Nutritional and Health Implications of Animal Source Foods: Nutrients and Bioactives

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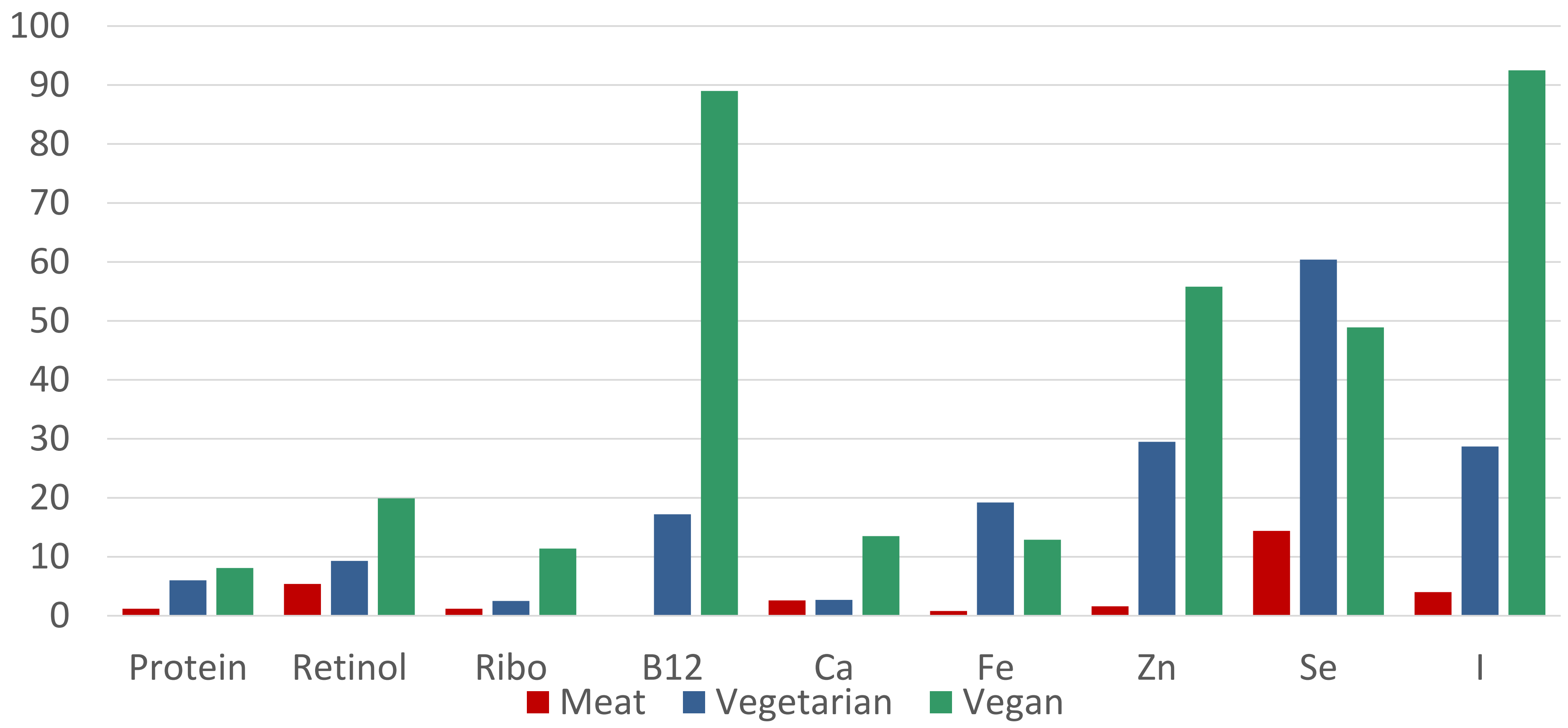
Animal source foods,
compared to plants, provide more of many nutrients: there is a cluster lacking in diets where ASF intake is low

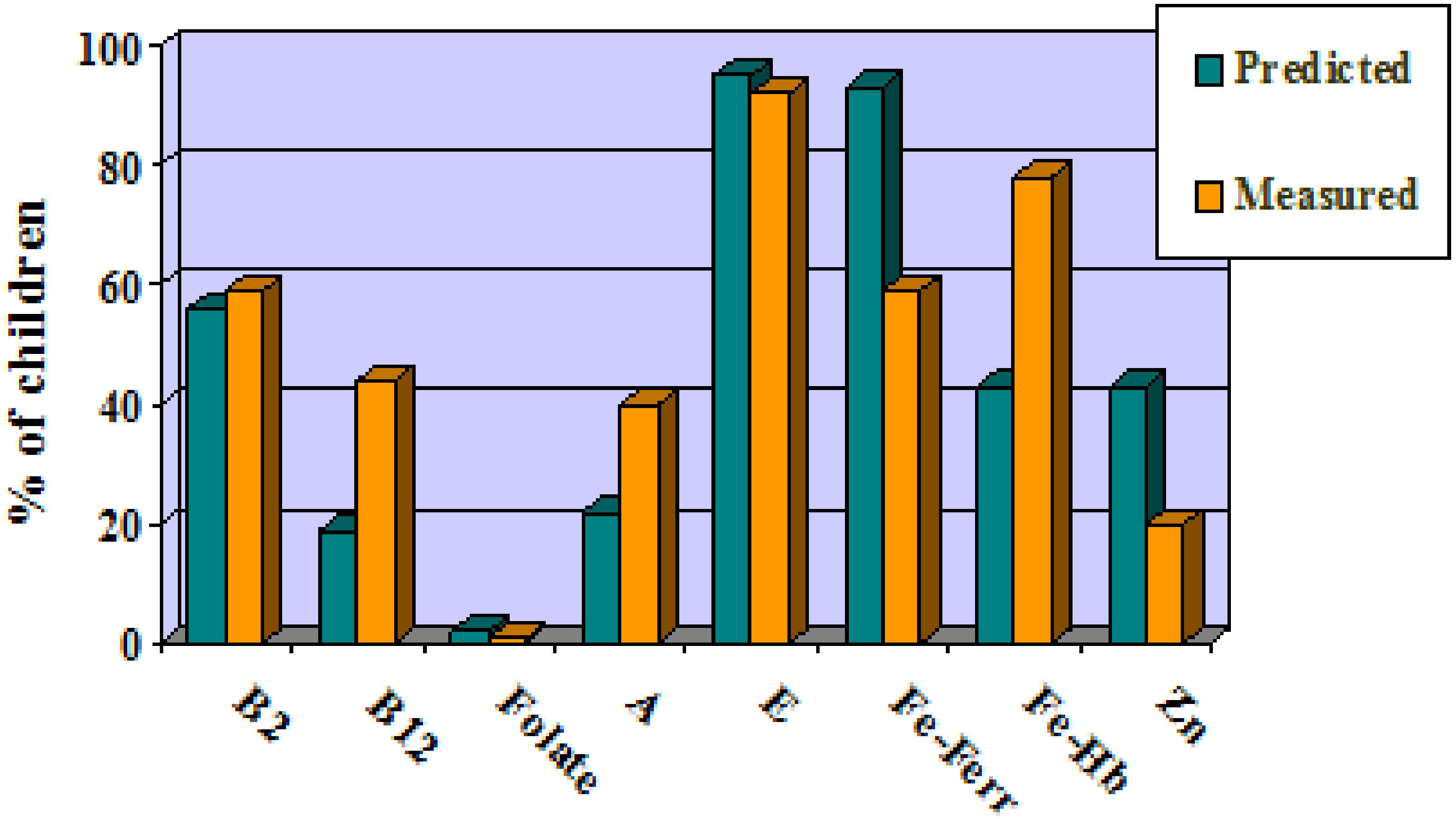
- ❑ High quality protein
- ❑ **Vitamin B-12** (the *only* dietary source)
- ❑ Thiamin, riboflavin, B-6
- ❑ **Vitamin A** (the *only* preformed source)
- ❑ Vitamin E
- ❑ **Iron** (the *only* dietary source of heme)
- ❑ **Zinc** (especially bioavailable)
- ❑ **Calcium**
- ❑ Vitamin D (the *only* dietary source)
- ❑ **Choline**

Observational studies

% inadequate intakes in meat eaters, vegetarians, and vegans: the EPIC Study UK (n=≈24000; Sobiecki 2016). Includes fortificants.



MN deficiencies in Mexican preschoolers: predicted from food intake, and measured biochemically



ASF intake and human function

Nutrition CRSP (e.g. Allen, Nutr. Rev. 1993)

Even at usual low intakes, higher ASF intake predicted better human function in Mexico, Kenya, Egypt (controlling for SES etc.)

In pregnancy: birthweight, infant growth, Bayley mental & motor scores.

In preschoolers: growth and size, behavior, affect (less apathy, crying, time doing nothing).

In schoolers: growth and size, school performance, Ravens matrices, verbal, block design, arithmetic, affect.

In RCTS, ASF improved growth, cognitive function, school performance, playground activity.

Meat consumption is associated with less stunting among toddlers in four diverse low-income settings

(Krebs et al., 2011)

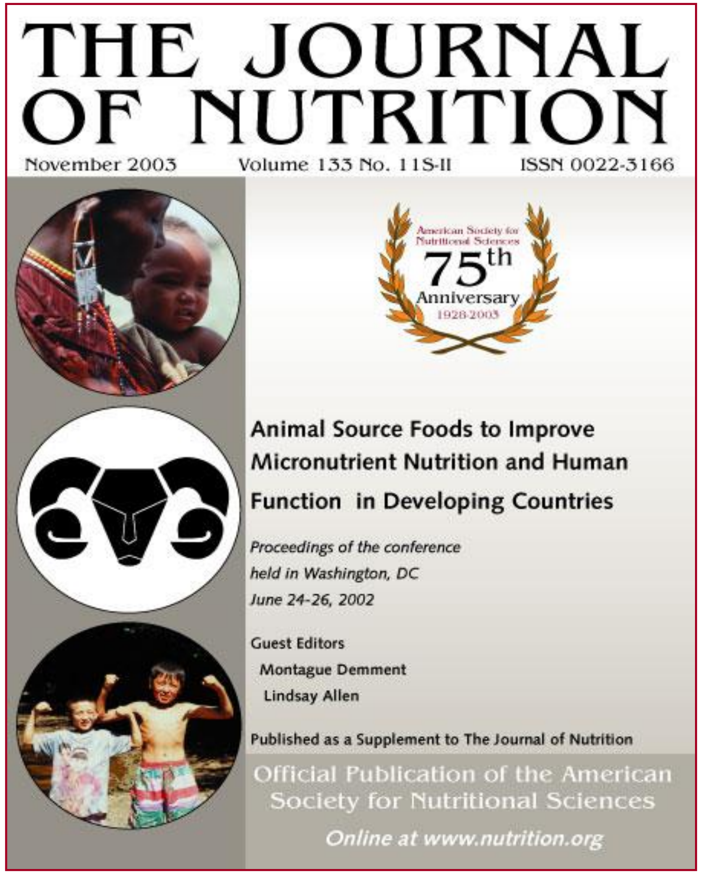
- Guatemala, DRC, Zambia, Pakistan
- Infants (6.9±1.4 mo., n=1500), toddlers (17.2±3.5 mo., n=1658)
- FFQ and anthropometry
- Stunting in 44-66%
- Meat consumed "regularly" by <25% infants and 62% toddlers
- Meat intake associated with 36% ↓ stunting (1-3 d/wk or most days, vs. once/mo. or never).
- Controlled for many variables, but was intake a marker for other differences in HH? Milk intake?

Variable “controls” in intervention trials

- Milk vs. meat vs. energy vs. no intervention (Kenya, 7-9 y)
- Meat vs. milk vs. energy (Kenya, 11-40 mo.)
- Meat vs. MN-fortified cereal (Guatemala, Zambia, DRC, Pakistan, 6-18 mo.)
- Meat vs. energy (Guatemala, 12-21 mo.)

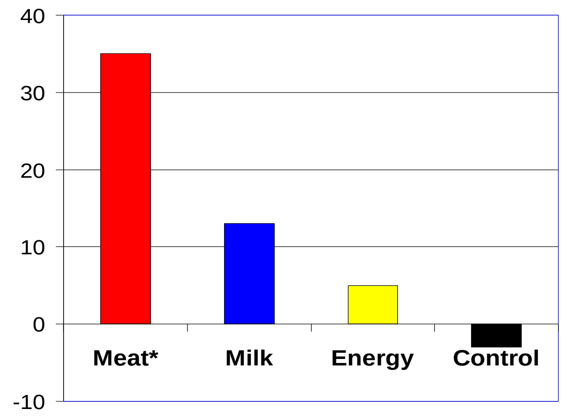
Milk vs. meat intervention trial in schoolers, Embu, Kenya
(n=554, 2 years)

30% stunting, famines, low ASF, 30-90% prevalence various deficiencies



Animal source food interventions in Kenya, 7- 10 y
(Neumann, C. et al.)

- For 2 years compared 4 interventions: control; or githeri with 85 g meat, 250 mL milk or equicaloric oil
- Meat improved:
  - cognitive performance (Raven’s, math)
  - school test scores
  - physical activity, initiative and leadership
  - arm muscle mass, B12 status
- Milk improved:
  - linear growth if stunted
  - B12 status

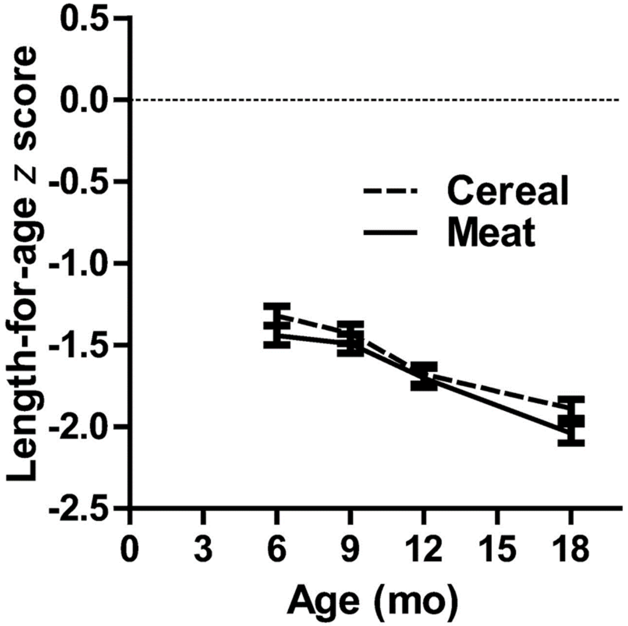


End of term test scores

RCT of meat vs. MN-fortified cereal in infants and toddlers with high stunting

Krebs et al., Am J Clin Nutr 2012

- DRC, Zambia, Guatemala, Pakistan, 6-18 mo.
- Lyophilized beef
- ≅ **30 g** cooked meat from 6-11 mo. And
- ≅ **45 g** from 12-18 mo.
- cf. to equicaloric fortified rice-soy cereal.

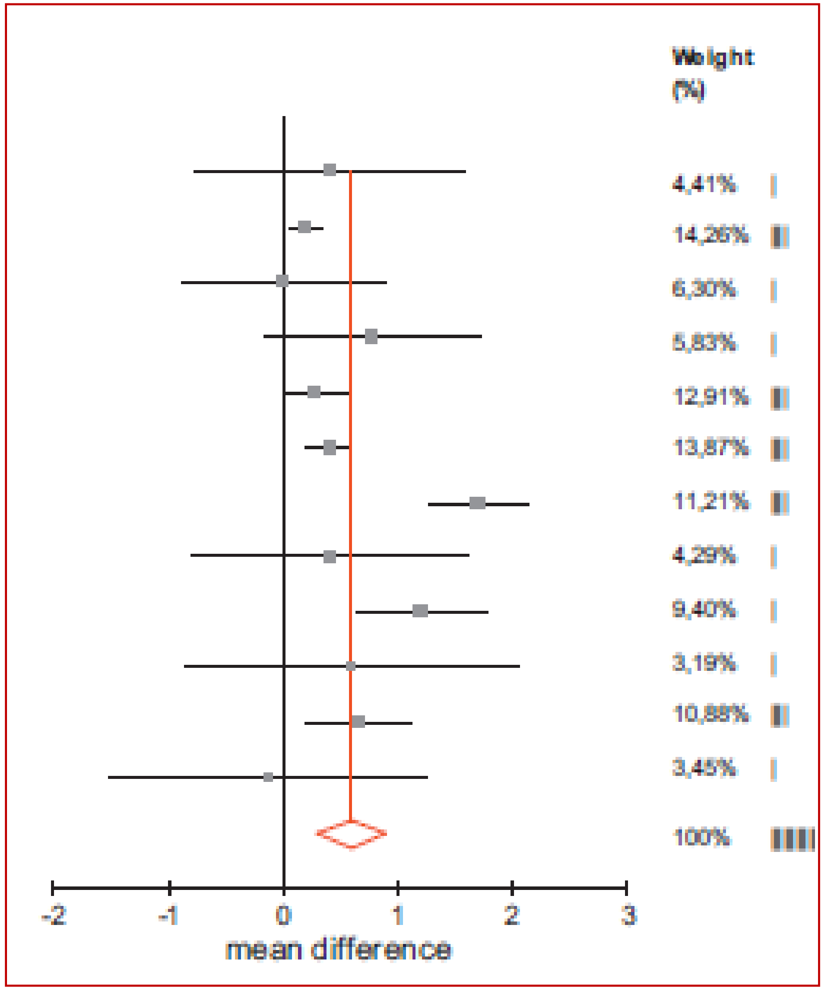


Milk and child growth

- 1920s in UK, daily milk at school increased height gains by 0.5-0.75 cm in 7 months vs. equicaloric controls.
- For infants in Dutch macrobiotic households (stunted, rickets, delays), adding 3 servings milk/week increased height.
- Usual milk intake is strongest predictor of child height in DHS (Africa, Latin America)
- In 7 regions, 12 studies, 3500 children, per 750 mL milk/d = 0.4 cm greater height (de Beer 2012, observational and RCTs)
- In our meta-analysis, 14/17 studies found milk intake positively associated with height/growth of children & adolescents (Dror & Allen, 2011). IGF-1?
- Usually no equicaloric control, few RCTs.

Meta-analysis of dairy products and physical stature (de Beer et al., 2012)

- 12 studies, n ≅ 3500.
- Most age 7-13 y.
- 7 countries/regions (including wealthy).
- Mix RCTs (recent) + observational.
- **+750 mL milk → 0.4 cm ↑ height.**



How much ASF do we need?

- *This is a really important question and we don't have the answer.*
- Many challenges:
  - ASF vary in composition.
  - What outcome? Usually adequacy of MN intakes.
  - Growth, anemia/MN status and deficiency prevention?
  - Optimal functional outcomes e.g. birthweight, breast milk composition?
  - Many confounders in observation/epidemiological studies.
  - Cost and difficulty of dose-response randomized intervention studies on several ASF. What controls?
  - Need data across life span.

Minimum Dietary Diversity Indicator for Women (MDD-W)
Global Dietary Diversity Indicator (2014)

All starchy staples	**Eggs**
Beans & peas	Vitamin A-rich leafy veg
Nuts & seeds	Other vit. A-rich veg & fruits
Dairy	Other veg
Flesh foods	Other fruits

Usual diets should contain ≥6 of 10 food groups. ≥15g/d to be included.

Criterion: probability of meeting recommended MN intakes, 9 sites.

Issues:

No real guidance on AMOUNTS of ASF needed.

Could consume ≥6 food groups but zero ASF.

But in the 9 sites, if scored 5+ then 84% had at least one ASF.

WHO's IYCF Indicator (2017)

- Children 6-23 months should consume ≥4 of these groups to achieve Minimum Diet Diversity (proxy for MN density adequacy):
  - Grains, roots & tubers
  - Legumes & nuts
  - Dairy products
  - Flesh foods
  - Eggs
  - Vitamin A-rich fruits and vegetables
  - Other fruits and vegetables

Same issues: Can eat 4 groups with no ASF, and g ASF needed not stated (maybe 10 g/time?). Debate on how to include breast milk.

Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Willett et al., 2019

	Macronutrient intake (possible range), g/day	Caloric intake, kcal/day
Whole grains*		
Rice, wheat, corn, and other†	232 (total gains 0–60% of energy)	811
Tubers or starchy vegetables		
Potatoes and cassava	50 (0–100)	39
Vegetables		
All vegetables	300 (200–600)	..
Dark green vegetables	100	23
Red and orange vegetables	100	30
Other vegetables	100	25
Fruits		
All fruit	200 (100–300)	126
Dairy foods		
Whole milk or derivative equivalents (eg, cheese)	250 (0–500)	153
Protein sources‡		
Beef and lamb	7 (0–14)	15
Pork	7 (0–14)	15
Chicken and other poultry	29 (0–58)	62
Eggs	13 (0–25)	19
Fish§	28 (0–100)	40
Legumes		
Dry beans, lentils, and peas*	50 (0–100)	172
Soy foods	25 (0–50)	112
Peanuts	25 (0–75)	142
Tree nuts	25	149

Terms and Conditions

Reference Diet is based on environmental concerns – but meets nutrient requirements?

84 g ASF/d + 250 mL milk

12% kcal

EAT diet nutrient analysis (J. Arsenault, UC Davis)

Group	Food	USDAcode	Grams	Energy, kcal
1	GRAINS		232	
1	WHEAT FLR,WHOLE-GRAIN,SOFT WHEAT	20649	58	193
1	CORN,YELLOW	20014	58	212
1	MILLET,RAW	20031	58	219
1	RICE,BROWN,LONG-GRAIN,RAW	20036	58	215
2	STARCHY TUBERS		50	
2	CASSAVA,RAW	11134	25	40
2	POTATOES,BKD,FLESH,W/SALT	11829	25	23
	DARK GREEN VEGETBALES		100	
3.1	LETTUCE,COS OR ROMAINE,RAW	11251	25	4
3.1	SPINACH,RAW	11457	25	6
3.1	COLLARDS,RAW	11161	25	8
3.1	BROCCOLI,RAW	11090	25	9
	RED ORANGE VEGETABLES		100	
3.2	PEPPERS,SWT,RED,RAW	11821	25	8
3.2	SQUASH,WNTR,BUTTERNUT,RAW	11485	25	11
3.2	TOMATOES,RED,RIPE,RAW,YEAR RND AVERAGE	11529	25	5
3.2	CARROTS,RAW	11124	25	10
	OTHER VEGETABLES		100	
3.3	ONIONS,RAW	11282	20	8
3.3	EGGPLANT,RAW	11209	20	5
3.3	OKRA,RAW	11278	20	7
3.3	GARLIC,RAW	11215	20	30
3.3	BEANS,SNAP,GREEN,RAW	11052	20	6
	FRUITS		200	
4	PEACHES,RAW	9236	25	10
4	WATERMELON,RAW	9326	25	8
4	ORANGES,RAW,WITH PEEL	9205	25	16
4	PEARS,RAW	9252	25	14

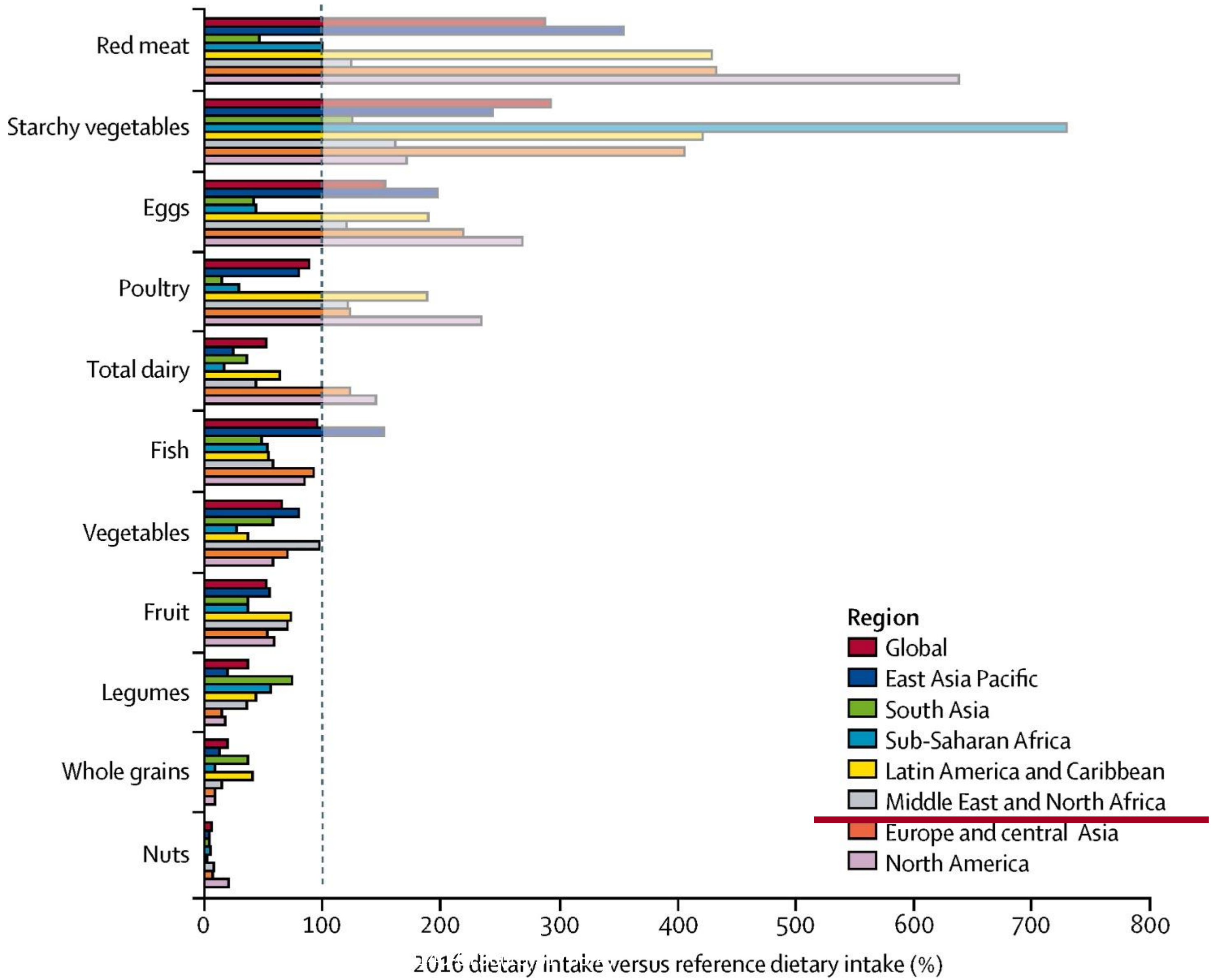
Group	Food	USDAcode	Grams	Energy, kcal
4	STRAWBERRIES,RAW	9316	25	8
4	MANGOS,RAW	9176	25	15
4	APPLES,RAW,WITH SKIN	9003	25	13
4	PINEAPPLE,RAW,ALL VAR	9266	25	13
	DAIRY		250	
5	MILK,WHL,3.25% MILKFAT,W/ ADDED VITAMIN D	1077	250	153
	PROTEIN SOURCES			
6.1	FISH,TILAPIA,RAW	15261	28	27
6.1	BEEF,GROUND,90% LN MEAT / 10% FAT,RAW	23562	7	12
6.1	PORK,FRSH,LOIN,WHL,LN,RAW	10024	7	10
6.1	EGG,WHL,RAW,FRSH	1123	13	19
6.1	CHICKEN,BROILERS OR FRYERS,MEAT ONLY,RAW	5011	29	35
6.2	LENTILS,RAW	16069	25	86
6.2	ALMONDS	12061	12.5	72
6.2	PEANUTS,ALL TYPES,RAW	16087	25	142
6.2	BEANS,WHITE,MATURE SEEDS,RAW	16049	25	83
6.2	WALNUTS,ENGLISH	12155	12.5	82
6.2	SOY MEAL,DEFATTED,RAW	16119	25	85
	ADDED FATS			
7	OIL,PNUT,SALAD OR COOKING	4042	8	71
7	OIL,OLIVE,SALAD OR COOKING	4053	8	71
7	LARD	4002	5	45
7	OIL,SUNFLOWER,LINOLEIC (LESS THAN 60%)	4060	8	71
7	OIL,PALM	4055	6.8	60
7	OIL,CANOLA	4582	8	71
7	OIL,SOYBN,SALAD OR COOKING	4044	8	71
	ADDED SUGARS			
8	SUGARS,GRANULATED	19335	31	120

EAT diet nutrient analysis (J. Arsenault, UC Davis)

Nutrient	Unit	EAT diet	Adult male RDA	Proportion of RDA	Adult female RDA	Proportion of RDA	Proportion of RDA adjusting diet for 2000 kcal
Energy	kcal	2496					
Protein	g	88.9					
Fat	g	100.8					
Carbohydrate	g	329.3					
Fiber	g	47.1					
Calcium	mg	760	1000	0.75	1000	0.75	**0.65**
Iron	mg	19.7	14.4**	1.37	32.4**	0.67	**0.49**
Magnesium	mg	676	420	1.61	320	2.11	1.69
Phosphorus	mg	1727	700	2.47	700	2.47	1.97
Zinc	mg	13.29	19**	**0.70**	9**	1.48	1.18
Copper	mcg	2.99	0.90	3.32	0.9	3.32	2.66
Manganese	mg	10.1	2.3	4.38	1.8	5.6	4.48
Selenium	mcg	79	55	1.45	55	1.45	1.16
Vitamin A	mcgRAE	851	900	0.95	700	1.22	0.97
Vitamin E	mg	19.4	15	1.30	15	1.3	1.04
Vitamin D	mcg	4.6	15	0.30	15	0.3	**0.24**
Vitamin C	mg	139	90	1.54	75	1.85	1.48
Thiamin	mg	1.87	1.2	1.56	1.1	1.7	1.36
Riboflavin	mg	1.62	1.3	1.24	1.1	1.47	1.18
Niacin	mg	22.4	16	1.40	14	1.6	1.28
Vitamin B6	mg	2.5	1.3	1.91	1.3	1.91	1.53
Vitamin B12	mcg	1.84	2.4	**0.77**	2.4	0.77	**0.61**
Folate	mcg DFE	559	400	1.40	400	1.40	1.12

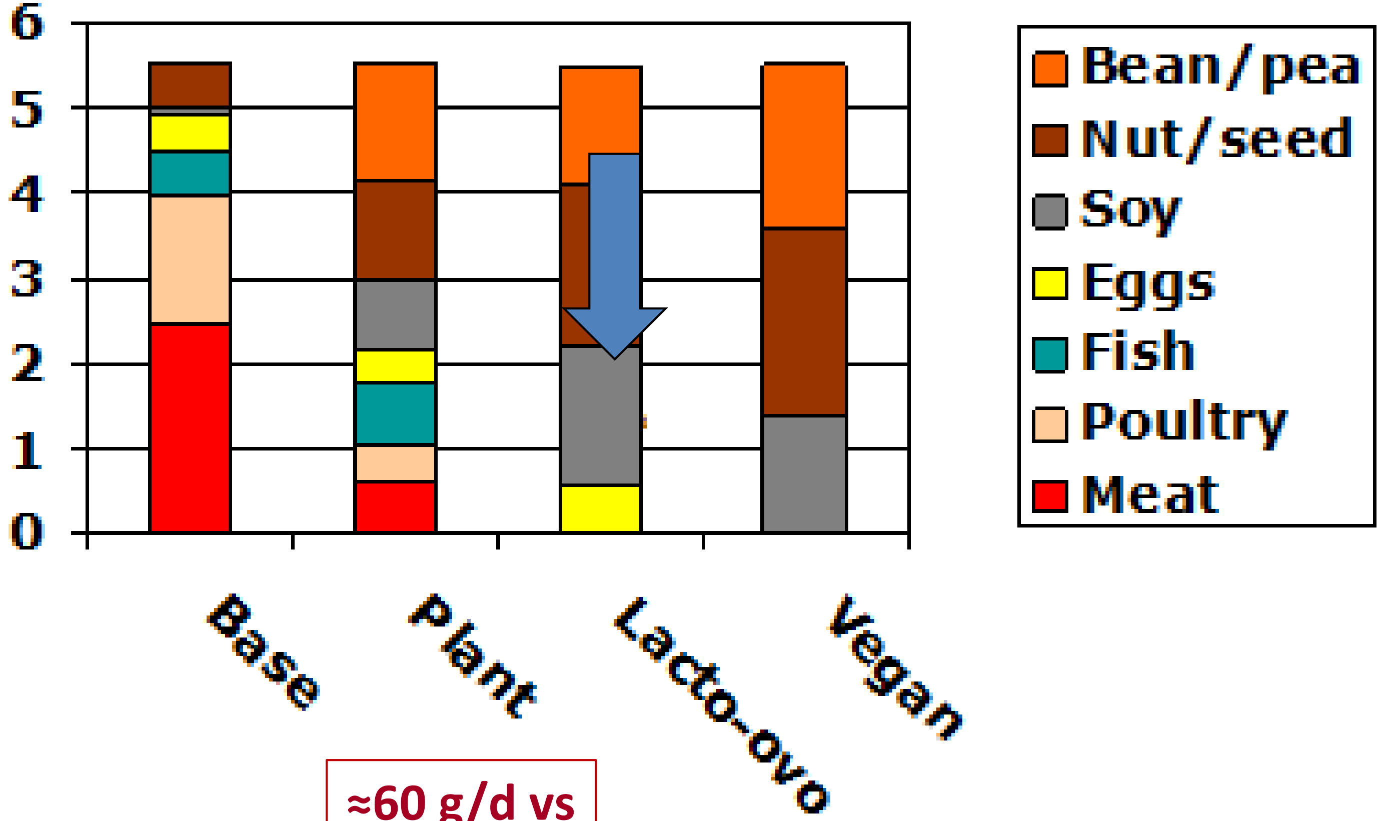
**Bioavailability adjustments to iron and zinc requirements due to high phytate diet with unrefined grains/legumes, iron RDA adjusted for 10% bioavailability (WHO 2004), zinc RDA from IZiNCG (2004) unrefined diet

Diet gap between dietary patterns in 2016 and reference diet intakes of food. Data on 2016 intakes from Global Burden of Disease database. Dotted line = reference diet.



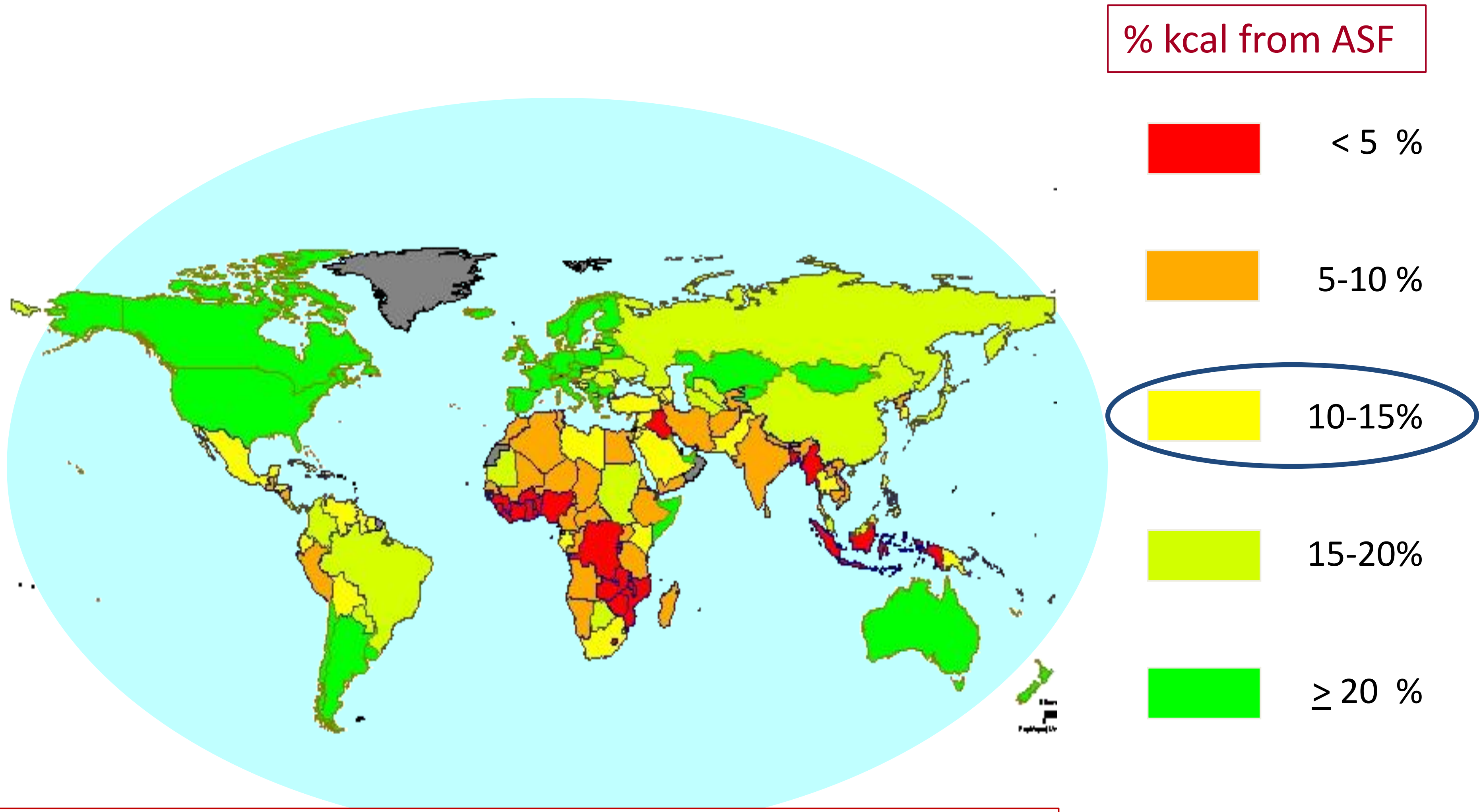
Dietary Guidelines for Americans

Translated to ounces per day



≈60 g/d vs 84 g/d in Ref Diet

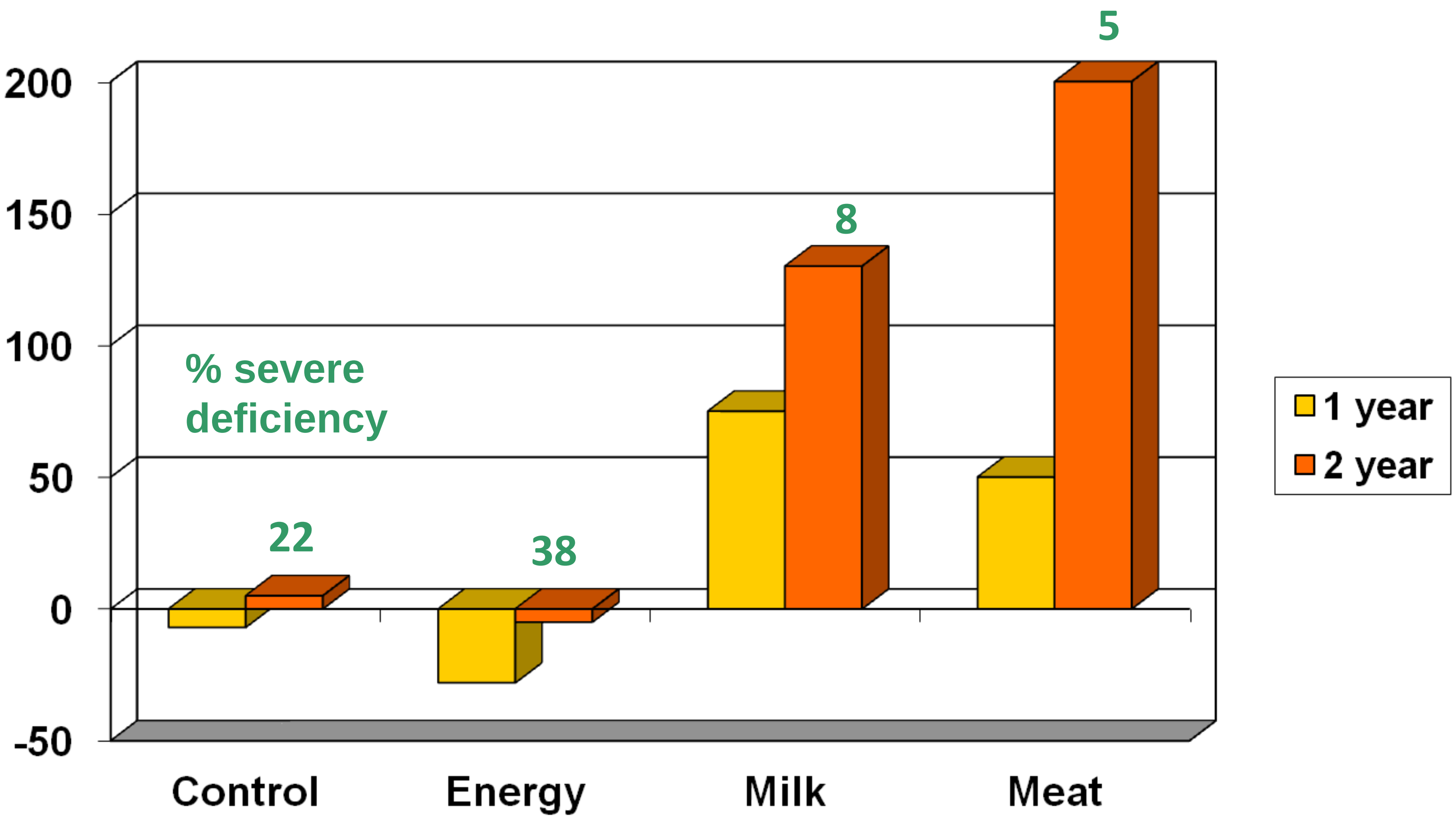
Can we use B12 status as proxy for usual ASF intake?



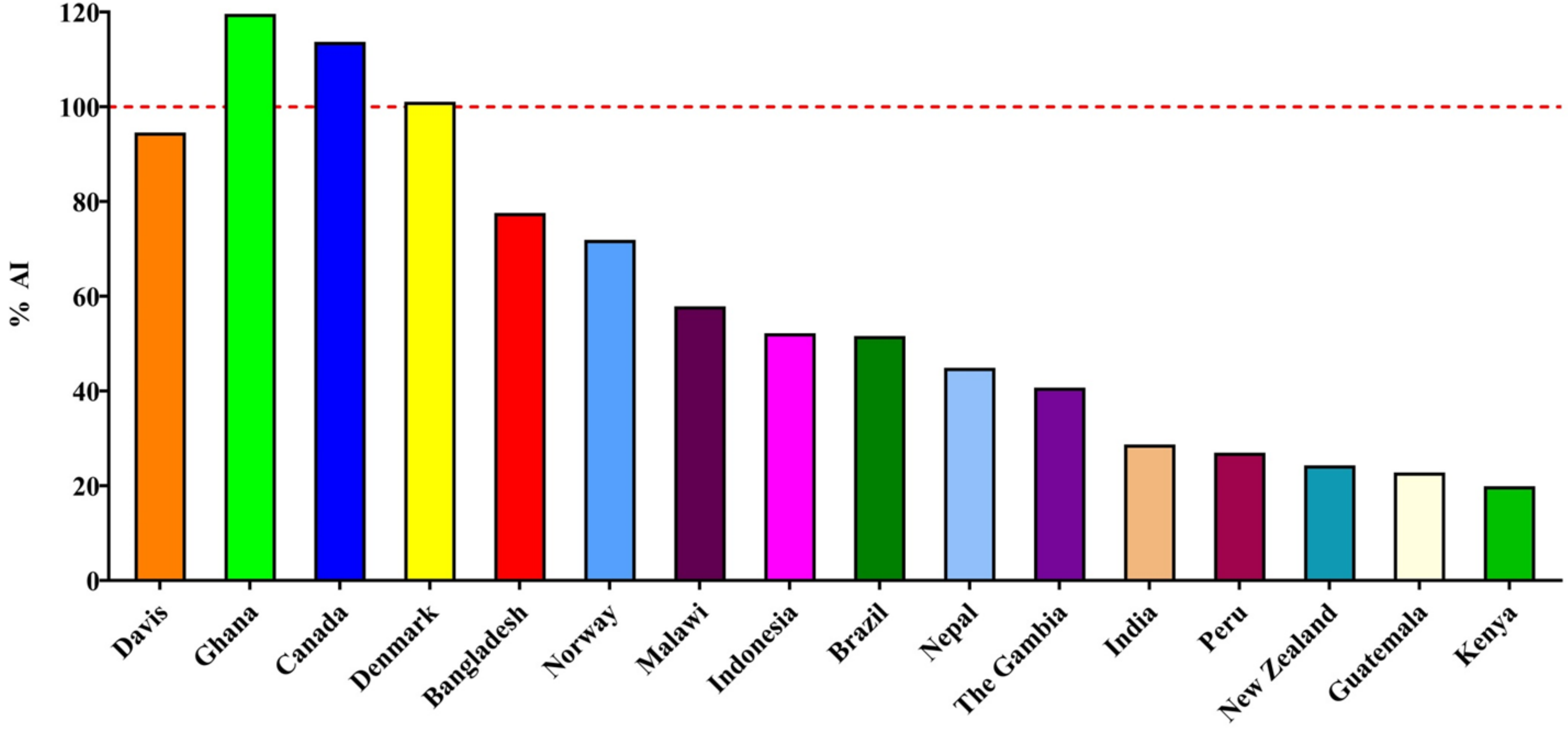
B12 deficiency prevalence high if ASF =10-15% kcal

(RD = 12% kcal)

Vitamin B12 status?
60-85 g meat or 250 mL milk/d for 2 y, Kenya schoolers
Change in plasma B12 (pg/mL)



Adequacy of B12 in breast milk?
Median values as % of Adequate Intake value



Need better guidelines for recommended range of ASF intake

- ASF are definitely required, especially for pregnant women, infants, children, adolescents.
- Supplements/fortification unlikely to be adequate substitutes.
- In general, excessive intake in wealthier regions (bad for health and environment) and inadequate in poor populations, but few dose-ranging RCTs.
- To meet MN requirements, LIC need to *increase* ASF.
- Dietary quality indicators do not capture ASF adequately or quantitatively e.g.
  - WHO's Infant and Young Child Feeding indicators
  - Global Minimum Dietary Diversity Indicator for Women……
- Use B12 status as a proxy indicator?

Kenya
Small Ruminant CRSP