ANSC 619
PHYSIOLOGICAL CHEMISTRY OF LIVESTOCK SPECIES
Muscle as Food

I. Protein in the diet

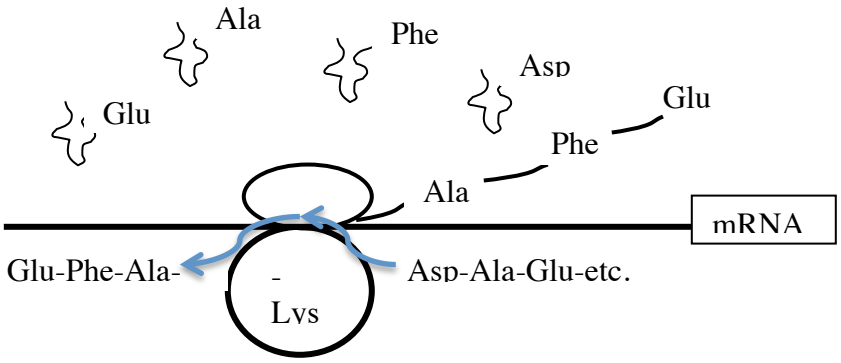
A. Function

1. To provide amino acids, not protein.

2. To prevent protein breakdown, diet must contain essential amino acids plus enough amino groups to make nonessential amino acids.

B. Definitions

1. ***Limiting amino acid*** – the essential amino acid found in shortest supply relative to amounts needed for protein synthesis.



2. ***Complete protein*** – protein containing all amino acids essential in human nutrition in amounts adequate for human use.

3. ***Complementary proteins*** – two or more proteins whose amino acid assortments complement each other so that missing essential amino acids in one are provided by the other(s).

4. ***High-quality protein*** – easily digestible, complete protein.

5. ***Digestibility*** – amount of amino acids absorbed per amount of protein intake.

6. ***Reference protein*** – egg protein, used by FAO/WHO as standard.

II. Protein Quality

A. Depends on essential (indispensable) amino acid composition.

B. Evaluation

1. Chemical score

$$\textbf{CS} = \frac{\textbf{Content of each indispensable amino acid in food protein}}{\textbf{Content of same amino acid in reference protein (e.g., egg)}}$$

a. Amino acid with lowest score is first limiting amino acid, etc.

b. More useful when compared to reference pattern for age group.

2. Biological value

$BV = Intake - (F - F_o) - (U - U_o)/I - (F - F_o) \times 100$

BV = (nitrogen retained/nitrogen absorbed) x 100

Where:

Intake = nitrogen intake; F = fecal nitrogen; F_o = fecal nitrogen on nitrogen-free diet; U = urinary nitrogen; U_o = urinary nitrogen on nitrogen-free diet

a. Measure of nitrogen retained for growth and/or maintenance.

b. Proteins exhibit greater BV when fed below maintenance levels.

3. Net protein utilization

$NPU = I - (F - F_o) - (U - U_o)/I$

a. Measures retention of food nitrogen rather than absorbed nitrogen.

b. Takes into account digestibility of food proteins (also = BV x digestibility).

Amino acids as a percent protein in foods

Protein food	Lysine	Sulfur AAs	Threonine	Tryptophan	Leucine	CS	BV	NPU
Ideal (for preschool child)	5.5	3.5	4.0	1.0	7.0			
Egg, 12.8% protein	6.4	5.5	5.0	1.6	8.8	100	100	94
Cow milk, 3.5% protein	7.8	3.3	4.6	1.4	9.8	95	93	82
Ground beef, 10% protein	**8.7**	**3.8**	**4.4**	**1.2**	**8.2**	**71**	**74**	**67**
Chicken, 20.6% protein	**8.8**	**4.0**	**4.3**	**1.2**	**7.2**			
Soybeans, 34.9% protein	6.9	3.4	4.3	1.5	8.4	47	73	61
Black beans, 23.6% protein	6.4	2.6	3.4	1.0	8.7			
Lentils, 25.0% protein	6.1	1.5	3.6	0.9	7.0	37	64	55
Cornmeal, 9.2% protein	2.9	3.2	4.0	0.6	3.0	49	72	36
Oatmeal, 14.2% protein	3.7	3.6	3.3	1.3	7.5	57	65	---
Spirulina plankton	4.0	2.8	4.2	1.1	5.8			
Collagen	**3.4**	**0.9**	**1.8**	**0.0**	**3.0**			

Digestibility of food proteins

Food	Digestibility of protein(%)
Eggs	97
Meat, poultry, fish	85-100
Milk	81
Wheat	91-95
Corn	90
Soybeans	90
Other legumes	73-85

III. Vitamins in meat

Name *Coenzyme*	***Major functions***	*Deficiency symptoms*	***RDA***	*Dietary sources*	*Toxicity*
Thiamine Thiamine pyrophosphate	Coenzyme in glycolysis	Beriberi, nerve tingling	1.1-1.5 mg	Sunflower seeds, pork, grains, beans	None possible from food.
Riboflavin FAD and FMN	Coenzymes in TCA and ETS	Inflammation of mouth, eye disorders	1.2-1.7 mg	Milk, mushrooms, spinach	None reported.
Niacin NAD^+ and $NADP^+$	Coenzymes in glycolysis, TCA, ETS, ß-oxidation	Pellagra, diarrhea	15-19 mg	Mushrooms, bran, tuna, chicken, beef, peanuts	Flushing of skin at > 100 mg.
Pantothenic acid Coenzyme A	TCA, ß-oxidation	Fatigue, headache, nausea	4-7 mg	Mushrooms, liver, broccoli, eggs	None.
Biotin Biocytin	Gluconeo-genesis	Dermatitis, anemia	30-100 µg	Cheese, egg yolks, peanut butter	Unknown.
Vitamin B_6 Pyridoxal phosphate	Amino acid metabolism	Headache, anemia	1.8-2 mg	Animal protein foods, spinach, broccoli	Nerve destruction at > 100 mg
Folate (folic acid) THFA	DNA, RNA, amino acid synthesis	Anemia, diarrhea, mental disorders	180-200 µg	Green leafy vegetables, organ meats	None.
Vitamin B_{12} Cobalamins	Folate metabolism, gluconeo-genesis	Anemia, poor nerve function	2 µg	Animal foods, especially organ meats	None.
Vitamin C Ascorbic acid	Collagen synthesis	Scurvy	60 mg	Citrus fruits, strawberries, broccoli	Doses > 1-2 g cause diarrhea.

IV. Fat in meat – marbling and added fat

A. Relationship between muscle lipid content, fiber type and meat quality

1. Greater lipid content = greater flavor desirability.
2. Greater lipid content implies greater marbling content.
3. Higher marbling scores associated with a greater percentage of ß-red myofibers.

B. Location of adipose tissues

1. Subcutaneous, which underlies the skin. Originates as brown adipose tissue in some species.
2. Intermuscular, which separates whole muscles. Also known as seam fat.
3. Intramuscular (marbling), which is located between muscle fiber bundles. Also known as interfascicular adipose tissue.

3. Abdominal, which occurs within the abdomen of animals. Invariably originates as brown adipose tissue.

4. Pericardial, which is found within the chest cavity. Also originates as brown adipose tissue.

RELATIONSHIP BETWEEN PERCENTAGE OF FAT in the longissimus muscle and mean flavor desirability ratings for loin and top round steaks of various maturities.

Quality grade	Actual intramuscular fat (%)	Mean flavor desirability ratings			
		Loin steak		Top round steak	
		A maturity	A, B, C, E maturity	A maturity	A, B, C, E maturity
Prime+	11.0 or more	6.23	5.89	4.99	4.58
Prime	10.0 to 10.9	6.20	5.96	4.97	4.77
Prime-	9.0 to 9.9	6.15	6.00	5.12	4.78
Choice+	8.0 to 8.9	6.02	5.68	5.24	4.80
Choice+	7.0 to 7.9	5.97	5.61	4.67	4.26
Choice	6.0 to 6.9	5.90	5.62	4.81	4.37
Choice-	5.0 to 5.9	5.82	5.44	5.40	4.60
Select+	4.0 to 4.9	5.65	5.37	4.63	4.41
Select	3.0 to 3.9	5.69	5.20	4.83	4.39
Standard+	2.0 to 2.9	5.38	4.81	4.55	4.20
Standard	1.0 to 1.9	5.00	4.35	4.77	4.15
Standard-	0.9 or less	4.62	4.01	---	4.31

C. Marbling in U.S. livestock

1. Only grain-fed cattle and pigs marble well.
2. Maximum fat percentage in beef is approximately 12%.
3. Most beef contains 3 – 5% total fat within the muscle (and less for pork).

D. Beef cattle production in Japan, Korea, and China

1. Japan, Korea, and China produce cattle with the same genetic background.
2. The genetics migrated from China to Korea to Japan.
3. Japan, Korea, and China feed their cattle for a very long period of time (19 months or more past weaning), using high-grain diets to increase marbling.
4. One beef breed type in Japan (J. Black or Wagyu), Korea (Hanwoo), and China (Yellow cattle) contributes to high-quality beef production.

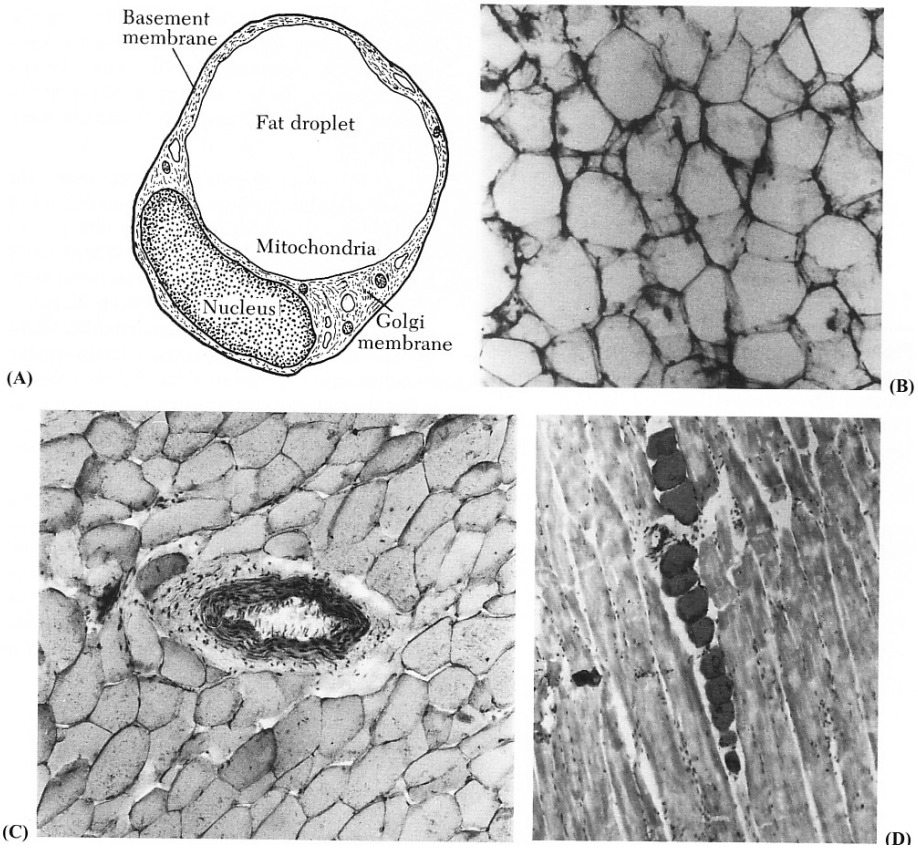
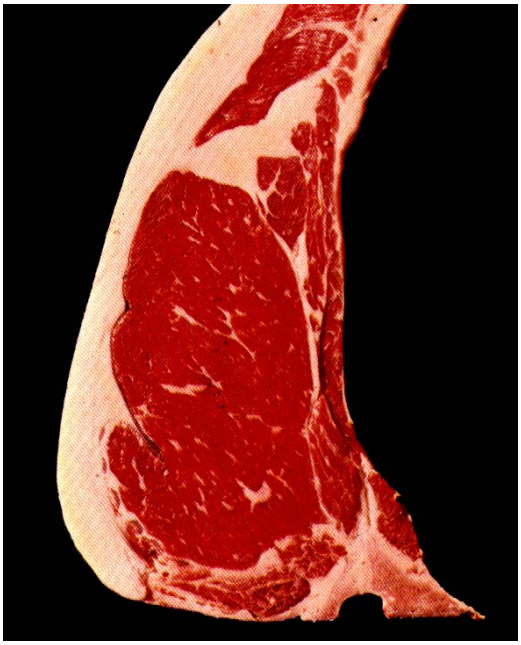


Diagram and photomicrographs of fat cells. (*upper left*) Diagram of a typical fat cell. (*upper right*) Photomicrograph of bovine subcutaneous fat cells. (*lower left*) Intermuscular bovine fat cells surrounding an artery. (*lower right*) Intramuscular bovine fat cells arranged longitudinally between muscle bundles.



U.S. Choice Beef (7% IML)

American Wagyu Beef (25% IML)