampled (5% of Production)	Sample Accuracy		
		SD = 2.5	SD = 3.5	SD = 4.5
10	1	3.90	5.46	7.10
20	1	4.01	5.62	7.22
30	2	2.81	3.94	5.06
40	2	2.83	3.96	5.10
50	3	2.30	3.22	4.14
60	3	2.31	3.24	4.16
70	4	2.00	2.80	3.59
80	4	2.00	2.80	3.60
90	5	1.79	2.50	3.22
100	5	1.79	2.51	3.23
200	10	1.27	1.77	2.28
300	15	1.03	1.45	1.86
400	20	0.90	1.25	1.61
500	25	0.80	1.12	1.44
1000	50	0.57	0.79	1.02
3000	150	0.33	0.40	0.59

Sample numbers are sufficient to achieve an overall statistically accurate result for any one production day.

80 CL may be a limited-volume product. 80 CL product is therefore sampled at a rate of, say 10% of production. Product may be accumulated over several days' production in order to assemble loadout quantities. Sufficient samples are tested while the lot is being assembled to yield a statistically accurate result for the lot. Results are reported to the Boning Room Manager as they become available.

75 CL (and lower) product is sampled in the same manner as that for 80 CL product.

Sampling Cartons

Samples may be taken from either fresh or frozen meat. Fresh meat is sampled by taking cores with a tube corer and frozen meat is sampled by drilling into meat with an auger type drill bit and collecting the drill shavings. For most types of meat, the results are not biased by sampling the meat in either fresh or frozen condition, provided that the corer or drill is sharp.

The following conditions apply to taking samples from either fresh or frozen meat:

1. A tube corer for sampling fresh meat should have a minimum diameter of

22 mm. An auger bit for sampling frozen meat should have a minimum diameter of 20 mm.

2. At least ten (10) drill or core samples should be taken from each carton of meat sampled.

3. Core or drill samples should be taken through a template which locates the position in the carton to be drilled. The template should sit on top of the meat and cover the whole surface. Holes (approximately 25 mm diameter) in the template determine the positions for drilling samples. When sampling fresh meat, press down on the template to apply an even pressure over the meat. When sampling hot-boned meat it is even more important to use a sharp corer and to press down hard on the template.

4. Drill or core the full depth of the carton.

5. When taking core samples, remove the core of meat from the coring tube after drilling each core.

6. Maintain the drill bit or corer tip in a sharp condition. The coring tip should be sharpened by occasionally grinding the outer bevelled surface and frequently honing both the outer and inner surfaces (preferably using the ball and cup honing tools available from the coring tip supplier).

   The sharpening angle between these surfaces should be 30 degrees or less. As the corer tips wear down they should be replaced (since it becomes impossible to maintain a blade angle of 30 degrees or less). If worn tips are over sharpened externally, the angle becomes greater than 30 degrees and is then too flat to quickly and cleanly cut through the material to be sampled. Differentiation then occurs in favour of fat over lean, leading to under-estimations of the lean content.

7. Ten (10) cores of fresh meat should yield a sample of at least 180 g. Shavings from ten (10) frozen meat drill holes should yield a sample of about 500 g.

For taking samples from fresh meat, an air ejection corer is recommended. This device facilitates removing cores from the tube after each core sample is taken. The air ejection corer is described in Meat Research Report No. 1/89, "The Air Ejection Corer for Sampling Chilled Boneless Cartoned Meat".

Sample Storage

Samples should be stored in a way which prevents loss of moisture, e.g. in a sealed plastic bag. The bag should be drawn tightly around the sample to expel any air in the bag. Samples should never be left uncovered.

For short-term storage (2 – 48 hours) the sample should be held at 2°C or less. For long-term storage, the sample should be frozen at -18°C or less.

When samples are taken out of long or short term storage, care must be taken to incorporate any moisture loss inside the sample bag into the sample, and to avoid allowing condensation to form on the sample.

Sample Preparation

Samples taken by coring or by drilling must be blended and homogenised before a subsample for testing is taken. It may be necessary to reduce the sample size for efficient homogenisation.

Pooled samples are likely to be from 500 g to 2 kg or greater, depending upon the number of cartons sampled. These samples should be well mixed, minced, or blended in a food processor, remixed and reduced in size by coning and quartering to produce a suitable sample size for homogenisation. The samples should be as cold as practicable to aid efficient homogenisation and to reduce fat throw-out during mincing or blending.

Mincer

If a mincer is used for sample preparation, the procedure is as follows:

1. Thoroughly mix the sample and mince it through a 6 mm plate.

2. Clean out any fat adhering to the barrel,

worm, cutters and plate of the mincer and add this to the minced sample. Samples greater than 1 kg may be reduced by half for further mincing. This is done by coning and quartering, namely forming the minced meat into a cone shape and dividing the cone into quadrants. Two diagonally opposite quadrants are then mixed.

3. Mince the sample through a 3 mm plate. Mix the minced sample thoroughly.

4. The sample is now ready for testing.

The mincer should be at least dry cleaned between each sample by removing any material accumulated around the bladed or place (it is unwise to try to mix this residue with the final sample due to the difficulty in ensuring an homogeneous sample). If the sample is to be followed by one of lower CL (higher fat) it is not necessary to clean the mincer, worm and barrel completely; simply remove the residue from around the cutters and plate. If the sample is to be followed by one of similar or higher CL, the worm and barrel at least should be thoroughly cleaned.

Complete washing **and drying** of mincer components during the work period is good; however, the extent to which it is necessary can be reduced provided thorough dry cleaning is undertaken when moving from a high-CL product to a low-CL product, or between two high-CL products. Washing is necessary after low-CL product.

Food Processor

If a food processor or blender is used for sample preparation, the procedure is as follows:

1. The sample should be mixed and (if necessary) divided into portions equal to the capacity of the food processor.

2. Portions of the sample should be blended in turn to a uniform paste. Care should be taken to avoid overblending, which will lead to excessive fat throw-out.

3. The blended portions should be mixed and reduced in size by coning and quartering.

4. The final sample should be blended in the food processor. Ideally, the blender should have sufficient capacity to blend the whole sample in one pass. In this case, there is no need to reduce the sample by coning and quartering.

5. The sample is now ready for testing.

The food processor (a **robust commercial blender is best**) should be at least dry cleaned between each sample by wiping out the bowl and wiping and material from the cutter blades.

Complete washing **and drying** of processor components during the work period is good; however the extent to which it is necessary can be reduced provided thorough dry cleaning is undertaken when moving from a high-CL product to a low-CL product, or between two high-CL products. Washing is necessary after a low-CL product.

Note

- Use only a food processor which has smooth-edged, NOT SERRATED-edged bladed.

- Use a food processor with the most powerful motor in relation to bowl capacity.

- Keep at least one spare set of food processor blades on hand, and KEEP THEM SHARP (sharpen at least daily).

- Do not use blunt blades – this will simply cause fat 'throw-out' before the meat is cut sufficiently fine.

- Chill samples as much as possible before chopping or mincing, to minimise fat throw-out during these operations.

Mincer/Food Processor

If a food processor is used in conjunction with a mincer, some of the problems encountered with the mincer can be overcome. In this application a heavy-duty food processor may be unnecessary. Domestic units, e.g. the

"Oskar", may be adequate, due to the lesser load placed on them by the preminced sample. The procedure is:

1. Thoroughly mix the sample and mince it through a 6 mm plate.

2. Clean out any fat adhering to the barrel, worm, cutters and plate, and add this to the minced sample. Mix the minced sample. The sample should be reduced to a size suitable for further processing (e.g. 700 g for the Sunbeam "Big Oskar" – Meat Research Report No. 6/88). This is done by coming and quartering.

3. Blend the sample to a uniform paste. Care should be taken to avoid over-blending, which will lead to excessive fat throw out.

4. The sample is now ready for testing.

It is important that the knives of the mincer or food processor are sharp, to achieve efficient homogenisation.

Cleaning of the equipment should be done on the same basis as for a mincer or food processor independently.

Equipment

Some suppliers of equipment are as follows:

J & B Haig Products, Brisbane, Qld,

- Corers and Tips

Robot Coupe® Australia Pty Ltd, Sydney NSW – Commercial Blenders

Sunbeam, "Oskar", All States – Domestic Blenders.

Appendix I

Calculation of Standard Deviation

The standard deviation used to calculate the probability that the average CL of samples represents the CL of a production within certain limits is the carton-to-carton SD. To calculate the carton-to-carton SD, the SD of results of analyses, i.e. the CL of composite samples from several cartons, must be calculated.

Standard deviation of results

The SD should be calculated from the results of no less than twenty (20) measurements of chemical lean as follows (each measurement can be a test on a composite of the core samples from two (2) or more cartons. The combined corings from five (5) or six (6) cartons will give a satisfactory sample for testing):

1. Determine the sum of all results and square the sum.

   The square of the sum = B

2. Square each result and determine the sum of the squared results.

   The sum of the squares = A

3. The number of analysis = n

4. The number of cartons in each analysis = X

5. Standard deviation = $\sqrt{\dfrac{A - \dfrac{B}{n}}{n - 1}} \times \sqrt{X}$

Carton-to-carton Standard Deviation

$$\text{Carton-to-carton standard deviation} = \text{standard deviation of composite sample} \times \sqrt{\text{number of cartons sampled to make up composite sample}}$$

Note: There are several inexpensive hand-held calculators with easy-to-use statistical functions which can be used to calculate standard deviation.