**Chapter 11: Lactation Physiology**

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***Key points to remember***

* Animals having hair and mammary gland belongs to the class Mammalia
* The word mammal comes from Latin word *mamma* which means breast or milk gland
* After birth, the young are nourished by milk, the physiological fluid of the mammary gland
* Milk contains three characteristics component: lactose, casein and milk fat
* The greatest variation in composition of milk occurs in milk fat percentage among species
* Mammary glands are modified sweat gland (sudoriferous) also serves as accessory glands to the reproductive system
* The mammary gland is composed of a teat, a duct system, lobes and lobules of secretory tissue drained by duct system
* In the placental animals, major mammary development occurs during pregnancy
* The mammary gland is derived from the ectoderm and mesoderm.
* Formation of mammary band (30days of age), subsequently transform to streak, line, crest, hillock and bud by 43 days of age
* Invagination of mammary bud cells into mesenchyme forms primary sprout formation, gives rise to secondary sprout, canalization proceeds to form gland cistern and teat cistern formation
* In cow, udder is supported by two, major groups of ligaments as median suspensory ligaments (MSL) and lateral suspensory ligaments
* The rear quarters make up the largest portion of the udder and secrete approximately 60% of the milk
* Each quarter of the udder has one teat to drain out the milk, 4 teats are present in cows and buffaloes
* Some additional teats are called supernumerary teats or extra teats
* Teats varies in shape from cylindrical to conical, rear teats are usually shorter than fore teats
* At the end of teat, the teat pore is present to drain out the milk. The pore remains closed between milking by a circular sphincter muscle called teat sphincter
* Internal structure of teat includes Teat (streak) canal, Furstenburg rosette, Annular (cricoid) rings and Teat cistern
* The ductular system of the mammary gland starts from alveoli to streak canal
* Milk is collected in the lumen of alveoli.
* Each alveolus is made up of single layer of epithelial cells
* Epithelial cells synthesise and secrete milk into lumen od alveoli
* About 150-220 alveoli form a lobule, many lobules arranged to form lobes
* The outer layer of alveolus contains myoepithelial cells, these cells have oxytocin receptors, binding of oxytocin to these receptors leads to contraction cause milk let-down
* The contraction of myoepithelial cells cause raise in intra-mammary pressure up to 60mmHg por more.
* 500ml of blood supplied to mammary gland to synthesise 1ml of milk.
* The venous circle is formed by anastomosing anterior and posterior mammary veins
* Initiation of milk secretion is called lactogenesis
* Galactopoeisis is defined as the maintenance of lactation
* The first secretion of mammary gland following parturition is known as colostrum
* Increased prolactin activity leads to higher mammary cell activity
* Growth hormone is essential for the formation of maintenance of lactation (galactopoietic)
* Adrenal corticoids at physiological levels is galactopoietic, however at high doses inhibits lactation
* Thyroid hormones are galactopoietic. Injections for short period increases milk production, but no benefit in feeding thyroprotein
* Estrogen administered in very low doses ids galactopoietic, higher dose have inhibitory effect
* Progesterone has no effect on gaclactopoeisis
* Milk secretion is affected by many factors such as parity, stage of lactation, milking interval, frequency of milking, residual milk and milking management practices
* A 24hr milk stasis leads to reduction in RNA:DNA ratio by 31%
* Mammary gland involution takes place after the peak lactation and after cessation of milk removal or suckling of young
* Inflammation of mammary gland is mastitis
* Test to detect mastitis depends on milk somatic cell counts, as gold standard for assessment of mastitis screening and as a measure of milk quality

***a. Fill in the blanks***

1. CMT test is an index of ………………and is directly related to ………in milk
2. The chloride content of milk ………and the lactose ……… with high environmental temperatures
3. The right and left halves of udder are separated internally by the ………
4. The ……… of the udder varies with age of the cow, the stage of lactation, the amount of milk in the udder and inherited difference among cows.
5. The rear teats are usually …………. than the fore teats
6. In cows, teat shape varies from …………..
7. The ………. and ……….. also serve as collecting vessels for part of the milk between milking
8. The place where veins enter the abdominal cavity are referred to …………
9. At the base of udder a …………. is formed by branches of left and right cranial and caudal mammary veins
10. The blood can leave the udder by either the …………… or the ………… vein in the lactating ruminant
11. Who…………… identified myoepithelial cells with silver nitrate impregnation techniques
12. Four categoreis of cellular lysosomes are …………., …………, ………. and ……….
13. Prolactin has little or no ………. activity in lactating cows
14. Low supplemental levels of thyroactive materials ……….. lactation and high levels have an ……….. effect.
15. ………… and ……….. are the minimal hormones required for maintaining viable mammary gland tissue explant *in vitro*
16. ………… binds adrenal corticoids and inhibit their biological activity
17. …………., ……….. and……….. and the sucking stimulus inhibit the release of PIF
18. The maintenance of lactation is depended upon ………… stimulus and ……………
19. Mammary gland is innervated with ……………. and ……………. fibers
20. The neurohormonal reflex theory of milk ejection was proposed by ………and ……….
21. The constituents primarily responsible for osmotic pressure of milk are ……….., ………… and ………….
22. Colostrum contains higher in ……..., ……., ……… and ……. and lower in K than milk
23. Colostrum contains ……….. percent but ……….. content than milk
24. Specific gravity of whole milk is ……..
25. Specific gravity of colostrum is ………
26. Cows freshening in the fall usually produces ………. than those calving in other seasons
27. At about ……֯ F, the food consumption and milk production approaches zero
28. The ……… content of milk increases and ……….. decreases with high temperature
29. Mastitis milk is lower in …………, ………… and ………… content
30. During mastitis milk ………. increases, ………… and ……….. content have smaller increase
31. Mastitis milk cause changes in ………. fractions however, do not change the overall percentage of protein
32. Increasing Vitamin …….. content in feed increases Ca absorption from intestine, but will not increase milk Calcium content
33. The calcium content in milk comes from blood …………..
34. Potassium, Calcium, Chlorine, Phosphorous, Mg and Na are the major ………. constituents of cow’s milk.
35. The content of ……… and ……….. in milk cannot be increased, even if the contents in the diet is markedly increased.
36. Two active forms of vitamin C in milk are………… and……………
37. Vitamin D in the cow milk comes from the activation of ………… in the feed or from animal exposure to sunlight which activates …………… in the skin of the animal
38. Two common screening test to estimate the extent of inflammation are ……………. and the ……………..

***b. Multiple choice Questions***

|  |  |
| --- | --- |
| 39. Alveoli arises from ………….. | |
| a. Lobes | c. Between Lobes |
| b. Intercalary ducts | d. Lobules |
| 40. Teats are also known as | |
| a. Ductus papillaris | c. Pappilae mamae |
| b. Sinus papillaris | d. None of the above |
| 41.Rear quarters secrete how much percent of milk? | |
| a. 60 | b.50 |
| c. 40 | d.30 |
| 42. During lactation, how much percent of cardiac output is utilized by mammary gland? | |
| a.10 | b.18 |
| b.20 | c.30 |
| 43. Milk of cows with clinical mastitis is lower in | |
| a. Lactose and potassium | b. Calcium and potassium |
| c. Sodium and Chlorine | d. Chloride and potassium |
| 44. Milk of cows with clinical mastitis is higher in | |
| a. Lactose and potassium | b. Calcium and potassium |
| c. Sodium and Chlorine | d. Chloride and potassium |
| 45. Decrease in SNF content is due to decrease in ……...content | |
| a. Protein | b. Fat |
| c. Salts | c. Lactose |
| 46. Major effect of infection and mastitis on milk composition is ………and ………contents | |
| a. Protein and Lactose | b. Fat and minerals |
| c. Lactose and mineral | d. Proein and Fat |
| 47. Severe changes on which milk composition appears after rather severe signs of clinical mastitis | |
| a. Protein | b. Fat |
| c. S.N.F | d. Water |
| 48. The milk fat content increases with decreasing temperature below……..֯F | |
| a. 45 | b. 55 |
| c. 65 | d. 75 |
| 49. The greatest variation in composition occurs in which component | |
| a. Lactose | b. Protein |
| c. Salts | d. Fat |
| 50. ………..and………… hormones increase the level of milk production of the dairy cows | |
| a. Somatotrophin and Thyroxine | c. Glucocorticoids and progesterone |
| b. Prolactin and progesterone | d. Estrogen and progesterone |
| 51. Extra teats are called |  |
| a. Supernumerary teat | b. Supranumerary teat |
| c. Subnummerary teat | d. Extramammary teat |
| 52. The udder is separated into two halves by a longitudinal groove called …………. | |
| a. Intermammary groove | b. Intramammary groove |
| c. Mammary groove | d. Recticular groove |
| 53. Extra teats are usually removed when calf is less than ……. of age | |
| a. 2 year | b. 1 year |
| c. 3 year | d. 4 year |
| 54. There is no significant increases in either udder weight or capacity after cows reached ……. of age. | |
| a. 2 years | b. 3 years |
| c. 3 years | d. 6 years |
| 55. ………… is the one with a large amount of connective tissue in comparison to secretory tissue. | |
| a. Hard udder | b. Tough udder |
| c. Soft udder | c. Smooth udder |
| 56. ………………. of the udder gives a nearly perfect balanced suspension of the udder | |
| a. Medial suspensory ligament | b. Lateral suspensory ligament |
| c. Abdominal ligament | d. Pelvic ligament |
| 57. The mammary gland are supplied with afferent sensory fibers as well as ……. fibers | |
| a. Sympathetic Efferent | b. Motor |
| c. Mixed | d. Parasympathetic Efferent |
| 58. ………. lymph nodes play a, major role in filtering lymph from mammary gland | |
| a. supramammary | b. submammary |
| c. Popliteal | d. Meseneteric |
| 59. ……………. cells located between the basement membrane and the epithelial cells of alveoli | |
| a. Epithelial cells | b. Podocytes |
| c. Endothelial | d. Myoepithelial |
| 60. ………acts on myoepithelial cells cause milk ejection | |
| a. Oxytocin | b. Estrogen |
| c. Progesterone | d. Vasopressin |
| 61. Group of alveoli forms lobules, one lobule in lactating cow composed of ………. alveoli | |
| a. 100-150 | b. 150-220 |
| c. 200-250 | d. 350-420 |
| 62. Fat droplets are easily recognised in histological sections by ……… special dye | |
| a. Sudan IV | c. Haematoxylin |
| b. Giemsa | d. Eosin |
| 63. Lactose is synthesised in………………. apparatus | |
| a. Golgi | b. Mitochondria |
| b. Rough endoplasmic reticulum | d. Smooth endoplasmic reticulum |
| 64. Lactase synthetase is made up two proteins…….and……………. | |
| a. Alpha-Lactalbumin and Galactosyl transferase | b. beta-Lactoglobulin and Galactosyl transferase |
| c. Protein C and D | d. beta-Lactalbumin and Galactosyl transferase |
| 65. ………….. and …………… hormones are required for initiation of lactation | |
| a. Growth hormone and Estrogen | b. Estrogen and Progesterone |
| c. Prolactin and adrenal corticoid | d. Relaxin and Prolactin |
| 66. Drop in the level of ………. and…………. hormones cause the milk secretion process. | |
| a. Progesterone and trancortin | b. Growth hormone and Prolactin |
| c. Growth hormone and Estrogen | d. Estrogen and Progesterone |
| 67. …………… inhibit alpha lactalbumin during pregnancy | |
| a. Progesterone | b. Growth hormone and Prolactin |
| c. Growth hormone and Estrogen | d. Estrogen and Progesterone |
| 68. ….……. rate limiting enzyme for lactose biosynthesis | |
| a. Hexokinase | b. Epimerase |
| c. Phoshomutase | d. Lactose synthetase |
| 69. The hypothalamus produces a ……… compound which inhibit prolactin production/release from the pituitary | |
| a. PIF | b. LIF |
| c. HIF | d. FIF |
| 70. The activation of the ………. center or the inhibition of ……… center favour secretion of pituitary hormones concerned in the maintenance of lactation | |
| a. appetite and sateity | b. hunger and appetite |
| c. Thirst and sateity | d. satiety and Thirst |
| 71. ………..... fibers are absent in mammary gland (general skin surface areas) | |
| a. Sympathetic | b. Parasympathetic |
| c. Motor | d. Sensory |
| 72. Oxytocin is ………. times more active than vasopressin in milk ejection | |
| a. 2-3 | b. 3-4 |
| c. 2.5-3.5 | d. 5-6 |
| 73. Half-life of oxytoxin in bloodstream of cow…………. minute | |
| a. 2.50-3.58 | b. 1.08-1.58 |
| c. 2.08-3.58 | d. 2.58-3.58 |
| 74. Oxytocin, polypeptide containing ……amino acid, molecular wt.… KDa | |
| a. 8, 1000 | b. 8, 2000 |
| c. 9,1000 | d. 9, 2000 |
| 75. The ……… percent tends to increase with longer milking intervals | |
| a. milk fat | b. milk protein |
| c. milk lactose | d. S. N. F |
| 76. Milking cows four times daily gives a ………. % increase in production over cows milked three times daily | |
| a. 2-5 | b. 5-10 |
| c. 10-12 | d. 10-15 |
| 77. The massaging of udder between milking’s caused a ………. % increase in production | |
| a. 1.0-1.5 | b. 2.5-5 |
| c. 5-7.5 | d. 2.5-7.5 |
| 78. Milking cows three times daily gives a ………. % increase in production over cows milked twice daily | |
| a. 15-20 | b. 5-10 |
| c. 7-15 | d. 2-5 |
| 79. Ratio of blood to milk yield ……. in cows |  |
| a. 250:1 | b. 500:1 |
| c. 800:1 | d. 600:1 |
| 80. The vitamin A content of colostrum is 10 times higher than milk | |
| a. 10 | b. 30 |
| c. 40 | c. 50 |
| 81. The percentage of ………….. are usually highest during winter months | |
| a. Fat and S.N.F | b. Protein and Lactose |
| c. Fat and Protein | d. Protein and S.N F |
| 82. Within the RH 60-80%, the milk yield is unaffected by temperature changes between | |
| a. 20 and 30 ֯F | b. 30 and 40 ֯F |
| c. 40 and 70 ֯F | d. 70 and 90 ֯F |
| 83. Mastitis milk is higher in …………. contents than normal milk | |
| a. Sodium and Chloride | b. Potassium and Chloride |
| c. Sodium and Phosphorous | d. Calcium and Chloride |
| 84. Most of the milk fat percent increase occurred during first …… months of lactation | |
| a. 1-2 | b. 2-3 |
| c. 3-4 | d. 6-7 |
| 85. Increase in the plane of nutrition by 25-35% above the normal feeding causes SNF% increase by ………% | |
| a. 0.2 | b. 1.5 |
| c. 2 | c. 2.5 |
| 86. Reductions to 25% below the feeding standards cause a decrease in SNF percentage of % | |
| a. 0.2-0.3 | b.0.3-0.4 |
| c. 0.4-0.5 | d. 0.5-0.6 |
| 87. The change in SNF content is mainly due to changes in …….. content of the milk | |
| a. Protein | b. Lactose |
| c. Salt | c. Water |
| 88. In a normal lactation curve, peak yield reaches by ……. weeks after calving | |
| a. 2-3 | b. 3-6 |
| c. 6-9 | d. 8-10 |
| 89. The milk ……. and ……… percentages are inversely proportional to milk yield | |
| a. Fat and Protein | b. Lactose and Protein |
| c. Fat and SNF | c. Lactose and Salts |
| 90. ……casein is not synthesised from mammary gland | |
| a. ꝩ | b. α |
| c.β | d. ∞ |
| 91. Most variable component of milk constituent? | |
| a. Fat | b. Protein |
| c. Lactose | C. S.N.F |
| 92. Milk fat is composed primarily of ………. | |
| a. Triglycerides | b. Monoglycerides |
| c. Diglycerides | d. Polyglycerides |
| 93. …….… % carbon atoms of milk fat came from acetate | |
| a. 20 | b. 30 |
| c. 40 | d. 50 |
| 94. Fat soluble vitamin ………and ……….is not synthesized by rumen bacteria or body, hence dependent upon the feed | |
| a. A and K | b. D and K |
| c. A and E | c. E and A |
| 95. Colostrum contains …….. times the vitamin E content of normal milk | |
| a. 2.5 - 7 | b. 7-12 |
| c. 8-9 | d. 10-12 |
| 96. The vitamin present in milk is in which form ………….. | |
| a. D3 | b. D1 |
| c. D4 | d. D2 |
| 97. The average vitamin D content in milk during summer is | |
| a. 12 IU/L | b. 25IU/L |
| c. 33 IU/L | d. 40IU/L |
| 98. Average value of vitamin D during winter months is ………… of milk | |
| a. 13.7 IU/L | b. 25 IU/L |
| c. 30 IU/L | d. 33 IU/L |
| 99. Increasing the tocopherol content of the diet increases vitamin ………content in milk | |
| a. E | b. A |
| a. K | d. D |
| 100. Colostrum contains …… times vitamin content of normal milk | |
| a. 1-2 | b. 2.5-7 |
| c. 8-10 | d. 10-12 |
| 101. pH of the milk is ………. | |
| a. 7.0 | b. 6.2 |
| c. 6.6 | d. 7.4 |
| 102. Ruminant animal can synthesise Vitamin… in the body but humans cannot | |
| a. A | b. B |
| c. C | d. D |
| 103. Colostrum contains ………. times more Vitamin D than normal milk | |
| a. 3-10 | b. 10-15 |
| c. 12-15 | d. 15-20 |
| 104. Vitamin …….. content in cows milk cannot be changed by dietry contents | |
| a. A | b. B |
| c. C | d. D |
| 105. Animals are most susceptible to infection during the …….. month of lactation and during the ……. few weeks of the dry period | |
| a. first, first | b. first, last |
| c. last, first | d. last, last |
| 106. The leukocyte pass from bloodstream into tissue by its ……….. movement | |
| a. Flickering | b. Ameboid |
| c. Rolling | d. Flagellar |
| 107. Mastitis milk has a lower concentration of ………. and increased sodium and noncasein proteins | |
| a. Calcium | b. Magnesium |
| c. Chlorine | d. Potassium |
| 108. Mastitis milk has higher ………. and glycogen content than normal milk | |
| a. Serotonin | b. Histamine |
| c. Oxytocin | d. Dopamine |

***c. Match the following***

A.

|  |  |
| --- | --- |
| 1. Gland cistern | a. ductus papillaris |
| 2. Teat cistern | b. sinus papillaris |
| 3. Annular fold | c. junction between gland and taet cistern |
| 4. Streak canal | d. Lactiferous sinus |
| 5. Furstenburg rosette | e. streak canal |

B.

|  |  |
| --- | --- |
| 1. Dry period | a. 191 |
| 2. Diurnal effect in fat | b. Carry over effect of residual milk |
| 3. Mammary secretory cells | c. High Lactoferrin |
| 4. Active involution | d. 45 |
| 5. Bovine GH | e. FIL |

C.

|  |  |
| --- | --- |
| 1. Teats in cow | a. 2.9 |
| 2. Teats in sow | b. 0.9 |
| 3. Casein in milk | c. 4 |
| 4. Ig in colostrum | d. 10 |
| 5. Ig in milk | e. 6 |

D.

|  |  |
| --- | --- |
| 1. Most costly disease | a. Less than 1 |
| 2. RNA index | b. Greater than 1 |
| 3. DNA index | c. Mastitis |
| 4. RQ of udder during lactation | d. cell numbers |
| 5. RQ of udder during pregnancy | e. Protein secretion |

E.

|  |  |
| --- | --- |
| 1. Fat in Horse milk | a. 5.5 |
| 2. Fat in Buffalo milk | b. 15.1 |
| 3. Fat in Jersey cow milk | c. 1.6 |
| 4. Fat in Elephant milk | d. 3.5 |
| 5.Fat in Goat milk | e. 8 |

**Answer Key**

***a. Fill in the blanks***

1. **Udder inflammation** and **leukocyte count**
2. **increases** and **decreases**
3. medial suspensory ligament
4. weight
5. shorter
6. cylindrical to conical
7. ducts and gland cisterns
8. Milk wells
9. venous circle
10. subcutaneous abdominal vein or the external pudendal vein
11. Richardson, 1949
12. storage granules, digestive vacuoles, autophagic vacuoles and residual bodies
13. galactopoietic
14. enhance, inhibitory
15. Insulin and cortisol
16. Transcortin
17. Reserpine, epinephrine and acetylcholine
18. suckling and milk removal
19. somatic sensory and sympathetic motor fibers
20. Ely and Petersen
21. Lactose, Sodium and Potassium
22. Ca, Mg, P, and Cl
23. high protein, lower lactose
24. 1.032
25. 1.056
26. more milk
27. 105
28. chloride, lactose
29. casein, lactose and potassium
30. globulin, serum albumin and proteose
31. protein
32. Vitamin D
33. Calcium
34. mineral
35. Iron and copper
36. ascorbic acid and dehydroascorbic acid
37. ergosterol, 7-dehydrocholesterol
38. California Mastitis test (CMT), Whiteside test

***b. Multiple choice Questions***

39. b. Intercalary ducts

40. c. Pappilae mamae

41. a. 60

42. a.10

43. a. Lactose and potassium

44. c. Sodium and Chlorine

45. c. Lactose

46. c. Lactose and mineral

47. a. Protein

48. d. 75

49. d. Fat

50. a. Somatotrophin and Thyroxine

51. a. Supernumerary teat

52. a. Intermammary groove

53. b. 1 year

54. d. 6 years

55. a. Hard udder

56. a. Medial suspensory ligament

57. a. Sympathetic Efferent

58. a. supramammary

59. d. Myoepithelial

60. a. Oxytocin

61. b. 150-220

62. a. Sudan IV

63. a. Golgi

64. a. Alpha-Lactalbumin and Galactosyl transferase

65. c. Prolactin and adrenal corticoid

66. a. Progesterone and trancortin

67. a. Progesterone

68. d. Lactose synthetase

69. a. PIF

70. a. appetite and sateity

71. b. Parasympathetic

72. d. 5-6

73. b. 1.08-1.58

74. a. 8, 1000

75. a. milk fat

76. b. 5-10

77. a. 1.0-1.5

78. a. 15-20

79. b. 500:1

80. a. 10

81. a. Fat and S.N.F

82. c. 40 and 70F

83. a. Sodium and Chloride

84. b. 2-3

85. a. 0.2

86. c. 0.4-0.5

87. a. Protein

88. b. 3-6

89. a. Fat and Protein

90. a. ꝩ

91. a. Fat

92. a. Triglycerides

93. b. 30

94. c. A and E

95. a. 2.5 - 7

96. d. D2

97. c. 33 IU/L

98. a. 13.7 IU/L

99. a. E

100. b. 2.5-7

101. c. 6.6

102. c. C

103. a. 3-10

104. c. C

105. a. first, first

106. b. Ameboid

107. d. Potassium

108. b. Histamine

***c. Match the following***

A. 1-d, 2-b 3-c, 4-a, 5-e

B. 1- e, 2-b, 3-e, 4-d, 5-a

C. 1-c, 2-d, 3-a, 4-e, 5-b

D. 1-c, 2-e, 3-d, 4- b, 5-a

E. 1-c, 2-e, 3-a, 4-b, 5-d