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The review gives an overview of the role of iodine in the body with special attention to milk and milk products as a source of iodine during pregnancy.

A publication for health professionals

DAIRY:
A source of iodine during pregnancy

Iodine is used almost exclusively as a core component of the thyroid hormones, thyroxine (T4; a pro-hormone) and 3,5,3'-triiodo-L-thyronine (T3; the active form). These hormones are necessary for physical growth and development, support the maturation of the nervous system and help to regulate energy expenditure and macronutrient metabolism. Iodine deficiency disorders (IDD) is a collective term for the many forms and effects of inadequate iodine status. This deficiency may be endemic (regularly occurring in a geographic region), genetic or sporadic. In the general population, the development of a goitre (i.e. visible swelling of the thyroid gland) is a well-known clinical sign of iodine deficiency.[1,2]

The role of iodine in pregnancy deserves special attention because of the additional effects of IDD on the foetus and neonate. The aim of this review is to outline this role, with special attention to milk and milk products. This is presented against the backdrop of iodine intake recommendations and consequences of inadequate intakes during pregnancy, and the review concludes with an outlook for the South African context.

GENERAL ROLE OF IODINE IN PREGNANCY

Iodine requirements, intake recommendations, actual intakes and iodine status of the pregnant woman

Pregnant women have highly increased iodine requirements. This is the result of higher maternal thyroxine production in order to transfer it to the unborn baby early in the first trimester of pregnancy when the thyroid of the foetus is not yet functioning. In addition, iodine as such is transferred to the foetus and there is an increased renal iodine clearance.[3]

Since iodine requirements in pregnancy have not been conclusively defined, some international dietary reference values do not contain estimated average requirements (EARs) for this stage of life. Consequently, intake recommendations vary by country or organisation and sometimes only adequate intakes (AIs) are published. Nonetheless, almost all countries recommend higher intakes during pregnancy.[2,4]

Some published iodine intake recommendations are summarised in Table 1. Usually, South Africa follows recommendations issued by the USA (Institute of Medicine) or the World Health Organization (WHO).

Table 1:
Selected daily iodine intake recommendations

		(ADEQUATE) INTAKE RECOMMENDATION (µg/d)		
		ADULT, NON-PREGNANT (>18) YEARS	PREGNANT WOMEN	LACTATING WOMEN
ORGANISATION	INSTITUTE OF MEDICINE (USA)	150	220	290
	WORLD HEALTH ORGANISATION	150	250	250

Assessing dietary iodine intake and status is challenging. A systematic review of dietary iodine intake from food sources in European countries showed that – from very limited national and subnational data – pregnant women consumed less than the recommended intake, except when taking iodine-containing supplements. The analysis did not take into account the iodine contribution from iodised salt.[4]

As only a very small fraction of iodine is excreted in the faeces, urinary iodine excretion is the most common way of estimating iodine intake (following the use of a correction factor). Sometimes a spot test is taken, yet the ideal is a 24-hour urine sample. The result is expressed as the median urinary iodine concentration (MUIC). Bath and colleagues[4] argue that, strictly speaking, this method refers to iodine *status* rather than intake, yet many publications do not make this distinction. In the South African scenario, MUIC is generally used as biomarker to assess adequacy of iodine status.[5] When the findings of different studies are compared or interpreted, both the method of assessment and the context of the study (where and when it was done) should be considered.

Table 2 shows the cut-off values recommended by the WHO when interpreting the iodine intake or status of pregnant and breastfeeding women.

Table 2:
Categorisation of iodine intakes of pregnant and lactating women, based on population MUIC* [3,6]

MEDIAN URINARY IODINE CONCENTRATION (µg/L)	IODINE INTAKE CATEGORY
PREGNANT WOMEN (ANY TRIMESTER)	
<150	Insufficient
150–249	Adequate
250–499	More than adequate
≥500	Excessive
LACTATING WOMEN	
<100	Insufficient
≥100	Adequate

Table 2 shows the broad categorisation of iodine status. Both insufficient and excessive iodine status should be avoided during pregnancy. Upper limits are seemingly not well studied[7] and range from 600 µg/L to 1100 µg/L.[4] In recent years, deficiency in the general population has been subcategorised: an MUIC of <20 µg/L in school-age children is considered indicative of a severely iodine-deficient region, whereas an MUIC of 20–99 µg/L in school-age children is seen as representing mild to moderate iodine deficiency in a region.[7] Owing to the non-availability of data specifically related to pregnant women, the data from school-age children is often used as a proxy at population level and for defining iodine status of a region.[6]

A systematic review of the situation in African countries used MUIC to describe the iodine-related situation of pregnant women on the continent.[8] In the review, national and subnational (regional) studies conducted between 2005 and 2020 revealed that pregnant women had an adequate iodine status only in a few African countries; mildly insufficient intake or severe inadequacy was observed in most countries. The pooled pregnancy MUIC was 145 µg/L (95% CI: 126–172 µg/L). Despite the implementation of salt iodisation, the iodine status of pregnant women remains suboptimal in Africa.

In South Africa specifically, some regional research has been conducted in the past decade. Mabasa and co-workers[9] found that, from data collected between 2012 and 2013 in the Mopani district in Limpopo, pregnant women had an MUIC of 145 µg/L in the first trimester and 132 µg/L in the third trimester. In addition, also based on MUIC, pregnant women who live in urban Johannesburg may be borderline iodine deficient. This was true for all three trimesters of pregnancy.[10] In the most recently published cross-sectional survey in South Africa which included 430, urban and 187 rural pregnant women, the MUIC of those residing in the urban Free State Province pointed to borderline adequate iodine status despite the widespread use of iodised salt.[11]

CONSEQUENCES OF IODINE DEFICIENCY IN PREGNANCY

The timing and severity of hypothyroxinaemia determine the consequences of iodine deficiency, with early gestation and early postnatal life seemingly most critical.[3] Thyroid hormones are required for brain development, including normal neural migration and myelin formation. It follows that attainment of adequate iodine levels before and during pregnancy is important and this also applies to breastfeeding.[1,3]

Severe iodine deficiency in pregnancy can lead to abortions or stillbirth, or congenital abnormalities, irreversible neurological (i.e. mental and sensory) defects, and myxedematous cretinism (i.e. also involving physical growth defects) in the developing foetus.[6]

A review by Pearce and co-workers showed that even mild maternal iodine deficiency and mild maternal thyroid hypofunction are associated with decreased cognition in children.[7] Furthermore, a systematic review by the Machamba team concluded that when pregnant women use iodine supplementation daily, it can contribute to better psychomotor development of children living in regions of mild to moderate iodine deficiency.[12] In Norway, where salt iodisation is not mandatory, it was found that the intake of milk and the use of iodine-containing supplements during pregnancy and in the post-partum period significantly increased the odds of having a MUIC above 100 µg/L.[13]

A meta-analysis of studies done on women with normal (euthyroid) iodine status showed that the MUIC of these pregnant women was not generally associated with the pregnancy outcomes and that the MUIC per se is an insufficient indicator for prediction of pregnancy complications.[14]

IODINE IN DAIRY AND OTHER SOURCES

Dietary iodine – mainly as inorganic iodide – can be obtained by consuming seaweed, fish and other seafood, dairy, iodised salt, eggs and dietary supplements. Although seaweed and marine foods are the most concentrated sources, they tend to be eaten in only small amounts by many communities. In a survey across European countries, milk, dairy products, fish, and eggs were found to be the important contributors to intake.[4] These findings suggest limited food sources of iodine are included in plant-based diets. However, very few of the countries that were included in the survey considered the role of iodised salt when they assessed iodine intakes.[4]

The iodine content of foods varies owing to differing amounts of iodine in soil (i.e. regional differences), seasonal differences (e.g. milk produced in summer has a lower iodine content than that produced in winter milk), farming practices (e.g. milk from organic farming contains less iodine than milk from conventional farming) and the amount of iodine in the feeds of the source animals.[2] In addition, iodine losses also occur during food processing and preparation (e.g. ultra high-temperature-treated milk has lower iodine levels). Ideally the composition should be based on chemical analysis, but in reality food composition tables are used most often.

The USDA released a Special Interest Database on iodine content of foods in 2020 to help with monitoring iodine intake (https://www.ars.usda.gov/northeast-area/beltsville-mdbhnrc/beltsville-human-nutrition-research-center/methods-andapplication-of-food-composition-laboratory/mafcl-site-pages/iodine/).

Despite this valuable database, total iodine intake is expected to be largely affected by consumption of iodised salt,[2] especially in low- and middle-income countries. In South Africa, mandatory iodisation of salt was introduced in 1995 at 40–60 parts per million (ppm).[15] Data collected between 2012 and 2013 show that the salt was adequately iodised (at 15 ppm) in only about half of households with pregnant women in the Limpopo province.[9]

Table 3 shows some information on the iodine content of selected foods. These international figures are used, as the South African food composition tables of SAFOODS (SA-MRC) do not contain values for iodine.

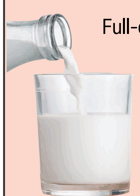
It has been claimed that most of the iodine in milk comes from indirect fortification through animal feeds and iodine-containing antiseptic use.[2] Against the backdrop of the large variability of iodine content in dairy, Brito supplemented the fodder of cows with seaweed rich in iodine and investigated the potential effect among pregnant women when they consumed the milk from those cows. The optimal dosages of fodder supplementation are still being investigated, but this research points to the potential, quantitative role of dairy in the iodine status of pregnant women.[16]

An elegant, randomised, crossover metabolic balance study among healthy adults was used to shed light on the bioavailability of iodine in cow's milk. The participants had an adequate iodine status (defined as an MUIC of 70–300 µg/L) at the start of the investigation. Results showed that although iodine absorption from milk decreased when the iodine dose it contained was increased, its bioavailability remained high.[17] This research suggests that iodine deficiency is not a prerequisite to benefit from the iodine in milk.

Ethical considerations make randomised control trials to conclusively determine the effect of iodine from dairy on pregnancy outcomes on an individual level a real challenge. Most studies are hence conducted at the population level.

Table 3:

Iodine content of sample portions of selected foods

FOOD ITEM	PORTION SIZE	IODINE CONTENT (µg/L)
Hake, baked 	90 g	158.0
Plain low-fat yoghurt 	200 g	126.0
 Full-cream milk	250 g	37.5
Egg 	1 large	26.0

Source: Association of UK Dietetics: Food Fact Sheet: Iodine. Available at: www.bda.uk.com/resource/iodine.html (accessed: 15 March 2023)

Concluding remarks and recommendations for the current South African scenario

The mandatory iodisation of salt in South Africa has the potential of universal protection against iodine deficiency on population level. However, current salt reduction policies are aimed at lowering salt intake, posing a possible threat to the national iodine status.[18] Simultaneously – and despite the fortification – there is emerging evidence of only borderline iodine adequacy in some regions.[9-11] In addition, the international trend towards more plant-based diets, known to be low in iodine, is expected to gain increasing popularity in South Africa.

Given the dire consequences of iodine deficiency and markedly higher iodine requirements during pregnancy, women in their reproductive years should ensure adequate iodine intake during pregnancy, ideally already in the months prior to conception. Optimally this should be a food-based approach that includes dairy products, because of the high bioavailability of iodine from milk.[17] In addition, milk and milk products provide many of the gap nutrients in the South African diet in general, and of the pregnant woman in particular.

Iodised salt is also a source of iodine, but salt intake should be within salt-reduction recommendations.[7] Those who avoid iodine-rich foods (e.g. vegetarians and vegans) or consume unfortified plant-based alternatives to cow's milk may be at risk of iodine deficiency. Iodine-containing supplements may be an option for them, yet high-dose iodine-containing supplements (> 150 µg/d) should be avoided. Kelp or seaweed supplements should not be used as an iodine source as they can lead to excessive intake.[1] There are some discrepancies in terms of dosages, yet practically all authorities agree that total iodine intake of women should be increased during pregnancy, typically to 250 µg per day.[6]

For South Africa a multipronged approach of well-monitored salt iodisation and intake, plus the promotion of a diverse diet that includes dairy is needed to minimise the risk of iodine deficiency among pregnant women. Dairy plays an important role in the diet of pregnant women.

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