INTRODUCTION :

The lactating mother supplies all the hydration and nutrients that a growing infant needs for the first 4–6 months of life. During pregnancy, the body prepares for lactation by stimulating the growth and development of branching lactiferous ducts and alveoli lined with milk-secreting lactocytes, and by creating colostrum. These functions are attributable to the actions of several hormones, including prolactin.

Lactation is the process by which milk is synthesized and secreted from the mammary glands of the postpartum female breast in response to an infant sucking at the nipple. Breast milk provides ideal nutrition and passive immunity for the infant, encourages mild uterine contractions to return the uterus to its pre-pregnancy size (i.e., involution), and induces a substantial metabolic increase in the mother, consuming the fat reserves stored during pregnancy.

PHYSIOLOGY OF LACTATION / THE PROCESS OF LACTATION :

The normal physiology of lactation is a process that begins to take effect well before the initial latch of the newborn infant. It requires the breast to change in composition, size, and shape during each stage of female development. Development includes puberty, pregnancy, and lactation.

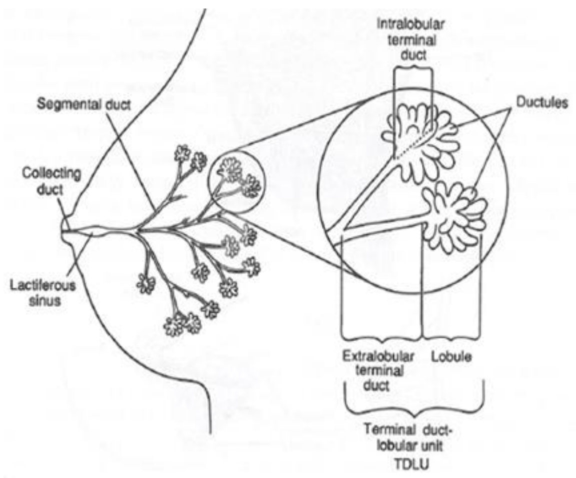
It is important to learn the normal anatomy and cellular composition of breast tissue to understand the physiologic process of lactation. The normal breast consists of 2 major structures (ducts and lobules), 2 types of epithelial cells (luminal and myoepithelial), and 2 types of strom (interlobular and intralobular). Six to 10 major duct orifices open on to the skin surface of the nipple. The uppermost portion is lined with keratinized squamous cells that abruptly change to the double-layered epithelium (luminal and myoepithelial) of the remainder of the duct and lobule system. Large ducts will eventually lead to the terminal duct lobular unit, and these terminal ducts will then branch into grape-like clusters of small acini to form a lobule. There are 3 types of lobules, type 1, 2, and 3 which form at different stages in a woman's development. Lobules increase progressively in number and size, and by the end of pregnancy, the breast is composed almost entirely of lobules separated by small amounts of the stroma. Only with the onset of pregnancy does the breast become completely mature and functional.

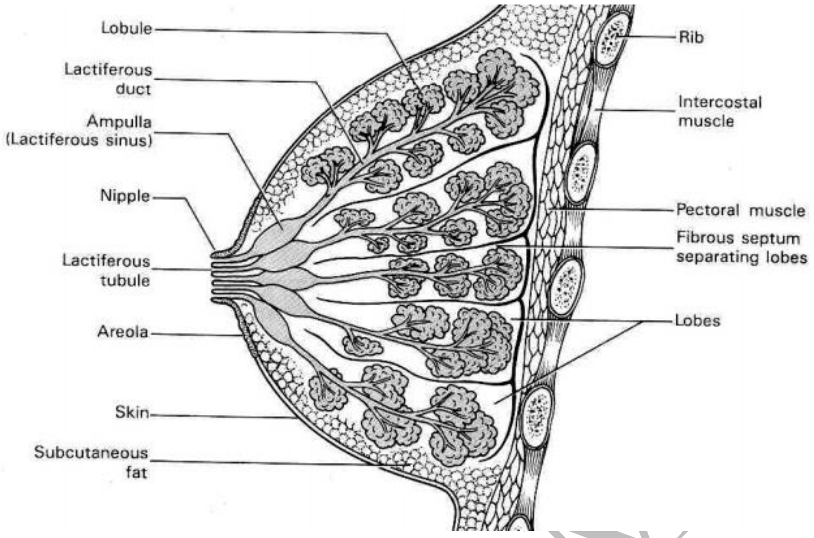
During puberty, lobule type 1 is formed. Changes in the level of estrogen and progesterone during each menstrual cycle stimulate lobule 1 to produce new alveolar buds and eventually evolve to more mature structures, known as type-2 and type-3 lobules. Once puberty is complete, no further changes occur to the female breast until pregnancy.

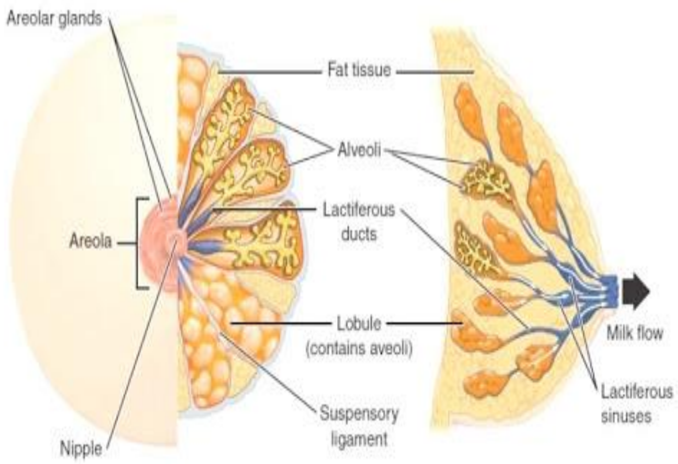
During pregnancy, stage-II mammogenesis (alveolar development and maturation of the epithelium) occurs largely in response to higher levels of progesterone. The increased volume of breast tissue during pregnancy is a result of the proliferation of secretory tissue. In early pregnancy, lobule type 3 is formed due to the influence of chorionic gonadotropin. These newly formed lobules have larger size and number of epithelial cells composing each acinus. In late pregnancy, the proliferation of new acini are reduced, and the lumen becomes distended with secretory material or colostrum.

The physiological basis of lactation is divided into four phases :

- Mammogenesis
- Lactogenesis
- Galactokinesis (ejection of milk)
- Galactopoiesis







Mammogenesis

Mammogenesis is the process of growth and development of the mammary gland in preparation for milk production. This process begins when the mammary gland is exposed to estrogen at puberty and is completed during the third trimester of pregnancy. Before pregnancy, the breast is predominantly adipose tissue without extensive glandular or ductal development. Under the influence of uninterrupted and rising concentrations of estrogen, progesterone, and prolactin during pregnancy, the breast increases in water, electrolyte, and fat content.

Hormonal Effects

Total estrogen excretion increases between early and late pregnancy. This reflects the rising plasma estrogen levels, which greatly stimulate the ductal formation begun at puberty and the differentiation of epithelial cells into ductal, acinar, and myoepithelial elements. As the acinar-ductal system expands, it replaces much of the fatty tissue of the breast and is organized into mature, functional. In addition to its effect on the mammary cells themselves, estrogen stimulates the synthesis and release of prolactin from the pituitary lactotrophs. Rising prolactin levels appear to be necessary for estrogen to exert its biologic effects on the mammary gland. In addition, prolactin induces the enzymes necessary for the acinar secretory activity seen after delivery.

Progesterone secretion also increases during pregnancy. In the presence of estrogen and prolactin, progesterone stimulates acinar proliferation and inhibits lactose synthesis. The high plasma concentrations of estrogen and progesterone present before delivery inhibit the active secretory effects of prolactin on mammary alveolar epithelium.

The initial stimulation of mammary epithelium occurs during the first few weeks of pregnancy. By the second trimester, colostrum, the first milk, appears in the alveoli of the acinar glands in small quantities, reflecting the beginning of protein synthesis under the influence of prolactin. By the third trimester, the alveoli contain significant amounts of colostrum, the epithelial cells are laden with fat droplets, and the adipose tissue of the breast has been markedly reduced and replaced by functioning glandular units.

LACTOGENESIS

Lactogenesis is the process of developing the ability to secrete milk and involves the maturation of alveolar cells. It takes place in 2 stages: secretory initiation and secretory activation.

Stage I lactogenesis (secretory initiation) takes place during the second half of pregnancy. The placenta supplies high levels of progesterone which inhibit further differentiation. In this stage, small amounts of milk can be secreted by week 16 gestation. By late pregnancy, some women can express colostrum.

Stage II lactogenesis (secretory activation) starts with copious milk production after delivery. With the removal of the placenta at delivery, the rapid drop in progesterone, as well as the presence of elevated levels of prolactin, cortisol, and insulin, are what stimulate this stage.

The success of a purposeful suppression of lactation depends on inhibiting the process of lactogenesis. Because lactogenesis does not begin in the human being until the rapid decrease in estrogen and progesterone that occurs at delivery and because it requires 2–3 days to be completed.

The mammary epithelium remains a presecretory tissue until the abrupt diminution in plasma estrogen and progesterone concentration that occurs at the time of delivery. Without the inhibitory influence of progesterone on mammary epithelium, prolactin and the other hormones active in the initiation of milk production can exert their effects on acinar cells. By 4–5 days postpartum, estrogen and progesterone concentrations in the plasma are less than normal follicular phase levels and the transition in the acinar epithelium from a presecretory to a secretory state is complete.

The inhibition of lactogenesis before delivery appears to be a consequence of high circulating levels of progesterone, which competitively inhibits the binding of cortisol to an intracellular receptor. This prevents cortisol from acting synergistically with prolactin to initiate milk production. The rapid fall in progesterone after deliver allows cortisol binding to occur and lactogenesis to proceed. Prolactin and cortisol are essential for lactogenesis, and growth hormone, insulin, and thyroxin play facultative roles.

GALACTOPOIESIS

Galactopoiesis is the maintenance of milk production once it has been established by completion of lactogenesis. The single most important factor in successful galactopoiesis is regular and frequent milk removal from the mammary gland. Milk removal stimulates further milk secretion by at least three mechanisms.

First, regular suckling promotes the regular synthesis and release of both prolactin and oxytocin, which are necessary for continued milk secretion.

Second, the breast has the capacity to store milk for a maximum of 48 hours before there is a substantial decrease in production. This reduced milk production is caused by the diminished stimulation of the glandular epithelium by prolactin and the vascular stasis caused by increased intramammary pressure resulting from distention of the mammary ducts and alveoli with stored milk. Blood flow to the mammary glands is significantly reduced by this increased intramammary pressure, which diminishes the nutrient and hormonal supply necessary for milk production.

Third, as in other milk-producing animals, the amount of milk produced daily is fairly closely related to the demand (i.e. the amount of milk removed the previous day), as long as the nutritional and hormonal requirements are met. Normal levels of prolactin (5–20 ng/ml), with surges of prolactin and oxytocin at the time of suckling, are also necessary for the maintenance of normal milk production.

Milk ejection reflux

The pituitary hormone play a important role for the mobilization of maternal micronutrients for breast milk.

Near the fifth week of pregnancy, the level of circulating prolactin begins to increase, eventually rising to approximately 10–20 times the pre-pregnancy concentration. During pregnancy, prolactin and other hormones prepare the breasts anatomically for the secretion of milk. However, estrogen, progesterone, and other placental hormones inhibit prolactin-mediated milk synthesis during pregnancy. It is not until the placenta is expelled that this inhibition is lifted and milk production commences.

After childbirth, the baseline prolactin level drops sharply, but it is restored for a 1-hour spike during each feeding to stimulate the production of milk for the next feeding. With each prolactin spike, estrogen and progesterone also increase slightly.

When the infant suckles, sensory nerve fibers in the areola trigger a neuroendocrine reflex that results in milk secretion from lactocytes into the alveoli. The posterior pituitary releases oxytocin, which stimulates myoepithelial cells to squeeze milk from the alveoli so it can drain into the lactiferous ducts, collect in the lactiferous sinuses, and discharge through the nipple pores. It takes less than 1 minute from the time when an infant begins suckling (the latent period) until milk is secreted (the let-down).

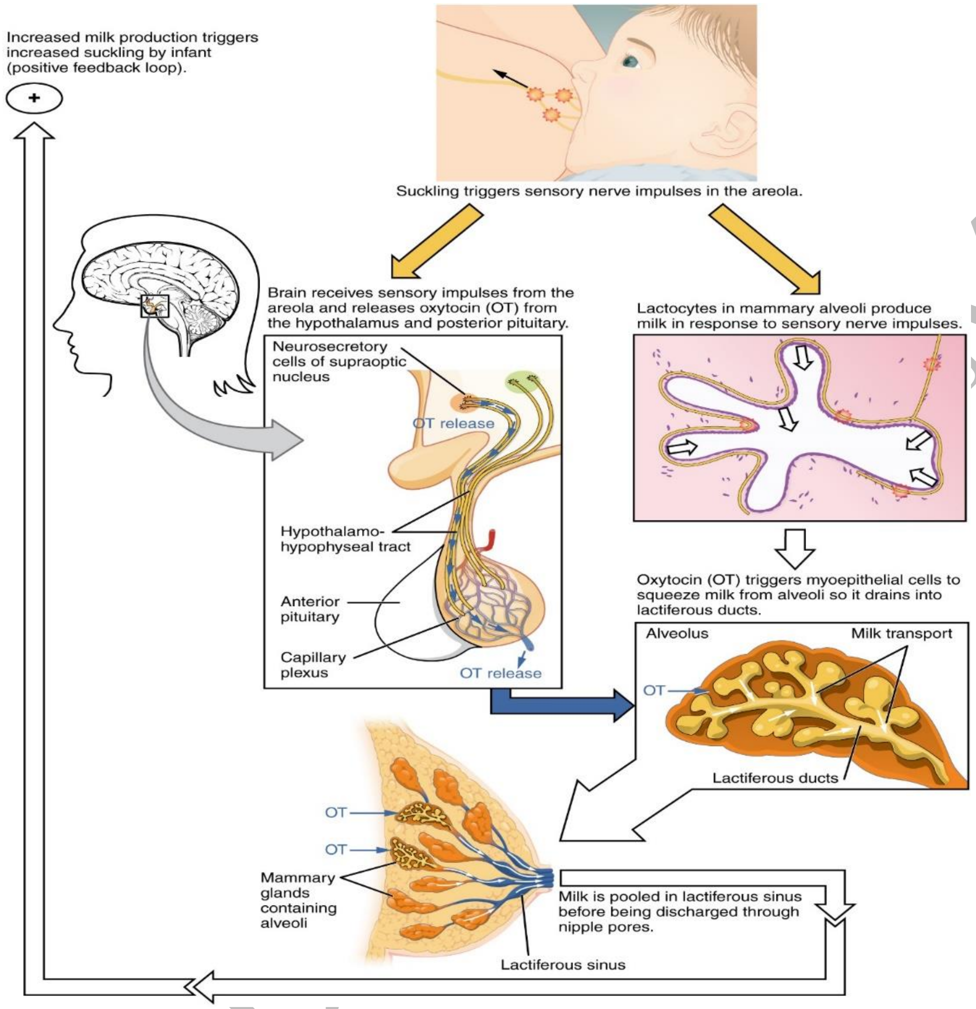


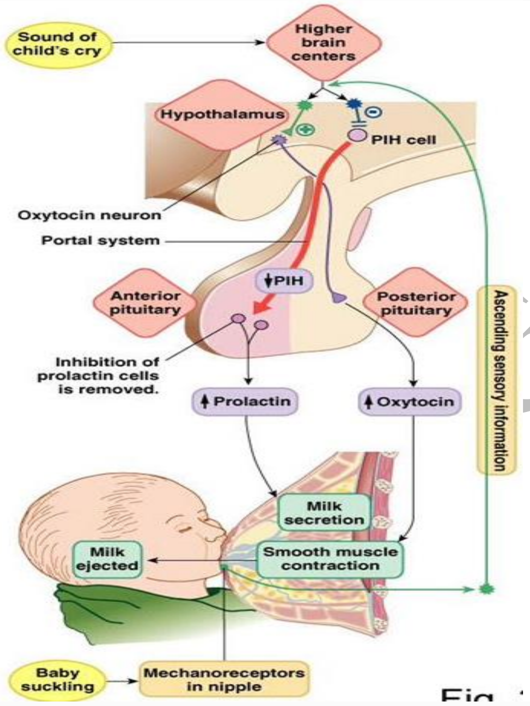
Figure :Let-Down Reflex. A positive feedback loop ensures continued milk production as long as the infant continues to breastfeed.

When the breast is stimulated, prolactin levels in the blood rise, peak in about 45 minutes, and return to the pre-breastfeeding state about three hours later. The release of prolactin triggers the cells in the alveoli to make milk. Prolactin also transfers to the breast milk. Some research indicates that prolactin in milk is greater at times of higher milk production, and lower when breasts are fuller, and that the highest levels tend to occur between 2 a.m. and 6 a.m.

The prolactin-mediated synthesis of milk changes with time. Frequent milk removal by breastfeeding (or pumping) will maintain high circulating prolactin levels for several months. However, even with continued breastfeeding, baseline prolactin will decrease over time to its pre-pregnancy level. In addition to prolactin and oxytocin, growth hormone, cortisol, parathyroid hormone, and insulin contribute to lactation, in part by facilitating the transport of maternal amino acids, fatty acids, glucose, and calcium to breast milk.

What is the let-down reflex?

The let-down reflex is what makes breastmilk flow. When your baby sucks at the breast, tiny nerves are stimulated. This causes two hormones – prolactin and oxytocin – to be released into your bloodstream. Prolactin helps make the milk, while oxytocin causes the breast to push out the milk. Milk is then released or let down through the nipple.



PIH –Prolacting Inhibiting Hormone

Hormonal influences

From the eighteenth week of pregnancy (the second and third trimesters), a woman's body produces hormones that stimulate the growth of the milk duct system in the breasts:

- Progesterone influences the growth in size of alveoli and lobes; high levels of progesterone inhibit lactation before birth. Progesterone levels drop after birth; this triggers the onset of copious milk production.
- Estrogen stimulates the milk duct system to grow and differentiate. Like progesterone, high levels of estrogen also inhibit lactation. Estrogen levels also drop at delivery and remain low for the first several months of breastfeeding.[4] Breastfeeding mothers should avoid estrogen-based birth control methods, as a spike in estrogen levels may reduce a mother's milk supply.
- Prolactin contributes to the increased growth and differentiation of the alveoli, and also influences differentiation of ductal structures. High levels of prolactin during pregnancy and breastfeeding also increase insulin resistance, increase growth factor levels (IGF-1) and modify lipid metabolism in preparation for breastfeeding. During lactation, prolactin is the main factor maintaining tight junctions of the ductal epithelium and regulating milk production through osmotic balance.
- Human placental lactogen (HPL) – from the second month of pregnancy, the placenta releases large amounts of HPL. This hormone is closely associated with prolactin and appears to be instrumental in breast, nipple, and areola growth before birth.

- Follicle stimulating hormone (FSH), luteinizing hormone (LH), and human chorionic gonadotropin (hCG), through control of estrogen and progesterone production, and also, by extension, prolactin and growth hormone production, are essential.
- Growth hormone (GH) is structurally very similar to prolactin and independently contributes to its galactopoiesis.
- Adrenocorticotropic hormone (ACTH) and glucocorticoids such as cortisol have an important lactation inducing function in several animal species, including humans. Glucocorticoids play a complex regulating role in the maintenance of tight junctions.
- Thyroid-stimulating hormone (TSH) and thyrotropin-releasing hormone (TRH) are very important galactopoietic hormones whose levels are naturally increased during pregnancy.
- Oxytocin contracts the smooth muscle of the uterus during and after birth. After birth, oxytocin contracts the smooth muscle layer of band-like cells surrounding the alveoli to squeeze the newly produced milk into the duct system. Oxytocin is necessary for the *milk ejection reflex*, or *let-down*, in response to suckling, to occur.

At birth, prolactin levels remain high, while the delivery of the placenta results in a sudden drop in progesterone, estrogen, and HPL levels. This abrupt withdrawal of progesterone in the presence of high prolactin levels stimulates the copious milk production of *Secretory Activation*.

Other hormones—notably insulin, thyroxine, and cortisol—are also involved, but their roles are not yet well understood. Although biochemical markers indicate that Secretory Activation begins about 30–40 hours after birth, mothers do not typically begin feeling increased breast fullness (the sensation of milk "coming in the breast") until 50–73 hours (2–3 days) after birth.

❖ CHANGES IN THE COMPOSITION OF BREAST MILK

In the final weeks of pregnancy, the alveoli swell with **colostrum**, a thick, yellowish substance that is high in protein but contains less fat and glucose than mature breast milk . Before childbirth, some women experience leakage of colostrum from the nipples. In contrast, mature breast milk does not leak during pregnancy and is not secreted until several days after childbirth.

*Cow's milk should never be given to an infant. Its composition is not suitable and its proteins are difficult for the infant to digest.

Compositions of Human Colostrum, Mature Breast Milk, and Cow's Milk (g/L)

	Human colostrum	Human breast milk	Cow's milk*
Total protein	23	11	31
Fat	30	45	38
Lactose	57	71	47
Calcium	0.5	0.3	1.4
Phosphorus	0.16	0.14	0.90
Sodium	0.50	0.15	0.41

Colostrum is secreted during the first 48–72 hours postpartum. Only a small volume of colostrum is produced—approximately 3 ounces in a 24-hour period—but it is sufficient for the newborn in the first few days of life. Colostrum is rich with immunoglobulins, which confer gastrointestinal, and also likely systemic, immunity as the newborn adjusts to a nonsterile environment.

After about the third postpartum day, the mother secretes transitional milk that represents an intermediate between mature milk and colostrum. This is followed by mature milk from approximately postpartum day 10. Cow's milk is not a substitute for breast milk. It contains less lactose, less fat, and more protein and minerals. Moreover, the proteins in cow's milk are difficult for an infant's immature digestive system to metabolize and absorb.

The first few weeks of breastfeeding may involve leakage, soreness, and periods of milk engorgement as the relationship between milk supply and infant demand becomes established. Once this period is complete, the mother will produce approximately 1.5 liters of milk per day for a single infant, and more if she has twins or triplets. As the infant goes through growth spurts, the milk supply constantly adjusts to accommodate changes in demand. A woman can continue to lactate for years, but once breastfeeding is stopped for approximately 1 week, any remaining milk will be reabsorbed; in most cases, no more will be produced, even if suckling or pumping is resumed.

Mature milk changes from the beginning to the end of a feeding. The early milk, called **foremilk**, is watery, translucent, and rich in lactose and protein. Its purpose is to quench the infant's thirst. **Hindmilk** is delivered toward the end of a feeding. It is opaque, creamy, and rich in fat, and serves to satisfy the infant's appetite.

colostrum
thick, yellowish substance secreted from a mother's breasts in the first postpartum days; rich in immunoglobulins
foremilk
watery, translucent breast milk that is secreted first during a feeding and is rich in lactose and protein; quenches the infant's thirst
hindmilk
opaque, creamy breast milk delivered toward the end of a feeding; rich in fat; satisfies the infant's appetite
lactation
process by which milk is synthesized and secreted from the mammary glands of the postpartum female breast in response to sucking at the nipple
let-down reflex
release of milk from the alveoli triggered by infant suckling
prolactin
pituitary hormone that establishes and maintains the supply of breast milk; also important for the mobilization of maternal micronutrients for breast milk

Review Questions

1. Alveoli are connected to the lactiferous sinuses by ________.

A. lactocytes
B. lactiferous ducts
C. nipple pores
D. lobules

2. How is colostrum most important to a newborn?

A. It helps boost the newborn's immune system.
B. It provides much needed fat.
C. It satisfies the newborn's thirst.
D. It satisfies the infant's appetite.

3. Mature breast milk ________.

A. has more sodium than cow's milk
B. has more calcium than cow's milk
C. has more protein than cow's milk
D. has more fat than cow's milk

Answers for Review Questions

1. B
2. A
3. D

Galactagogue

A galactagogue or galactogogue (pronounced gah-lak´tah-gog) is a substance that promotes that can help a breastfeeding mother to increase her breast milk supply. The word itself is a combination of the Greek terms "galact-" meaning milk, and "-ogogue" meaning leading to or promoting. It may be synthetic, plant-derived, or endogenous. They may be used to treat low milk supply. Herbs are commonly used to boost low milk supply, but certain actions, foods, and medications can help a breastfeeding mom make more breast milk as well.

Foods that increase breast milk and promote lactation are sometimes called lactogenic foods. Here are some of the foods breastfeeding moms use as galactagogues:

- Oatmeal
- Barley
- Green leafy vegetables
- Brewer's yeast
- Almonds
- Brown rice

Herbs

Many plants and spices are used as galactagogues, these breastfeeding herbs include:[2]

- Fenugreek
- Alfalfa
- Fennel

- Ginger
- Garlic

The advantages of colostrum

For the first 2-4 days of your baby's life, your breasts will secrete colostrum, a yellowish fluid rich in proteins.

- These valuable proteins are essential to the development of a healthy immune system.
- The protein is easily digested and absorbed by the body, especially by the rapidly developing brain.
- Colostrum provides factors that promote maturation of the gut and good digestion.
- Colostrum is the most superior and well-designed nutrition for your baby in the first few days of life.

Breast milk is nutritionally superior to formula

- Human milk contains both saturated and unsaturated fats, as well as cholesterol, an important constituent of brain and nerve tissue.
- The fat in breast milk is more digestible than that in formula.
- The energy breast milk provides is more efficiently utilised, than the energy provided by formula.
- Breast milk contains a full range of vitamins and minerals in an easily digestible combination.
- Special immune system protective proteins are present in breast milk. These proteins offer protection against diarrhoea, food allergies
- and infections. The immunoprotective components of human milk include:
- Lactoferrin : binds to iron, thus rendering it unavailable to viruses and bacteria.
- Lysozymes and milk leucocytes: destroy viruses and bacteria
- Secretory IgA: immunoglobulin that destroys viruses and bacteria
- Bifidus factor**:** promotes the growth of beneficial bacteria in the gut and limits the growth of disease-causing bacteria.

Advantages of breastfeeding for the baby

- Superior nutrition
- There is an increased resistance to infections, and therefore fewer incidents of illness and hospitalisation
- Decreased risk of allergies and lactose intolerance
- Breast milk is sterile
- Baby experiences less nappy rash and thrush
- Baby is less likely to develop allergies
- Baby experiences fewer stomach upsets and constipation
- Breastfed infants tend to have fewer cavities
- Breastfeeding promotes the proper development of baby's jaw and teeth.
- Breastfed infants tend to have higher IQs due to good brain development early in life
- Babies benefit emotionally, because they are held more
- Breastfeeding promotes mother-baby bonding
- In the long term, breastfed babies have a decreased risk of malnutrition, obesity and heart disease compared to formula fed babies.

Advantages of breastfeeding for the mother

- The baby's sucking causes a mothers uterus to contract and reduces the flow of blood after delivery
- During lactation, menstruation ceases, offering a form of contraception
- Mothers who breastfeed tend to lose weight and achieve their pre-pregnancy figure more easily than mothers who bottle feed
- Mothers who breastfeed are less likely to develop breast cancer later in life
- Breastfeeding is more economical than formula feeding
- There are less trips to the doctor and less money is spent on medications
- Breastfeeding promotes mother-baby bonding
- Hormones released during breast-feeding create feelings of warmth and calm in the mother

How to care for nipples while breastfeeding

The lactating mother may experience nipple pain in the early days of breastfeeding. **As many as 90% of new moms have some nipple soreness.** It is a very common condition that is temporary, usually going away after a few days. Most mothers find nipple soreness peaks on the fifth day of breastfeeding and then resolves.

- Nipples are definitely hard at work these days, so be sure to give them some tender loving care in between those (seemingly endless) feedings. Wash nipples with water only—no need for soap or any cleansers.
- Expose your nipples to the air after each feeding to make sure they're completely dry before you cover them up again with your nursing bra.
- Add a little dry heat from a blow dryer set to low warm to help with the drying process—something that's especially useful if you live in a humid climate.
- If you use nursing pads, change them often—not only so your nipples stay dry, but also to keep bacteria at bay.

What causes nipple pain?

Sore and painful nipples are very common for breastfeeding mothers. Here are a few causes of nipple pain, listed roughly from most common to least:

- **Tenderness from breastfeeding**. All new moms—and especially first time moms—should expect to feel some tenderness in their nipples in the first week or two of nursing. Moms whose babies suck especially vigorously may find their nipple soreness lasts longer, and these moms may even end up with cracked or bleeding nipples.
- **Latch issues**. Improper positioning or shallow latching are definitely a recipe for sore or blistered nipples. If baby isn't positioned properly, or if baby is gumming only on the nipple instead of the areola, there's a greater chance you'll end up with sore or blistered nipples.
- **Pumping equipment.** Using a too large or too small pump flange can cause sore nipples and even nipple blisters.
- **Skin dryness.** Eczema, very dry skin or contact dermatitis (from nipple creams or soaps) can lead to sore, tender, painful nipples.
- **Clogged milk duct**. Sometimes a clogged milk duct can cause blistered nipples .
- **Thrush**. A yeast infection that marks its arrival with white spots on the nipples and corresponding white patches in baby's mouth, thrush can cause sharp, burning pain during breastfeeding. Nipples may also appear red and shiny, with flaking skin.
- **Mastitis**. A potentially serious breast infection that usually begins when germs from baby's mouth enter a milk duct through a crack in your nipple, mastitis can result in severe nipple and breast soreness (as well as redness, heat, swelling and even fever).
- Wearing bras that are too tight on the nipples.

Treating nipple pain

- **Alternate sides.** Start nursing from the less tender or painful side first. Your little one will suck more energetically on the first side compared to the second side, so start her on the breast that's less tender.
- **Cool and soothe.** Chilled wet tea bags, gel pads or dressings can bring soothing comfort for sore nipples. If the pain is severe at the beginning of each feed, apply some ice to the nipple before latching baby on to help numb the area slightly.
- **Soak in salt water.** A saline rinse or soak after nursing can sometimes soothe pain and may also aid in healing.
- **Dab on breast milk.** Here's a trick from the new mama's medicine bag: Express a few drops of breast milk at the end of a feed and rub that liquid gold onto your nipples. The antibodies in your breast milk can keep your nipples healthy and speed any needed healing, bringing sweet nipple relief faster.
- **Apply a warm compress.** For pain from nipple blisters or milk blebs, soaking the area with a saline mixture and then applying warm compresses to the milk blister prior to nursing helps treat and soothe.
- **Consider a lactation consultant**