THE DRY MATTER CONTENT OF BEEF MUSCLES

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Introduction

In food products with high moisture content the water is not quantitatively stable during their storage and processing.
It is then interesting to refer the various other components of the products not to the "fresh" weight but to the stable basis they represent all together. In weight this set is not very different from the residue obtained by drying the products in standardized conditions. This dry matter (DM) can be considered as a reliable basis for the assessment of the chemical composition of the products.
In fact food products with high moisture content -like meat- are largely marketed only on a raw basis, whatever could be the variation of their dry matter.
In the present study we tried to find out the extent of the variation of dry matter of beef muscles explained by as well the anatomical location within the carcass as the origin of the animal. The relationship between DM content and energy value of beef has been also considered.

Experimental

Animals were slaughtered in the slaughter house of the INRA center at Theix and chilled in order to avoid any cold shortening.
Carcasses were dissected the next day after slaughter and the required muscles were wrapped in a plastic bag and stored at 0°C.
Slices 5 cm thick were taken the third or the fourth day *post mortem* and carefully trimmed of external fat and aponevrosis, and then ground on standard conditions (laboratory cutter "ROBOT COUPE") in order to obtain a fine and homogeneous mixture.
Dry matter was estimated by drying at 102°C until constant weight.
Lipids were estimated using Folch method.
All determinations were made twice and results were expressed as percent of fresh material.

Samples were taken from 10 beef carcasses, selected to represent a commercial typical group of carcasses existing on the French market for sex, age, slaughter weight and conformation.
Carcass weight was :316.2 ± 66.9 Kg, age estimated according to BRAZAL and al (1971) was 51.2 ± 23.7 months and conformation score (using FEZ standards, DUMONT and al (1975)) 9.1 ± 3.3.
53 muscles locations were examinated in each carcass (cf table I) and usually concerned the medial part of each muscle. In the largest muscles 2 or 3 locations were considered.
Statistical treatment comprised analysis of variance with two factors, multiple comparison of means and the nonparametric method of Friedman.

Results and discussion

For the whole determinations, mean value of dry matter is 24.47 per cent of fresh product. Standard deviation is 1.45. This mean value is very near by 25 per cent (value generally admitted for "meat"). For the whole results, the range is very large (21.3 - 31.0). Variation of mean values by muscle type is less important (22.32 to 28.36).
Analysis of variance shows a very highly significant muscle effect (F=17.05 for 52/468 D.F.).
However multiple comparison of means doesn't allow to separate particular groups of muscles. Only the two richest (muscles *Spinalis dorsi* and *Diaphragma pars lateralis*) stand out from the others.
Correlations two by two between the muscles shows two important facts :
1- There is no correlation between *Diaphragma* and the other muscles and so is if we consider other parameters (haeminic iron (BOUSSET, DUMONT 1984), isoLDH (BOUSSET 1981)). In this case one can ask if *Diaphragma* is a real "skeletal" muscle like the other muscles.
2- There are significant correlations at level p=0.05 for *Longissimus dorsi pars lomborum* with all muscles except for *Diaphragma* and *Vastus internus*. Consequently so, dry matter of *Longissimus dorsi* could be an indicatory of the other muscles dry matter.
From the whole 530 analysis and 53 muscle locations for each animal, we have studied distributions from an arrangement of 10 classes. In every case distribution have dissymetric forms and there are more samples with low dry matter. 286 samples are into classes 3 and 4 and 453 into classes 2-3-4-5.
If we consider distributions for each animal 40% muscle locations are generally into classes 2 and 3.
Because of these dissymetric distributions it could be more appropriated to realize non parametric tests. Median of wole data is 24.4, no different of mean value and so are medians of each muscle. Friedman's test of variance analysis with two levels giving chi2 = 0,62 shows highly significant muscle effect. Nonparametric analysis confirms variance analysis realized before.

Table I Dry matter of muscles mean and standard deviation

Brachialis	22.82	0.72	Pect. super. trans.	24.41	0.92
Splenius	22.96	0.96	Vastus lateralis	24.41	0.90
Sartorius	23.14	1.01	Biceps femoris (1/8 inf.)	24.43	0.70
Pect. super. prof.	23.25	0.94	Transversus abdominis	24.44	1.24
Vastus internus	23.27	0.89	Semitendinosus (1/4 inf.)	24.47	1.14
Gracilis	23.35	0.83	Biceps brachii	24.58	1.03
Omotransversus	23.47	0.86	Iliacus	24.64	1.38
Semitendinosus (1/4 inf.)	23.54	0.80	Biceps femoris (middle)	24.65	0.96
Brachiocephalicus	23.58	0.73	Gluteus medius	24.69	0.88
Gluteus profundus	23.67	0.94	Tensor fasciae latae	24.72	1.03
Supraspinatus	23.68	1.13	Adductor	24.75	1.20
Obliquus exter. abdo.	23.70	0.71	Longissimus dorsi (lomb)	24.78	1.18
Subcapularis	23.80	0.80	Trici. brachii.caput.long.	24.87	0.91
Trici.brachii.caput.lat.	23.85	0.88	Longissimus dorsi (thora.)	24.96	0.96
Pectineus	23.89	0.68	Cutaneus trunci	25.05	1.44
Gastrocnemius internus	23.91	0.89	Serratus vent. cervicis	25.10	1.40
Pectoralis profondus	23.97	0.66	Semimembranosus (middle)	25.18	1.00
Gastrocnemius externus	24.13	0.92	Psoas major	25.25	1.41
Latissimus dorsi	24.15	0.86	Obliquus inter abdom.	25.31	1.47
Longus colli pars thoracis	24.16	0.89	Semimembranosus (1/4 sup.)	25.33	0.94
Rectus femoris	24.17	0.96	Rectus abdominis	25.60	1.90
Semispinalis capitis	24.18	0.97	Diaphragma pars medialis	25.62	2.23
Teres major	24.19	0.95	Spinalis dorsi(8 thor. v.)	25.81	1.86
Semitendinosus (middle)	24.26	1.00	Infraspinatus	26.07	1.64
Pectoralis profondus	24.31	0.70	Spinalis dorsi(3-4 thor.v.)	26.77	2.04
Semimembranosus (1/4 inf.)	24.35	1.24	Diaphragma pars lateralis	28.36	1.53
Biceps femoris (1/4 sup.)	24.36	1.05			

Because animals have been selected in order to obtain a large variability,interpretation between animals is more difficult (cf values reported table II). However we can notice that multiple comparison of means divides these animals into 6 groups. Mean of the first group is 22.7; it is clearly different of the other groups. Study of muscles categorizing in 10 classes, shows data of this group are only present into classes 1 to 3.
In general, females have a higher dry matter value ; these animals are older too.
Callow's studies (1947)showing relation between lipids and water contents of boneless meat have suggested determination of lipid content from dry matter value. Some authors (e.g. CASSEY J.C. and CROSLAND (1982), DUMONT B.L. and HUDZIK E. (1983)) have proposed equations to predict composition of meat cuts or meat products, containing muscles and fatty tissues with variable proportions. However it seems that relation between lipid content and dry matter content, only in muscle tissues stricto sensu, has not been yet studied.
Using the different equations proposed for meat cuts or meat products, the 0% lipids value corresponds to dry matter value of about 23%. This value is generally agreed as conventional reference for fat free meat products. Muscle completely fat free is biologically inconceivable. Nevertheless we can work on lean and very lean muscles, trying to approach this value as near as possible.

Table II Dry matter of muscles of different animals

N animal	mean	st. deviation	age	sex	*
5	22.69	0.88	48	c.m.	a
7	23.72	0.63	36	m	b
4	23.83	1.18	24	c.m.	b c
9	24.09	1.04	24	f	c
6	24.56	1.49	36	c.m.	d
2	24.91	1.53	72	f	e
8	25.00	1.16	84	h	e
1	25.02	0.85	42	f	e
10	25.37	1.10	90	f	f
3	25.47	1.70	56	f	f

* Mean with the same letter are not different

cm = castrated male, m = male, f = female

In order to estimate this ultimate value we have calculated regression equation of dry matter (DM) on lipids(L). Twenty eight samples have been selected in order to obtain a good variation scale of the dry matter in beef. The obtained equation is :

$$DM = 0.81L + 22.17 \qquad r = 0.909$$

giving 22.17% dry matter for a theoretical value of 0% lipids. This value is obviously lower than the reference value 23%. This last value would be thus doubtful. However in our samples there is no muscle with lipids value lower than 1%. More, values from 1 to 3% are less near by regression line than the other dots. The true value of dry matter, corresponding to 0% lipids value, would be slightly different from value obtained by extrapolation.

From the extreme samples studied in our experiment (respectively 21.4 p. cent DM and 1.88 p. cent L compared to 32.0 p. cent DM and 10.61 p. cent L) the approximate energy value of 100 g of fresh meat varies from 360 to 700 kJ. Within these two values we can find all intermediate values.

The energy value E (in kJ) can be estimated from the dry matter content of the fresh muscle (DM) from the following formula :

$$E = 38\ DM - 455$$

Conclusion

From this work we can conclude :

a- the mean value of meat dry matter is about 25%. Its variability is large : 21 to 31%. However 85% muscles are between 22.3 and 26.2%.

b- dry matter is strongly determined by lipid content, which affects the energy value of beef (from 380 to 720 kJ in our experiment).

c- The 23% dry matter reference value for fat free meat seems to be too high. Studies on muscles with very low lipid content should be carried on in further studies.

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