Cracking the Egg Potential During Pregnancy and Lactation

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Key messages

- This paper sets forth a nutritional rationale why eggs, and interventions to provide more eggs to at-risk pregnant and lactating women, in addition to iron and folic acid supplements, may be a sensible strategy to reduce neonatal deaths and stunting.
- Eggs provide a balanced source of energy and protein as well as essential fatty acids and a large range of vitamins, minerals, and other bioactive compounds that could likely improve nutrition during pregnancy and birth outcomes.
- Eggs have great potential to improve nutrition among vulnerable populations living in resource-poor settings. Eggs are also likely to be especially important in vegetarian populations.
- Maternal consumption of eggs during lactation can also enhance the breast milk content of certain nutrients and thus potentially contribute to child nutrition and development when children are breastfed. Nevertheless, egg consumption is relatively low among women of reproductive age.
- Chicken production and egg consumption may be a locally available and feasible option to improve maternal diets during pregnancy and lactation.

The value of a simple egg

It should not be surprising that a simple egg, which provides a chicken embryo nutritive support from conception to the time it hatches, might also be an important food to support fetal growth and development during pregnancy. Eggs have great potential to improve nutrition among vulnerable populations living in resource-poor settings.[1] They provide a nearly complete source of protein and are also an important source of essential fatty acids, choline, vitamins A and B_{12}, selenium, and other critical nutrients. At the same time, compared to other animal-source foods, they cost less and are available and valued as a food in virtually all parts of the world.

A woman's nutrition before and during pregnancy is essential to ensure optimal fetal growth and development as well as for her own health and wellbeing. The 2013 Lancet Series on Maternal and Child Nutrition provided evidence that poor maternal nutrition is the cause of more than 200,000 neonatal deaths and 20% of stunting in children less than five years of age.[2] It also identified balanced energy protein supplements and supplements of calcium and multiple micronutrients as promising interventions to reduce intrauterine growth restriction and small-for-gestational-age births.[3] In this paper, we set forth a nutritional rationale why eggs, and interventions to provide more eggs to at-risk pregnant and lactating women, in addition to iron and folic acid supplements, may be a sensible strategy to reduce neonatal deaths and stunting.

The contribution of eggs to nutrient requirements during pregnancy and lactation

Eggs provide a balanced source of energy and protein as well as essential fatty acids and a large range of vitamins, minerals, and other bioactive compounds that could likely improve nutrition

Chickens in the Cotopaxi Province, Ecuador

during pregnancy and birth outcomes. The recommended levels of nutrient intake for pregnant and lactating women, the nutrient content of a 50 g egg, and the proportion of the required intake met by consuming two 50 g eggs are presented in **Table 1**. The proportion of dietary requirements for pregnant and lactating women provided by eggs is summarized by categories in **Table 2**. During pregnancy and lactation, two 50 g eggs provide more than 25% of the nutrient requirement of riboflavin (vitamin B_2), cobalamin (vitamin B_{12}), phosphorus, selenium and choline.

Yet, egg consumption is relatively low among women of reproductive age. Round V of the Demographic and Health Surveys conducted between 2005 and 2010 collected dietary information from women of reproductive age (**Table 3**). Egg consumption the day prior to the survey ranged from 2.9% in India to 62.5% in Honduras and was lower in African countries compared to those in Latin America and the Caribbean with the exception of Haiti, where consumption was also very low.[4]

Fetal cells grow in size and number at a rapid rate, requiring a steady and increasing pool of nutrients, such as protein. Pregnant women also have their own protein needs.[5] An ideal food during pregnancy is one with a high digestible indispensable amino acid score (DIAAS).[6] Eggs, similar to other animal-source foods, are classified as one of the highest quality proteins, using the new DIAAS indicator.

While protein deposition in maternal and fetal tissues increases throughout pregnancy, most occurs during the third trimester. The current Estimated Average Requirement (EAR) and Recommended Daily Allowance (RDA) recommendation is for all stages of pregnancy and does not take into account the changing needs during its different trimesters. A recent study suggested that protein requirements are substantially higher than current recommendations at about 14%–18% of total energy.[5] When the protein intake is balanced at < 25% of energy, a reduced risk of low birth weight has been observed. However, excess protein may also be harmful. One study found that high protein diets in low-income New York City women were associated with greater risk of small-for-gestational-age infants when the protein intake was > 34% of calories.[7] Two eggs per day would provide ~70 kcal from protein, which would not put a woman in excess of 34% of her caloric intake from protein.

The nutritional value of an egg, however, goes beyond high-quality protein. It is also an important source of fatty acids, which vary in accordance with hen species and the diet they receive. Moreover, chicken feed can be enhanced with docosahexaenoic acid (DHA), which in turn enhances the content in eggs.[8] Essential fatty acids and DHA in particular are critical for early brain development.[9] Studies have shown that cholesterol, relatively high in eggs, does not increase the risk of heart dis-

TABLE 1: Recommended levels of nutrient intake (RDA or AI) for pregnant and lactating women, nutrient content of eggs, and the proportion of dietary intake provided by eggs[38,39]

Nutrients	Unit	AI/RDA Pregnancy (19–50 y)	AI/RDA Lactation (19–50 y)	Large Egg (50g)	Egg per 100g	% of pregnancy AI/RDA provided by 2 large eggs	% of lactation AI/RDA provided by 2 large eggs
Energy	kcal	–	–	72	144	–	–
Protein	g	71	71	6.28	12.56	17.7	17.7
Lipids (total)	g	ND	ND	4.76	9.51	–	–
Linoleic Acid (18:2n-6)*	g	13.0	13	0.77	1.54	11.8	11.8
α-Linolenic Acid (18:3n-3)	g	1.3	1.3	0.02	0.04	2.9	3.1
DHA (22:6n-3)	g	–	–	0.03	0.06	–	–
Vitamins							
Vitamin A, RAE	µg	770	1300	80	160	20.8	12.3
Thiamin (B_1)	mg	1.4	1.4	0.02	0.04	2.8	2.8
Riboflavin (B_2)	mg	1.4	1.6	0.23	0.46	32.6	28.5
Niacin (B_3)	mg	18	17	0.04	0.08	0.4	0.24
Pantothenic acid (B_5)*	mg	6	7	0.77	1.53	25.7	22.0
Pryridoxin (Vitamin B_6)	mg	1.9	2.0	0.09	0.17	8.9	8.5
Cobalamin (Vitamin B_{12})	µg	2.6	2.8	0.44	0.89	33.8	31.4
Folate, DFE	µg	600	500	24	47	8.0	9.6
Choline*	mg	450	550	146.9	293.8	65.3	53.4
Vitamin C (ascorbic acid)	mg	85	120	0	0	0	0
Vitamin D (D_2+D_3)	µg	15	15	1	2	13.3	13.3
Vitamin E (α-tocopherol)	mg	15	19	0.52	1.05	6.9	5.5
Vitamin K	µg	90	90	0.2	0.3	0	0
Minerals							
Calcium*	mg	1000	1000	28	56	5.6	5.6
Copper	mg	1.0	1.3	0.04	0.07	8.0	6.2
Iodine	µg	220	290	0	0	0	0
Iron	mg	27	9	0.88	1.75	6.5	19.6
Magnesium	mg	350	310	6	12	3.4	3.9
Manganese*	mg	2.0	2.6	0.01	0.03	1.4	1.1
Phosphorus	mg	700	700	99	198	28.3	28.3
Potassium*	mg	4700	5100	69	138	2.9	2.7
Selenium	µg	60	70	15.4	30.7	51.3	44.0
Sodium	mg	–	–	71	142	–	–
Zinc	mg	11	12	0.64	1.29	11.6	10.7

Adequate Intakes (AIs) are denoted with an *; otherwise values are Recommended Dietary Allowances (RDAs).

ease and stroke.[10] In fact, one study suggested that low serum cholesterol during pregnancy is associated with adverse birth outcomes.[11] Eggs are also relatively low in saturated fat, with only about 1.5 g per egg.

Eggs are an important source of choline, an important precursor of phospholipids, which are needed for cell division, growth and membrane signaling.[12,13] Inadequate intake during pregnancy has been associated with neural tube defects,[14] changes in brain structure and function in the offspring,[15] and adverse pregnancy outcomes.[16] Through its role as a methyl donor, choline may also have epigenetic effects during pregnancy.[17] Although choline is found in a number of plant-based and animal-source foods, none surpasses eggs with respect to choline per kilocalorie. More than 50% of the nutrient requirement for pregnant and lactating women is provided by two 50 g eggs (**Table 1**).

Eggs are also a good source of bioavailable vitamin A and carotenoids, vitamins E, D, and B_{12} and folate. The relative contribution of vitamin B_{12} may be particularly relevant in Latin America and the Caribbean, as deficiency continues to be a problem in most locations and population groups of those regions.[18] This may be the case among the poor in other parts of the world as well. Observational studies have shown an association between eggs and reduced risk of night blindness,[19,20] as well as xerophthalmia.[21,22] Data collected between 1995 and 2005 show that 14.3% and 18.4% of pregnant women have serum retinol <0.70 µmol/L in Africa and Asia, respectively.[2] Night blindness was reported by 9.4% of pregnant women in Africa and 7.8% of women in Asia. Vitamin A supplementation in pregnancy reduces night blindness, which is also associated with increased low birth weight and infant morbidity.[23] As shown in **Table 1**, two 50 g eggs provide 21% and 12% of the vitamin A requirement for pregnant and lactating women, respectively.

Although eggs are generally low in minerals, selenium is an important exception, with two 50g eggs providing 51% of the dietary requirement for pregnant women and 44% of the daily requirement for lactating women (**Table 1**). Selenium plays important epigenetic and antioxidant roles that may be especially important during pregnancy.[24]

The potential role of eggs to enhance concentration of key nutrients in breast milk

Maternal consumption of eggs during lactation can also enhance the breast milk content of certain nutrients and thus contribute to child nutrition and potentially development when children are breastfed. The concentration of nutrients in breast milk is most affected by a mother's intake of water-soluble vitamins. It is also influenced by her intake and stores of fat-soluble vitamins, though to a lesser extent. Micronutrients have been classified into two groups, according to the effect of maternal intake and the status of the micronutrient content of breast milk.[25] In Group 1 are those affected by maternal status including thiamin, riboflavin, vitamin B_6, vitamin B_{12}, vitamin A, iodine, and selenium. More recently, choline and vitamin D have been added to this list (Lindsay Allen, personal communication). Vitamin C also is transferred through breast milk. In Group 2 are those not affected by maternal status, including folate, vitamin D, calcium, iron, copper and zinc. During lactation, low maternal intake or stores of micronutrients in Group 1 reduces the amount in breast milk, which may negatively affect a child's development.[26] Therefore, adequate intake of Group 1 micronutrients is necessary to ensure breast-milk adequacy.

In addition to water-soluble vitamins and selenium, fatty acids in breast milk are extremely sensitive to maternal consumption and body composition, with implications for infants' neurological development.[27] The transfer of n-6 (omega-6) and n-3 (omega-3) fatty acids from the maternal diet into breast milk occurs with little interconversion of 18:2n-6 to 20:4n-6 or 18:3n-3 to DHA. There is also little evidence of regulation by the mammary gland to maintain individual fatty acids constant with varying maternal fatty acid nutrition. DHA has gained attention because of its high concentrations and roles in the brain and retina. A recent study among Chinese women showed that supplementation of DHA during pregnancy increases the concentration of polyunsaturated fatty acids in breast milk.[28]

However, a recent systematic review concluded that there have not been rigorous studies between the dietary intake of

TABLE 2: Proportion of daily nutrient requirement (RDA or AI) provided by two 50 g eggs during pregnancy and lactation

Pregnancy	Lactation
0 – < 5%	**0 – < 5%**
Niacin	Niacin
Vitamin C	Vitamin C
Vitamin K	Vitamin K
Iodine	Iodine
α-Linolenic acid	α-Linolenic acid
Vitamin B_1	Vitamin B_1
Manganese	Manganese
Magnesium	Magnesium
Potassium	Potassium
≥ 5 – < 15%	**≥ 5 – < 15%**
Vitamin B_6	Vitamin B_6
Vitamin E	Vitamin E
Folate	Folate
Linoleic acid	Calcium
Vitamin D	Copper
Zinc	Linoleic acid
Calcium	Vitamin A
Copper	Vitamin D
Iron	Zinc
≥ 15 – < 25%	**≥ 15 – < 25%**
Protein	Protein
Vitamin A	Pantothenic acid
Iron	
≥ 25%	**≥ 25%**
Riboflavin	
Pantothenic Acid	Riboflavin
Vitamin B_{12}	Vitamin B_{12}
Phosphorus	Phosphorus
Selenium	Selenium
Choline	Choline

TABLE 3: Percentage of women aged 15–49 who gave birth in the last 3 years who consumed eggs in the preceding 24 hours, DHS Surveys 2007–2010[40]

World region	Year	Eggs (%)
sub-Saharan Africa		
Ethiopia	2005	3.8
Ghana	2008	21.6
Liberia	2007	19.6
Namibia	2006–07	20.5
Nigeria	2008	17.7
Sierra Leone	2008	12.1
Uganda	2006	3.6
Zambia	2007	14.0
Zimbabwe	2006–07	11.1
South/Southeast Asia		
Cambodia	2005	19.9
India	2005–06	2.9
Indonesia	2007	n.a.
Nepal	2006	6.1
Philippines	2008	39.4
Latin America and the Caribbean		
Dominican Republic	2007	47.0
Haiti	2005–06	6.9
Honduras	2006–07	62.5

single nutrients and their presence in human milk.[29] Reasons cited by the authors include the difficulties in the collection of dietary data as well as the availability of appropriate breast-milk samples. In most studies, sample size was limited, the period of dietary recall relative to the timing of the sample obtained inconsistent, and there was a lack of control of potential confounding factors. Therefore, to understand the effect of egg consumption on the composition of breast milk, studies should have clear protocols for milk storage and analysis, definition of the time lag between the diet and milk analysis, and adjustment for other factors such as energy intakes and anthropometric characteristics.

Role of eggs in vegetarian populations

Eggs are likely to be especially important in vegetarian populations. In India, with a population of approximately 1.25 billion, nearly one-third are vegetarian. The 2005–2006 India National Family Health Survey showed that low birth weight affects nearly 20% of births and is associated with low socioeconomic status.[30] As noted in **Table 3**, egg consumption among Indian women of reproductive age is extremely low.

Cultural and economic aspects of egg consumption

In some cultures, egg consumption during pregnancy may be taboo. For example, Nepali women have cited religion as a reason for not consuming eggs.[31] In contrast, in rural Zambia, only about 5% of households believed that eggs were taboo for pregnant women, while 83% said that eggs were nutritious for pregnant women and 90% held this view for lactating women.[32] Generally, these kinds of barriers may be overcome with well-informed and carefully conducted social marketing and behavior change communication strategies.[33] For example, in a recent large-scale intervention in Bangladesh, egg consumption among children 6 to 24 months of age in the intensive intervention group increased from 18% to 48% compared to 19% to 31% among children in the non-intensive group.[34]

Economic barriers appear more important than cultural ones. Data from Demographic and Health Surveys show a high correlation between egg consumption and socioeconomic status, with consumption increasing in a dose-response manner with wealth quintile (**Table 4**).[35] In rural Zambia, 43% of households reported that cost was the primary limitation to routine egg consumption.[32] Although rural households often raise chickens, they frequently sell the eggs to purchase other essential items. For example, in Zambia, before chicken survival and productivity were improved, households would sell the eggs or chickens rather than consume them.[36] However, as a result of a technical assistance project to develop community-operated, semi-intensive egg production facilities, which resulted in higher egg yields, both producer income and community consumption of eggs improved. Homestead and/or small community chicken-and-egg production in the context of inputs to increase yield and protect children from chicken feces may simultaneously address nutrition and poverty.[1]

Eggs provide convenient solutions to problems of food preparation, storage, and transport. Eggs can be purchased in a single unit or units. Furthermore they are easy to prepare, require little fuel because of quick cooking, and can be eaten alone or mixed into a variety of dishes. Hard-boiled eggs can also be easily transported for consumption elsewhere, which is particularly important for women who farm, take care of animals, go to the market or work in other activities outside the home.

Environmental concerns

Raising chickens at home may increase exposure to chicken feces and pose risks of diarrheal infections, environmental enteric disorder and respiratory infections.[37] Particularly among young children, these illnesses are risk factors for mortality and linear growth retardation. At the same time, studies show that ownership of small animals is associated with improved nutrition. Keeping young children away from chicken feces though better poultry practices can mitigate the negative effects of chicken

TABLE 4: Percentage of women aged 15–49 who gave birth in the last 3 years who consumed eggs in the preceding 24 hours by household wealth quintile, DHS Surveys 2007–2010[41]

Country	Year	Wealth quintile	Eggs (%)
Ghana	2008	Lowest	13.8
		Second	16.4
		Middle	24.5
		Fourth	26.7
		Highest	31.8
Liberia	2007	Lowest	17.7
		Second	13.1
		Middle	14.6
		Fourth	24.1
		Highest	35.4
Madagascar	2008–09	Lowest	2.6
		Second	3.7
		Middle	4.9
		Fourth	4.8
		Highest	18.1
Nigeria	2008	Lowest	11.0
		Second	12.0
		Middle	14.3
		Fourth	23.4
		Highest	31.9
Tanzania	2010	Lowest	3.1
		Second	4.4
		Middle	5.5
		Fourth	6.8
		Highest	9.4
Zambia	2007	Lowest	9.3
		Second	10.0
		Middle	10.5
		Fourth	21.6
		Highest	23.5

feces. Interventions to improve poultry production and egg consumption among pregnant and lactating women would need to put in place reasonable control measures to reduce household exposure to chicken feces.

Summary

Chickens and eggs are ubiquitous globally and well known to be highly nutritious. While there are no rigorous studies identifying health benefits to mothers and newborns or benefits to child cognition of interventions to improve consumption during pregnancy and lactation, such interventions would appear to be attractive. Chicken production and egg consumption may be a locally available and feasible option to improve maternal diets during pregnancy and lactation.

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