Principles of nutrition of infants and children – breast and formula feeding

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Proper nutrition in infancy is essential for

- Normal growth
- Resistance to infections
- Long-term adult health
- Optimal neurologic and cognitive development

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Breastfeeding

- Human milk should be the sole source of nutrition for the first 6 months of life
- Breastfeeding should be continued as long as desired
- Breastfeeding has short- and long-term advantages for infant neurodevelopment
- The first 2 days of breastfeeding and the first hour of life, may determine the success of breastfeeding

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Stages of breast milk

- Colostrum
- Transitional milk
- Mature milk

	Energy (kcal/100 ml)	Protein (g/100 ml)	Fat (g/100 ml)	Carbohydrate (g/100 ml)
Colostrum 1–5 days	53.6 ± 2.5	2.5 ± 0.2	2.2 ± 0.2	5.6 ± 0.6
Transition breastmilk 3 –14 days	57.7 ± 4.2	1.7 ± 0.1	3.0 ± 0.1	5.9 ± 0.4
Mature breastmilk from about 14 days	65.2 ± 1.1	1.3 ± 0.1	3.8 ± 0.1	6.7 ± 0.2

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Colostrum

- A high-density, low-volume milk, ideal for the newborn infant
- Less fat, lactose and water-soluble vitamins
- More protein, zinc and fat-soluble vitamins
- Rich in antibodies and immunoglobulins

https://upload.wikimedia.org/wikipedia/commons/e/e6/From_Colostrum_to_Breastmilk_-_4241.jpg

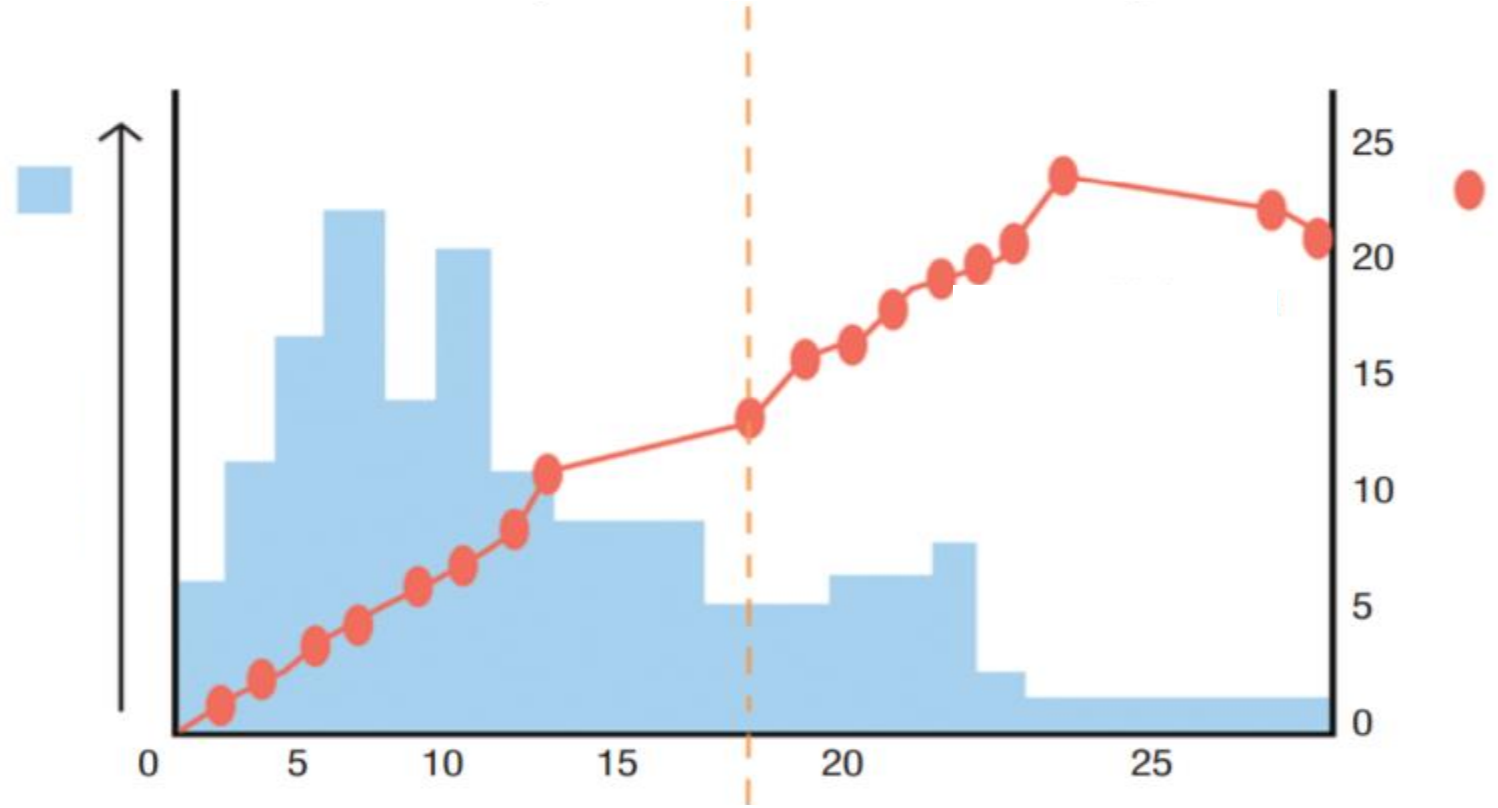
Transitional milk

- Is produced from around the 3rd day after delivery
- It is less concentrated feed than colostrum
- Higer water content

Mature milk

- Mature milk production is controlled by hormones and feedback mechanisms
- Through each feed the composition of milk changes
- At the beginning of the feeding milk has a high water content and low fat content
- As the feeding progress the fat content increases

Amount of breast milk (g)



Fat content (g/l)

Duration of feeding (minutes)

Breast milk vs. cow milk

	Breast milk	Cow milk
Energy (kcal)	68	68
Protein (g)	1	3,3
Whey protein: casein (%)	60:40	20:80
Fat (g)	3,9	3,8
Carbohydrate (g)	7,2	4,7
Ca (mg)	28	120
P (mg)	14	92
Mg (mg)	3,5	12
Na (mg)	18	48
K (mg)	52,5	157
Cl (ug)	42	102

Breast milk vs. cow milk

	Breast milk	Cow milk
Cl (ug)	42	102
Zn (ug)	120	350
Cu (ug)	25	10
Fe (ug)	40	46
Vit. A (IU)	223	100
Vit. D (IU)	2,2	2,4
Vit. E (IU)	0,23	0,09
Vit. K (mg)	0,21	0,49
Vit. B1(ug)	21	30
Vit. B2 (ug)	35	175
Vit. B6 (ug)	9,3	47

Benefits for infants

Decreases the incidence of:

- diarrhea
- respiratory illness
- otitis media
- bacteremia
- bacterial meningitis
- necrotising enterocolitis
- sudden infant death syndrome
- leukaemia
- obesity in adulthood

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Less likely to experience feeding difficulties associated with allergy (eczema) or intolerance (colic)

Breastfeeding can build a strong emotional bond between mother and baby

Benefits for mothers

- Decreased risk of postpartum hemorrhages
- More rapid uterine involution
- Longer period of amenorrhea
- Decreased postpartum depression
- Reduced risk of ovarian and breast cancer
- Decresed risk of osteoporosis

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Adequacy of milk intake

- Rate of weight gain provides the most objective indicator of adequate milk intake
- Total weight loss after birth should not exceed 7-10%
- Birth weight should be regained by 10 days
- The mean feeding frequency during the early weeks postpartum is 8-12 times per day
- Infants double in weight by age 4-6 months and triple their weight by 12 month of age
- Height reaches twice birth length by 3-4 years

Weight gain standards according to dr Ruth Lawrence

Age	Weight gain per day	PWeight gain per week
0-3 months	26-31 g	182-217 g
3-6 months	17-18 g	119-126 g
6-9 months	12-13 g	84-91 g
9-12 months	9 g	63 g

Normal growth, failure to thrive and obesity in breastfed infant. W: Lawrence R. A., Lawrence R. M.: Breastfeeding. A guide for the medical profession. Elsevier Mosby, Philadelphia, Pennsylvania, 2005: 427–460

Table 8.2 Variability of frequency and length of breastfeeds

Age of baby	Frequency of feeds	Length of feeds
First 48 hours	Infrequent and as few as 3 feeds in first 24 hours	Variable
From day 3 to 7	Increase in frequency on day 3 to up to 12 feeds in 24 hours and then slowly decreasing in frequency	Very variable, both between babies and from feed to feed
After 7 days	Variable between infants but most feed about 6–8 times in 24 hours	Still variable but each baby will begin to develop an individual pattern over a 24–hour period

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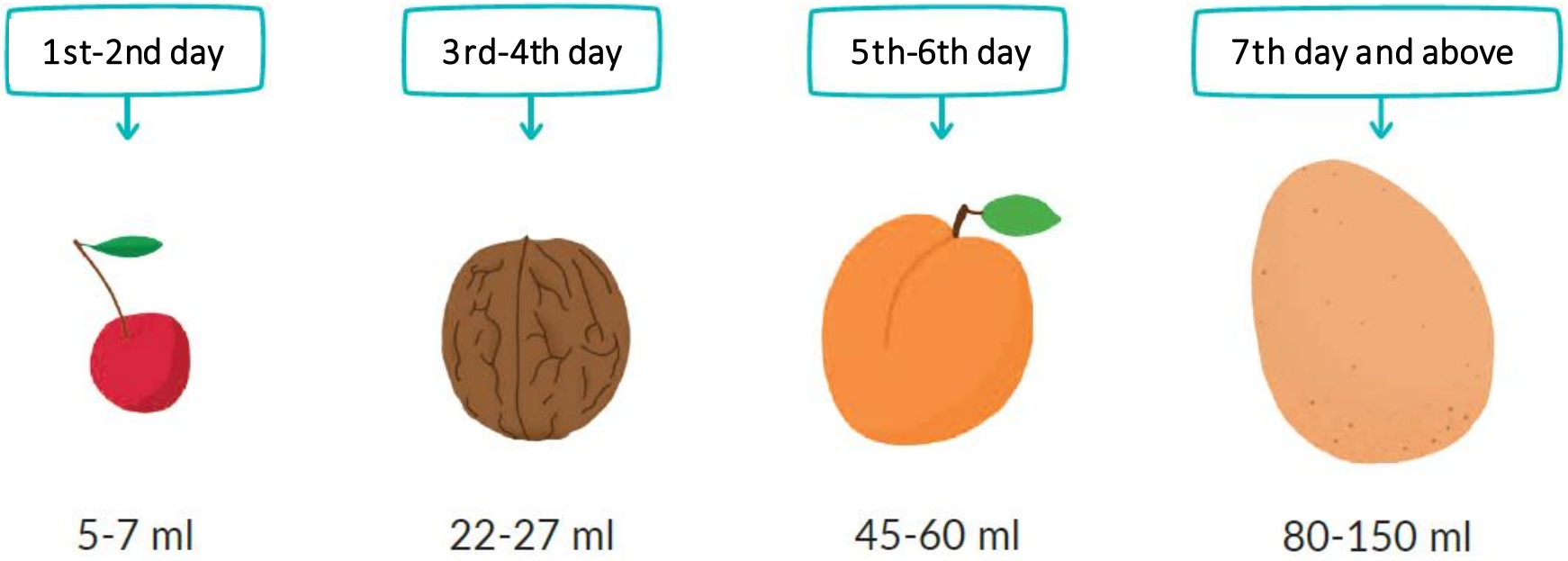
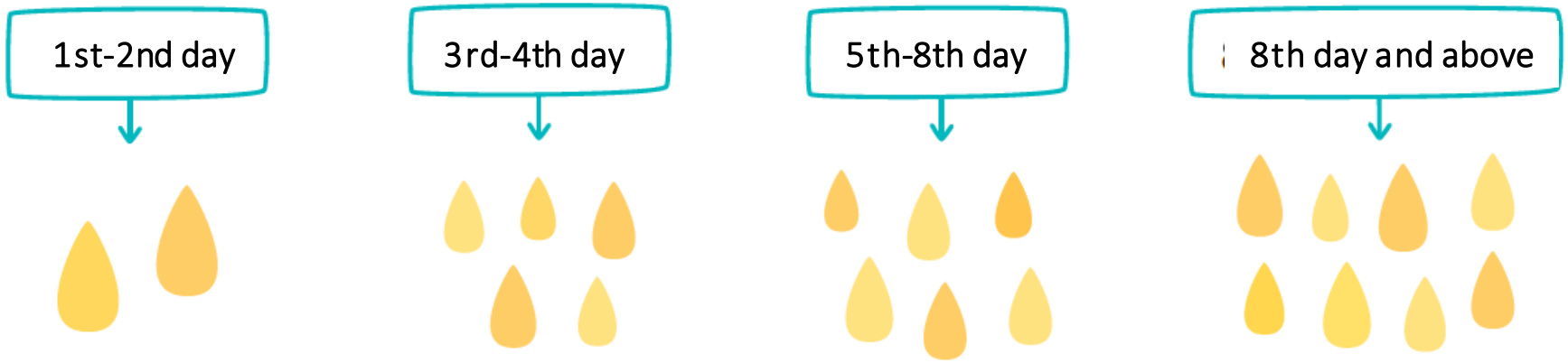
The size of the stomach



Kołacz-Kordzińska Z. Początki karmienia piersią. Jak dobrze zacząć? Gdańsk: Urząd Marszałkowski Województwa Pomorskiego, 2018.

Number of wet diapers



1-2 slightly wet diapers

3-5 wet diapers

4-6 wet diapers

6-8 wet diapers

Kołacz-Kordzińska Z. Początki karmienia piersią. Jak dobrze zacząć? Gdańsk: Urząd Marszałkowski Województwa Pomorskiego, 2018.

Number of stools passed

1st-2nd day

Meconium stools are the thick, sticky, black or greenish-black bowel movements

3rd-4th day

Transitional stools are the loose, yellow-green watery stools

from 5th day

Baby may pass a stool after each feeding

Kołacz-Kordzińska Z. Początki karmienia piersią. Jak dobrze zacząć? Gdańsk: Urząd Marszałkowski Województwa Pomorskiego, 2018.

Infant contraindications for breastfeeding

- Galactosemia
- Congenital lactase deficiency

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Maternal contraindications for breastfeeding

- Tuberculosis
- Brucellosis
- Human immunodeficiency virus
- T-cell lymphotropic virus type I or type II
- Ebola virus
- Use of phencyclidine (PCP), cocaine, or amphetamines
- Alcohol addiction
- Taking certain medications
- Radiopharmaceutical agents

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Type of milk formula

Infant formula

Food used by infants during the first months of life and satisfying by themselves the nutritional requirements of such infants until the introduction of appropriate complementary feeding

Follow-on formula

Food used by infants when appropriate complementary feeding is introduced and constituting the principal liquid element in a progressively diversified diet of such infants

Growing-up milk (toddler milk)

- Suitable from 1 year
- Growing-up and toddler milks are marketed as an alternative to whole cows' milk for toddlers and children over 1 year old
- There is no evidence to suggest that these products provide extra nutritional benefits for young children

Composition of milk formula recommended by EFSA

	Infant formula /100 kcal	Follow-on formula /100 kcal
Vitamins		
Vit. A (µg)	70-114	
Vit. D (µg)	2-2,5	2-3
Vit. B_{12} (µg)	0,1-0,5	
Vit. C (mg)	4-30	
Vit. E (mg)	0,6-2,5	0,6-5
Vit. K (µg)	1-25	
Vit. B1 (µg)	40-300	
Vit. B2 (µg)	60-400	
Vit. PP (µg)	400-1500	
Vit. B6 (µg)	20-175	
Folic acid (µg)	15-47,6	
Vit. H (µg)	1-7,5	
Vit. B5 (mg)	0,4-2	

	Infant formula /100 kcal	Follow-on formula /100 kcal
Energy kJ (kcal)/100 ml	250 (60)-295 (70)	
Macronutrients		
Protein (g)	1,8-2,5	1,6-2,5
Carbohydrate (g) Lactose (g)	9-14 > 4,5	
Fat (g)	4,4-6,0	
LA (mg)	500 - 1200	
DHA (mg)	20-50	
ALA (mg)	50-100	

Commission Directive 2006/141/EC of 22 December 2006 on infant formulae and follow-on formulae and amending Directive 1999/21/EC.

Composition of milk formula recommended by EFSA

	Infant formula /100 kcal	Follow-on formula /100 kcal
Minerals		
Ca (mg)	50-140	
Cl (mg)	60-160	
Cu (µg)	60-100	
F (µg)	≤ 100	
Fe (mg)	0,3-1,3	0,6-2
J (µg)	15-29	
Mg (mg)	5-15	
Mn (µg)	1-100	

	Infant formula /100 kcal	Follow-on formula /100 kcal
Minerals		
P (mg)	25-90	
K (mg)	80-160	
Se (µg)	3-8,6	
Na (µg)	25-60	
Zn (µg)	0,5-1	
Mo (µg)	≤ 14	

Commission Directive 2006/141/EC of 22 December 2006 on infant formulae and follow-on formulae and amending Directive 1999/21/EC.

Additional ingredients that may be added to milk formula

- Nucleotides
- Probiotics
- GOS/FOS

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Goats' milk formula

- They are produced to the same nutritional standards as cow's milk-based formula
- Goats' milk formula is not less likely to cause allergies than cows' milk formula
- Goats' milk formulas are not suitable for infants with cows' milk allergy

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Soya formula

- Lactose-free formula
- Recommended for use in lactose intolerance and galactosemia
- It is occasionally used as an alternative to cows' milk
- There are some concerns about the fact that soya contains phytoestrogens

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Hypoallergenic formula

- If infant is diagnosed as being allergic to cows' milk, formula with fully hydrolysed (broken down) proteins should be prescribed (protein sources: casein, whey protein, hydrolysed rice protein)
- Formula with partially hydrolysed proteins is recommended for infants from the risk of allergies

Elemental formula

- For infants who are still symptomatic after trying hypoallergenic formula
- Th formula is made from pure amino acids that require minimal digestion and do not contain allergenic/ inflammatory properties

Other types of formula milk

- Anti-reflux formula
- Comfort formula
- Lactose-free formula
- Good night formula
- Hungrier baby formula
- Preterm infant formula

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Form of milk formula

- Powdered formula - is the least expensive; each scoop of powdered formula must be mixed with water
- Concentrated liquid formula - must be mixed with water
- Ready-to-use formula - the most convenient type of infant formula; it does not need to be mixed with water; the most expensive option

Complementary foods

- Complementary foods (solids and liquids other than breast milk or infant formula) should not be introduced before 4 months (17 weeks) but should not be delayed beyond 6 months (26 weeks)
- By this age, an exclusively breast fed infant requires additional sources of several nutrients, including protein, iron, and zinc
- Parents should gradually introduce one food at a time, and they should wait 2-3 days before introducing a new one and watch for signs of an allergic reaction

Foods to offer

- All cooked vegetables
- All soft or cooked fruits
- All cereal foods
- Well-cooked lean meat, poultry, fish and eggs
- Lentils, hummus, chick peas and other
- Pulses, nut butters
- Plain yogurt or fromage frais

Table 9.3 Appropriate items from each food group

Food groups	Appropriate foods to introduce
1: Bread, rice, potatoes, pasta and other starchy foods	Potato, toast crusts, rice, couscous, pasta, quinoa, porridge and other breakfast cereals
2: Fruit and vegetables	Soft ripe fruits, cooked harder fruits, cooked vegetables
3: Milk, cheese and yogurt	Yogurt, cheese, unsweetened custard and milk puddings
4: Meat, fish, eggs, nut butters and pulses	Well-cooked and soft textured meat, fish, eggs, pulses (peas, beans and lentils) and nut butters or pastes of finely ground nuts

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Table 9.6 Foods to limit and avoid

Foods	Reason
Foods to limit	
Foods with added sugar	They provide excess calories with fewer nutrientsInfants are born with a preference for sweet foods and complementary feeding is a time for learning to like the other savoury other tastesIn homemade puddings and cooked fruit a small amount may be added if necessary to reduce the tart flavour of very sharp fruits
Foods with added salt such as adult ready meals and commercial sauces, soups and packet snacks	An excess of salt could cause dehydration if an infant becomes ill. However, nutritious foods that are preserved with salt, such as bread and cheese, do not need to be limited as infants need a certain amount of sodium to grow. See Chapter 2, page xx
Liver	Should be limited to 1 small serving per week because of the very high levels of vitamin A
Foods to avoid	
Unpasteurised Honey	It carries a small risk of botulism
Under-cooked meat, fish and shellfishUnpasteurised soft cheeses	Likely to cause gastroenteritis
Under-cooked or foods containing raw eggs unless they contain carry the British Lion Mark	Only partially cooked eggs with a British Lion Mark are safe (Figure 9.1)
Large fish such as marlin, swordfish and shark	May contain mercury
Whole nuts	A choking hazard and nuts can cause severe reactions if inhaled

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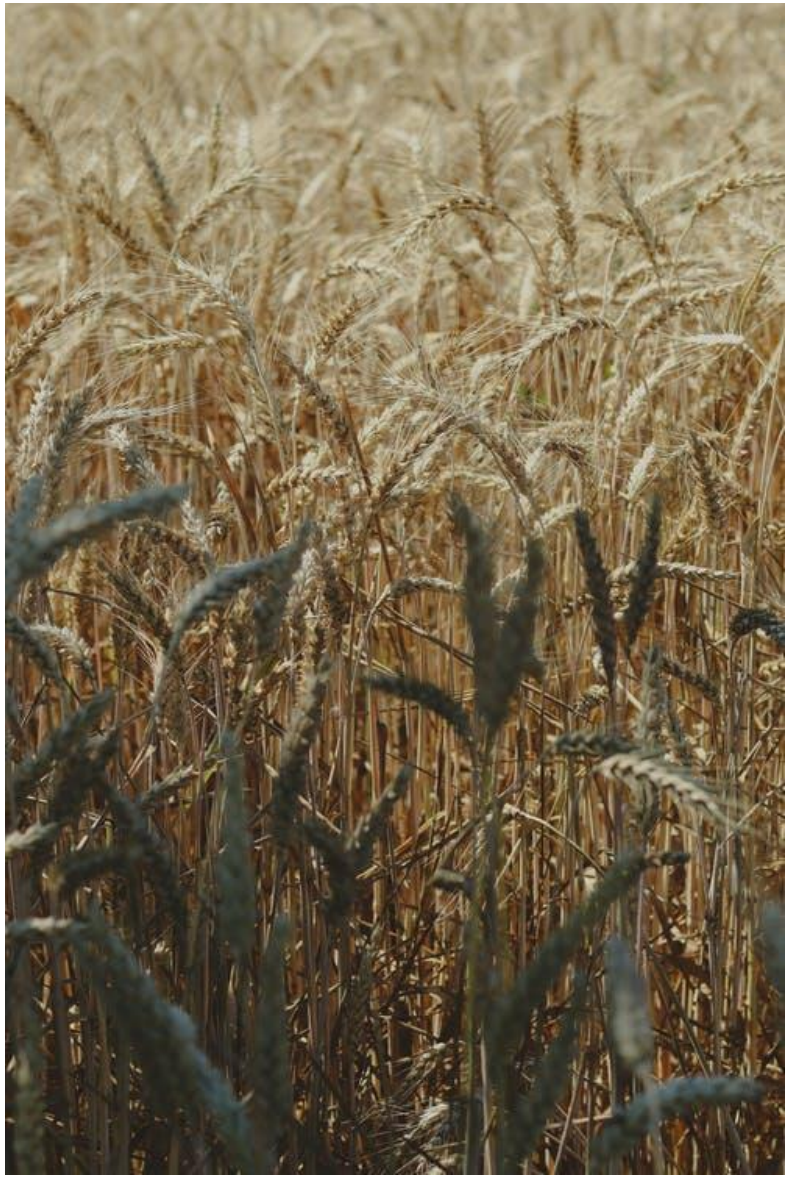
Cereals

- Cereals are commonly introduced around 6 months of age
- By tradition solid cereals are usually introduced first
- There is no evidence that a particular order is better than others for the infants
- Single-grain iron-fortified cereals (rice, oatmeal, barley) are recommended as starting cereals

Gluten

- Gluten may be introduced into the infant's diet anytime between 4 and 12 months of age



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Foods with high allergic potential

- The avoidance of foods with high allergic potential in infancy (e.g., fish, tree nuts, peanuts, dairy products, and eggs) is not recommended
- Early introduction may actually help to prevent food allergies

Water

- Healthy infants do not need extra water
- Breast milk and formula provide all the fluids needed
- With the introduction of solid foods, water should be added to the infant’s diet

Milk

- It should not be used as the main drink before 12 months of age
- Children over 12 months should not intake more than 500 ml/d of cow's milk
- Medium-fat (2%) or whole milk is recommended until 2 years or age, after which low-fat milk is recommended
- Excessive milk intake should be avoided because may result in iron deficiency anemia

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Juices

- Should be started only after 12 months of age, given in a cup (as opposed to a bottle), and limited to 125 ml per daily of 100% natural juice, and it should be unsweetened
- Juices should also be offered only with meals or snacks
- Too much juice may cause diarrhea, and weight gain
- An infant should never be put to sleep with a bottle or sippy cup filled with milk, formula, or juice because this can result in early childhood

Honey

- Honey (risk of infant botulism) should not be given before 1 year of age

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Salt and sugar

- Salt and sugar should not be added to complementary foods
- The intake of free sugars should be minimised
- Sugar sweetened beverages should be avoided

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Fennel

- Fennel tea is sometimes used as a treatment for infant colic and digestive symptoms
- Fennel contains estragole, which is a naturally occurring genotoxic carcinogen
- Fennel oil and fennel tea are not recommended in children younger than 4 years of age due to the lack of adequate safety data

Rice drinks

- To reduce exposure to inorganic arsenic, which is considered a first-level carcinogen, rice drinks should not be used for infants and young children

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Home-made vs. commercial complementary foods

- Complementary foods can be home-prepared or commercially produced
- Well-prepared home-made foods may offer the opportunity for a greater variety of culturally appropriate flavours and textures, with greater energy density
- Food preparation and cooking methods may alter nutrient content
- There is, also the potential for homemade foods to be unsuitable, e.g., with the addition of sugar or salt

Vegetarian and vegan diet

- Particular care is required to ensure an adequate nutrient intake when vegetarian or vegan diets are used
- A vegan diet may meet nutrient requirements
- Vegan diets with appropriate supplements may support normal growth and development
- If a parent chooses to wean an infant onto a vegan diet this should be done under regular medical and expert dietetic supervision
- Careful attention is required to provide the infant with sufficient vitamin B12 and vitamin D, and iron, zinc, folate, n-3 fatty acids (especially DHA), protein, and calcium, and to ensure adequate energy density of the diet

Summary of infant feeding guidelines[1]

Age range	Feed	Solids	Consistency	Feeding method
Birth to 6 months	Exclusive breastfeeding	• If started before 6 months, puréed fruit and vegetables. No added sugar or salt • Solids not to be introduced before 17 weeks	Smooth purée	Spoon feed
Around 6 months	Continue breastfeeding If formula feeding, use follow-on formula	• No added salt or sugar • No honey Include:	Thicker consistency with some lumps; soft finger foods	Encourage self-feeding Introduce a free-flow beaker for fluids
9–12 months	Continue breastfeeding If formula feeding, use follow-on formula	• Fruit, vegetables • Meat, fish, poultry, pulses, beans, eggs	Mashed, chopped or minced food; soft finger foods	Continue to develop self-feeding skills and use of free-flowing beaker
12 months and older	Continue breastfeeding If formula feeding, use follow-on formula Cow's milk may be introduced as a drink at 12 months	• Rice pasta, potatoes, bread, cereals • Cheese, yoghurt	Mashed, chopped or minced family foods; finger foods	Stop bottle feeding; use free-flow beaker for fluids

Bartleman J. Infatn aand child nutrition. Medicine. 2019;47(3): 195-198.

Nutrition of toddlers and older children

- The first 1,000 days of life are an important time to engage in healthy nutrition behaviors that will promote wellbeing
- Accelerated postnatal growth in infants and young children is an important risk factor for obesity

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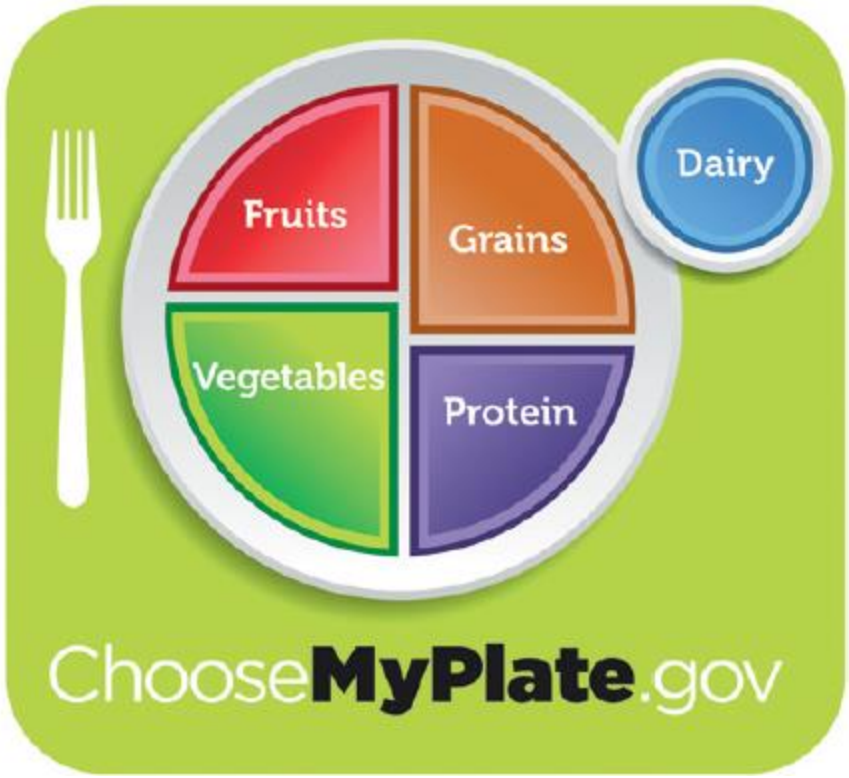
General recommendation

- Child should eat three meals a day and two healthy snacks
- Child should be eating meals with the family
- The parent's role is to decide the what, when, and where of the meals
- The child's role is to decide if, what, and how much to eat



Vegetables and fruits

- Encourage the child to eat a variety of fresh, cooked, frozen, or dried vegetables and fruits—rather than juice
- Aim to provide a variety of vegetables and fruits, including dark green, red, and orange, beans and peas, starchy and others
- When selecting canned or frozen vegetables, look for options lower in sodium
- Look for canned fruit that says it is light or packed in its own juice, meaning it is low in added sugar
- Keep in mind that one-half cup of dried fruit counts as one cup-equivalent of fruit

Grains

- Choose whole grains, such as whole-wheat bread, oatmeal, quinoa, or brown or wild rice
- Limit refined grains

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Dairy

- Encourage the child to eat and drink fat-free or low-fat dairy products, such as milk, yogurt, cheese, or fortified soy beverages

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Protein

Recommended sources:

- Seafood
- Fish
- Lean meat
- Poultry
- Eggs
- Beans, peas and soy products
- Nuts and seeds

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Fats

- Saturated fatty acids (SFA) should be limited
- SFA mainly come from animal sources of food, such as red meat, poultry, and full-fat dairy products
- Consume unsaturated fats
- Healthier fats are naturally present in oils, olives, nuts, seeds, avocados, fishes and seafood
- Limit trans-fats by avoiding foods that contain partially hydrogenated oil

Added sugar

- Limit added sugars
- Naturally occurring sugars, such as those in fruit, veggies, grains, meat, and milk, are not added sugars
- Examples of added sugars include serving sugar, brown sugar, corn sweetener, corn syrup, honey, and others

Salt

- High salt intake increased risk for heart diseases
- Recommended salt intake for children varies from 1,900-2,300 mg a day, depending on age
- Sodium-heavy breads, pizza, cold cuts, processed snacks, and soups should be avoided

Nutrition of adolescents

- Poor eating habits may develop during adolescence
- Skipped meals, binge eating with friends or alone, dieting, and consumption of nutrient-poor, calorically dense foods are common problems
- Excessive consumption of sugar from soda and fruit drinks may contribute to excess weight gain
- Poor calcium intake during adolescence may predispose the adult to future osteoporotic hip fracture
- Good calcium sources include milk, yogurt, fortified orange juice, cheese, soybeans, and tofu
- Inadequate iron intake may result in symptoms of fatigue and iron deficiency anemia
- Iron needs increase during growth spurts
- Teenage girls are especially prone to anemia from menstrual blood loss

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