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USAID/GAIN MICRONUTRIENT FORTIFICATION PROJECT
IN CENTRAL ASIA, AFGHANISTAN AND PAKISTAN

ANALYSIS AND JUSTIFICATION OF THE POSSIBILITY OF HARMONIZING STANDARDS FOR HIGH-EXTRACTION WHEAT FLOUR FORTIFICATION IN AFGHANISTAN AND PAKISTAN

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1. Comparison of standards for high-extraction wheat flour fortification, operating in Afghanistan and Pakistan with the relevant recommendations of the World Health Organization (WHO).

According to an interim consensus statement, endorsed by WHO and other institutions about recommendations on wheat and maize flour fortification [1] (reference), the average levels of nutrients that can be added to fortifying wheat flour depending on the:

- estimated average per capita consumption (g/day) of wheat flour – for all the recommended micronutrients;
- extraction level of flour (low or high) – for iron and zinc;
- fortifying nutrient – for all the recommended micronutrients, and others are required by the nutrition situation of the country (Table 1).

NaFeEDTA, ferrous sulfate, ferrous fumarate and electrolytic iron may serve as the source of iron. However electrolytic iron cannot be used neither as an iron source in cases where the estimated average per capita consumption of wheat flour is less than 150 g/day nor for high-extraction flour (i.e. whole flour). (high-extraction-rate = ≥80% wheat flour [2]; so, low-extraction-rate = <80% wheat flour). This is because very high levels of electrolytic iron that are needed could negatively affect sensory properties of fortified flour.

The average per capita consumption of wheat flour in the member countries is [3]:

- 311,3 g/day in Pakistan;
- 439,0 g/day in Afghanistan.

Due to differences in the average per day consumption of wheat flour per person:

- Pakistan and Afghanistan– to countries where average consumption of wheat flour per capita is >300 g/day.

Overall, the average levels of per capita per day consumption of flour in the both countries are high and may contribute to the harmonization of standards for flour fortification.

In Afghanistan , flour is expected to be fortified by 4 micronutrients (vitamins B_9 and B_{12}, iron and zinc); in Pakistan, currently only 2 micronutrients - vitamin B_9 and iron, are required at the national level (Table 2).

The levels of added micronutrients to the flour:

- In Afghanistan and Pakistan, data referred to the flour called Atta, which traditionally refers to high-extraction flour.

The levels of added micronutrients to the flour in comparison with the WHO-endorsed recommendations are:

- slightly higher in Pakistan for vitamin B_9;
- somewhat lower in Pakistan for iron;
- lower in Afghanistan for zinc;
- other parameters in those countries comply with the recommendations of WHO.

Table 1 – WHO interim consensus statement about recommendations for fortified flours, 2009[a]**:** Average levels of nutrients to consider adding to fortified wheat flour based on extraction, fortificant compound, and estimated per capita flour availability

Nutrient	Flour extraction rate	Compound	Level of nutrient to be added in parts per million (ppm) by estimated average per capita wheat flour availability (g/day)[b]			
			<75g/day[c]	75-149 g/day	150-300 g/day	>300g/day
Iron	Low	NaFeEDTA	40	40	20	15
		Ferrous sulphate	60	60	30	20
		Ferrous fumarate	60	60	30	20
		Electrolytic iron	NR[d]	NR[d]	60	40
	High	NaFeEDTA	40	40	20	15
Folic acid	Low or high	Folic acid	5.0	2.6	1.3	1.0
Vitamin B_{12}	Low or high	Cyanocobalamin	0.04	0.02	0.01	0.008
Vitamin A	Low or high	Vit A palmitate	5.9	3	1.5	1
Zinc[e]	Low	Zinc oxide	95	55	40	30
	High	Zinc oxide	100	100	80	70

Notes:

[a] – WHO, FAO, UNICEF, GAIN, MI, & FFI. Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva, World Health Organization, 2009 (http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort_ru.pdf.

[b] – These estimated levels consider only wheat flour as main fortification vehicle in a public health program. If other mass-fortification programs with other food vehicles are implemented effectively, these suggested fortification levels may need to be adjusted downwards as needed.

[c] – Estimated per capita consumption of <75 g/day does not allow for addition of sufficient level of fortificant to cover micronutrients needs for women of childbearing age. Fortification of additional food vehicles and other interventions should be considered.

[d] – NR = Not Recommended because very high levels of electrolytic iron needed could negatively affect sensory properties of fortified flour.

[e] – These amounts of zinc fortification assume 5 mg zinc intake and no additional phytate intake from other dietary sources

Table 2 – Summary data on the levels of micronutrients to be added in parts per million (ppm) to fortified wheat flour according to standards in Central Asian Republics, Afghanistan and Pakistan

Items	Pakistan Atta [4]	Afghanistan Atta [5]
Vitamin B_1	n/f	n/f
Vitamin B_2	n/f	n/f
Vitamin B_3	n/f	n/f
Vitamin B_9 **WHO, 2009**	1,5 **1,0**	1,0 **1,0**
Vitamin B_{12} **WHO, 2009**	n/f **0,008**	0,008 **0,008**
Iron **WHO, 2009**	10,0 **15,0** Sodium Iron EDTA	15,0 **15,0** Sodium Iron EDTA
Zinc **WHO, 2009**	n/a **30,0**	30,0 **30**[OD1]**,0**

Notes:

n/f – not fortified
Wheat flour consumption in g/capita/day:
> 300 in Afghanistan and Pakistan

2. Standards for mandatory and voluntary fortification of wheat flour.

It seems to be appropriate to develop the following standards for:

- Mandatory fortification of flour with micronutrients recommended by the World Health Organization, namely, by vitamins B_9 and B_{12}, iron and zinc for all types of flour, plus B_1, B_2, and B_3 for refined (low extraction) flour;
- As the high-extraction wheat flour contains good amounts of the latter vitamins; those would not be added to this type of flour.
- Carry out studies of vitamin A and vitamin D deficiencies in all the countries in order to establish if the addition of these other micronutrients would be appropriate for the whole region.

3. Setting the level of bioavailability of minerals from high-extraction wheat flour in Afghanistan and Pakistan.

The Food Agriculture Organization of the United Nations/World Health Organization set iron bioavailability at 5% for a strict vegetarian diet, at 10% when some meat and ascorbic acid was added, and at 15% for diets rich in meat and fruits [6].

The diet of the population of Afghanistan and Pakistan can be referred to the group with 5% (low) bioavailability of minerals, because the average per capita intake is:

- high (311 g/day in Pakistan and 439 g/day in Afghanistan) for wheat flour, which is mainly high-extracted one (inhibitors of iron absorption);
- very low (45 g/day in Pakistan and 34 g/day in Afghanistan) for meat and meat products, which contain heme iron (promotor of iron absorption);
- very low for vegetables (72 g/day in Pakistan and 79 g/day in Afghanistan) and fruits (80 g/day in Pakistan and 93 g/day in Afghanistan), which are the reach sources of vitamin C (promotor of iron absorption).

This subdivision of diet dependent levels of minerals bioavailability should be taken into account for calculating the levels of micronutrients in fortified flour and comparing them with vitamin and mineral requirements in human nutrition according to WHO/FAO data [7].

The total iron content of a diet provides little information about its content of bioavailable iron, which is considerably influenced by the foods in the diet and can vary 10-fold from different meals of similar iron content [8]. Although a vegetarian diet is likely to contain iron in amounts equivalent to amounts in a nonvegetarian diet, the iron from a vegetarian diet is likely to be substantially less available for absorption [9] because of differences in the chemical form of iron and the accompanying constituents that enhance or inhibit iron absorption [10].

The chemical form of iron is an important factor affecting the iron availability of vegetarian diets. In the diet inorganic iron-salts (non-heme) are present in plants and animal tissues, and organic iron (heme), which comes from hemoglobin (blood) and myoglobin (red muscle), is present in animal food sources. Heme-iron absorption is less affected by dietary compounds with the exception of calcium compounds [11].

Less than 40% of the iron in meat, poultry, and fish [12] is in the heme form, which is more efficiently absorbed than the remaining nonheme iron present in these and all other foods [13]. Nonvegetarian diets with substantial amounts of red meat supply about 2 mg/d, or 10–15%, of the total iron in the heme form [6]. Heme iron is better absorbed (around 15–40%) than nonheme iron (around 1–15%) [14].

Whole cereals contain phytic acids and polyphenols, which decrease iron bioavailability [15]. The phytic acid levels in low extraction wheat flour is low compared to high extraction flour. Also bread in most of the countries in CAR is fermented using yeast. Pakistan and Afghanistan have high consumption of unleavened bread made from high extraction flour. This means the phytic acid is not broken in the latter country by the fermentation step.

The fact is that the whole wheat flour (i.e. high extraction flour) is a good source of phytic acid, which is the main inhibitor of non-heme iron absorption from plant products. The phosphate groups of phytic acid are negatively charged under physiologically relevant conditions, resulting in phytate chelation of cations such as iron and zinc, making these minerals less available for absorption [14]. Consuming 5-10 mg of phytic acid can reduce iron absorption by 50% [15, 16]. Phytate content in refined (white) flour is about 100 mg/100 g, and in wheat and whole-wheat flour it is about 600 mg/100 g [17]. Polyphenols also forms insoluble complexes with iron thereby reducing its bioavailability to the body.

The bioavailability of the heme iron from meat and meat products [18] is significantly higher (15-40%) than the bioavailability of non-heme iron from plant foods [19]. Heme-iron absorption is less affected by dietary compounds with the exception of calcium compounds [20].

The inhibitory effect of calcium on iron absorption was recognized many years ago, and the presence of large amounts of calcium can inhibit the absorption of iron from a fortified food [21]. Different studies have been conducted but they often give conflicting results because several factors influence the interaction between calcium and iron absorption [11].

Milk and dairy products are good sources of calcium. But, absorption of iron and zinc from milk products is higher than from vegetable products, even it is considered that calcium from milk and milk products found as calcium phosphate, inhibit absorption of non-heme and heme iron [11], and again there are conflicting results. For example, goat milk consumption leads to a better recovery of body Fe stores, minimizing Ca-Fe interactions and improving Fe status and its absorption [22]. The absorption of iron from the cereal-based diets was not inhibited by cow's milk [23]. On the other hand, milk contains calcium and caseins, which inhibit absorption of both non-heme and heme iron. It enters into the mucosal cells by different pathways and leave in the same form which implies that calcium inhibit the intracellular transport of iron [24].

To ensure an appropriate iron absorption, the intake of iron should be high enough to improve or maintain iron status. This condition might be attained adding sufficient iron to the fortification vehicle and/or incorporating simultaneously absorption enhancers. In the case of wheat flour fortification, the only practical enhancer to add is EDTA or using as an iron source NaFeEDTA; iron in the form of ferric sodium EDTA is 2 to 3 times more bioavailable than from other mineral sources and that it is efficiently incorporated into haemoglobin [25]; iron from ferric sodium EDTA has a high bioavailability despite the presence of inhibitory factors that form insoluble complexes

[26]. Vitamin C, which can increase absorption of both native iron and fortification iron due to both its reducing power and chelating actions [27], is destroyed during baking. Bovine hemoglobin is not easily accepted or it is too expensive for being used as a fortificant.

More than half of the zinc in US diets is derived from animal foods, and one quarter of the zinc comes from beef [28]. The bioavailability of zinc from vegetarian diets is also to be less than that of nonvegetarian diets. Plant foods rich in zinc—such as legumes, whole grains, nuts, and seeds – are also high in phytic acid, an inhibitor of zinc bioavailability [29]. Bioavailability of zinc is enhanced by dietary protein [30], but plant sources of protein are also generally high in phytic acid. Because of lower absorption of zinc, those consuming vegetarian diets, especially with phytate-zinc molar ratios > 15, may require as much as 50% more zinc than nonvegetarians [31, 32].

Thus, the iron and zinc from vegetarian diets are generally less bioavailable than from nonvegetarian diets because of reduced meat intake as well as the tendency to consume more phytic acid and other plant-based inhibitors of iron and zinc absorption.

Iron bioavailability is estimated to be around 5-12% for vegetarian diets and 14-18% for mixed diets. These values are used to generate dietary reference values for all population groups. Considering all factors that may influence iron bioavailability, the estimated average absorption iron rate for a typical western diet is between 15-18% [33-36].

4. Premix formulation for fortification of high-extraction wheat flour.

In view of the above WHO recommendations, the average per capita consumption of wheat flour g/day in the participating countries, and the characteristics of diets with low and moderate bioavailability of minerals, premix composition is formulated for mandatory fortification of high-extraction flour, which is presented in Table 3.

Table 3 – The main parameters of the premix for fortification of high-extraction wheat flour.

Nutrient	Fortificant compound	Selected FL (mg/kg flour)	Amount of fortificant (mg/kg flour)	Premix Formulation			
				Fortificant (g/kg premix)	Nutrient (g/kg premix)	Cost (US$/kg)	% Cost
Vit. B-9 (Folate)	Folic Acid	1,0	1,1	4,4	4,0	$0,49	6,5
Vit. B-12	Vit. B-12 0.1% WS	0,008	8,0	32,0	0,03	$1,28	16,9
Iron	NaFeEDTA	15,0	115,4	461,5	60.0	$3,00	39,6
Zinc	Zinc oxide	30,0	37,5	150,0	120,0	$0,45	5,9
	Filling material (at least 25%)		40,5	352,0		$0,35	4,6
		TOTAL	202,5	**1000,0**			
	Estimated cost of manufacturing, quality control and delivery (Approx. US$2/kg premix)					$2,00	26,4
			Approximate Cost per kg =			**$7,57**	**100,0**
Estimated cost of micronutrient premix per metric ton of fortified product*:						**$1,89**	
						0,38 % of the Price	

Minimum Amount (grams per MT)	202
Selected Amount (grams per MT)	250**

Maximum Dilution Factor = 1/	4938
Selected Dilution Factor = 1/	4000

Notes:

* - The costs of the fortificants are always the largest cost of the fortification process, when it carried out by formal and centralized factories.

** - This value should be larger than the estimated minimum amount per metric ton (above).

5. Establishment of production and regulatory parameters for fortification of high-extraction wheat flour.

Based on the composition of the premix, production and regulatory parameters for fortification of high-extraction flour are established, which are presented in Table 4.

Table 4 – The main production and regulatory parameters for fortification of high-extraction wheat flour

Nutrient	Fortificant compound	Selected FL (mg/kg flour)	Production Parameters			Regulatory Parameters	
			mFL (1) (mg/kg flour)	Average (2) (mg/kg flour)	MFL (3) (mg/kg flour)	LmL (4) (mg/kg flour)	MTL (5) (mg/kg flour)
Vit. B-9 (Folate)	Folic Acid	1,0	0,8	1,4	2,0	0,7	2,0
Vit. B-12	Vit. B-12 0.1% WS	0,008	0,004	0,008	0,012	0,004	0,012
Iron	NaFeEDTA	15,0	36,0	53,0	70,0	36,0	70,0
Zinc	Zinc oxide	30,0	40,0	59,0	78,0	40,0	78,0

Notes:
(1) mFL = Minimum Fortification Level, using equation 2.
(2) Average = Selected Fortification Level + Intrinsic content of micronutrient in unfortified food.
(3) MFL = Maximum Fortification Level, using equation 3.
(4) LmL= Legal Minimum Level, using equation 4.
(5) MTL = Maximum Tolerable Level, equivalent to MFL but only for those micronutrients with safety concerns, and rounded.

6. Daily intake of micronutrients by population groups in the composition of high-extraction fortified wheat flour, in Afghanistan and Pakistan, in % EAR/day and % RNI/day.

Terms [37]**:**

EAR = Estimated Average Requirement is the daily intake which meets the nutrient requirements of 50% apparently healthy individuals in an age- and sex-specific population.

RNI = Recommended nutrient intake is the daily intake which meets the nutrient requirements of almost all (97.5%) apparently healthy individuals in an age- and sex-specific population.

All basic calculations in this and other sections are conducted using the Formulator, developed by Omar Dary и Michael Hainsworth [38].

In terms of daily intake of nutrients, in % EAR/day and % RNI/day, in different age and gender population groups (Table 5) of two countries are located in the following ascending order:

Nutrient/Country	% EAR/day	% RNI/day
Folic acid:		
Pakistan	96% to 135%	76% to 109%
Afghanistan	135% to 192%	108% to 154%
Vitamin B_{12}:		
Pakistan	74% to 113%	62% to 88%
Afghanistan	105% to 160%	87% to 124%
Iron:		
Pakistan	21% to 85%	11% to 35%
Afghanistan	30% to 119%	16% to 49%
Zinc:		
Pakistan	50% to 90%	42% to 75%
Afghanistan	71% to 127%	59% to 106%

Table 5 – Daily intake of micronutrients by population groups in the composition of high-extraction fortified wheat flour, in Afghanistan and Pakistan, in % EAR/day and % RNI/day

Nutrient	Additional daily intake of nutrients by population groups, in			
	Afghanistan		Pakistan	
	% EAR/day	% RNI/day	% EAR/day	% RNI/day
Children, 1-3 years				
Vitamin B-9 (Folate)	189,8	151,9	134,6	107,7
Vitamin B-12	159,5	122,7	113,1	87,0
Iron (NaFeEDTA)	97,9	42,0	69,4	29,8
Zinc	70,5	58,7	50,0	41,6
Children, 4-6 years				
Vitamin B-9 (Folate)	180,9	144,7	128,3	102,6
Vitamin B-12	140,3	116,9	99,5	82,9
Iron (NaFeEDTA)	119,4	49,1	84,7	34,8
Zinc	77,4	64,5	54,9	45,7
Children, 7-9 years				
Vitamin B-9 (Folate)	151,4	121,1	107,3	85,9
Vitamin B-12	117,4	97,8	83,3	69,4
Iron (NaFeEDTA)	106,1	43,7	75,2	31,0
Zinc	83,3	69,4	59,0	49,2
Males, 10-18 years				
Vitamin B-9 (Folate)	177,0	141,6	125,5	100,4

Nutrient	Additional daily intake of nutrients by population groups, in			
	Afghanistan		Pakistan	
	% EAR/day	% RNI/day	% EAR/day	% RNI/day
Vitamin B-12	137,3	114,4	97,4	81,1
Iron (NaFeEDTA)	48,5	34,6	34,4	24,5
Zinc	85,0	70,9	60,3	50,2
Males, 19-50 years				
Vitamin B-9 (Folate)	192,4	153,9	136,4	109,1
Vitamin B-12	149,3	124,4	105,8	88,2
Iron (NaFeEDTA)	63,9	48,1	45,3	34,1
Zinc	112,9	94,1	80,0	66,7
Males, 51-65 years				
Vitamin B-9 (Folate)	188,6	150,8	136,4	109,1
Vitamin B-12	146,3	121,9	105,8	88,2
Iron (NaFeEDTA)	62,6	47,1	45,3	34,1
Zinc	110,6	92,2	80,0	66,7
Males, +65 years				
Vitamin B-9 (Folate)	157,8	126,2	111,9	89,5
Vitamin B-12	122,4	102,0	86,8	72,3
Iron (NaFeEDTA)	52,4	39,4	37,2	27,9
Zinc	92,6	77,1	65,6	54,7
Females, 10-18 years				
Vitamin B-9 (Folate)	148,2	118,5	105,1	84,0
Vitamin B-12	114,9	95,8	81,5	67,9
Iron (NaFeEDTA)	29,6	15,6	21,0	11,1
Zinc	84,5	70,4	59,9	49,9
Females, 19-50 years				
Vitamin B-9 (Folate)	152,0	121,6	107,8	86,2
Vitamin B-12	117,9	98,3	83,6	69,7
Iron (NaFeEDTA)	39,3	17,7	27,9	12,5
Zinc	127,4	106,2	90,3	75,3
Females, 41-65 years				
Vitamin B-9 (Folate)	150,1	120,1	106,4	85,1
Vitamin B-12	116,4	97,0	82,6	68,8
Iron (NaFeEDTA)	100,9	45,5	71,6	32,2
Zinc	125,8	104,8	89,2	74,3
Females, +65 years				
Vitamin B-9 (Folate)	134,7	107,7	95,5	76,4
Vitamin B-12	104,5	87,1	74,1	61,7
Iron (NaFeEDTA)	65,3	40,8	46,3	28,9
Zinc	112,9	94,1	80,0	66,7

Notes:

EAR = Estimated Average Requirement is the daily intake which meets the nutrient requirements of 50% apparently healthy individuals in an age- and sex-specific population.

RNI = Recommended nutrient intake is the daily intake which meets the nutrient requirements of almost all (97.5%) apparently healthy individuals in an age- and sex-specific population.

8. Brief description of the annexes.

Annexes 1 and 2 provide detailed characteristics of fortified high-extraction wheat flour using a premix, the main parameters of which are shown in Table 3. In particular, the following data are given in these annexes:

- Addition levels each of four micronutrients (vitamins B_9 and B_{12}, iron as NaFeEDTA, and zinc) to flour, in mg/kg flour
- Adjusted upper limit for each of the micronutrients (vitamins B_9 and B_{12}, iron as NaFeEDTA, and zinc), in mg/kg flour
- Daily intake of micronutrients in the composition of fortified wheat flour, in:
  - mg/day
  - % EAR/day
  - % RNI/day

The mentioned information in each member country are presented for the following age and gender groups of population in accordance with WHO recommendations:

1. Children, 1-3 years
2. Children, 4-6 years
3. Children, 7-9 years
4. Males, 10-18 years
5. Males, 19-50 years
6. Males, 51-65 years
7. Males, + 65 years
8. Females, 10-18 years
9. Females, 19-50 years
10. Females, 51-65 years
11. Females, + 65 years

Total 2 annexes are drawn up by the number of countries:

- Afghanistan – Annex 1
- Pakistan – Annex 1

9. Conclusion.

1. For the mandatory fortification of high-extraction wheat flour the following 4 micronutrients are selected:
   - Vitamin B_9 (folate)
   - Vitamin B_{12} (cyanocobalamin)
   - Iron (as Ferrous sulfate dried and NaFeEDTA)
   - Zinc (zinc oxide)
2. The proposed addition levels of micronutrients in high-extraction flour:
   - prepared taking into account the average per capita consumption of flour (in g/day) in the participating countries;
   - fully comply with WHO recommendations
3. The proposed levels of high-extraction flour fortification by **zinc and vitamins B_9 and B_{12}** ensure acceptable levels of total daily intake (in % RNI/day) of these micronutrients in the composition of fortified wheat flour for all gender and age population groups in both countries:

Nutrient	Afghanistan	Pakistan
Vitamin B-9 (Folate)	108% to 154%	76% to 109%
Vitamin B-12	87% to 124%	62% to 88%
Zinc	59% to 106%	42% to 75%

4. The proposed levels of high-extraction flour fortification by iron don’t ensure acceptable levels of total daily intake (in% RNI/day) of **iron** in females of 10-50 years old in both countries:
   - Pakistan: 11% to 13%
   - Afghanistan: 16% to 18%
5. Even in the other age and gender population groups the proposed levels of high-extraction flour fortification by iron ensure less than 50% RNI/day levels of total daily intake of **iron** in both countries:
   - Pakistan: 25% to 34%
   - Afghanistan: 35% to 49%

Annex 1 – High-extraction wheat flour fortification characteristics and daily intake of micronutrients by population groups in the composition of fortified wheat flour, in Afghanistan

Afghanistan: High-extraction wheat flour fortification

Nutrient	Addition level to flour, mg/kg	Adjusted upper limit, mg/day	Daily intake of micronutrients in the composition of fortified wheat flour		
			mg/day[a]	% EAR/day	% RNI/day
Children, 1-3 years: P-50 Food Intake of target group = 162,4 g/day					
Vit. B-9 (Folate)	1,0	0,3	0,134	189,8	151,9
Vit. B-12	0,008	N.D.	0,001	159,5	122,7
Iron (NaFeEDTA)	15,0	4,7	2,436	97,9	42,0
Zinc	30,0	7,0	4,873	70,5	58,7
Children, 4-6 years: P-50 Food Intake of target group = 206,3 g/day					
Vit. B-9 (Folate)	1,0	0,4	0,170	180,9	144,7
Vit. B-12	0,008	N.D.	0,001	140,3	116,9
Iron (NaFeEDTA)	15,0	7,2	3,095	119,4	49,1
Zinc	30,0	12,0	6,190	77,4	64,5
Children, 7-9 years: P-50 Food Intake of target group = 259,0g/day					
Vit. B-9 (Folate)	1,0	0,5	0,214	151,4	121,1
Vit. B-12	0,008	N.D.	0,002	117,4	97,8
Iron (NaFeEDTA)	15,0	10,1	3,885	106,1	43,7
Zinc	30,0	12,0	7,770	83,3	69,4
Males, 10-18 years: P-50 Food Intake of target group = 403,9 g/day					
Vit. B-9 (Folate)	1,0	0,7	0,333	177,0	141,6
Vit. B-12	0,008	N.D.	0,003	137,3	114,4
Iron (NaFeEDTA)	15,0	19,8	6,058	48,5	34,6
Zinc	30,0	28,0	12,116	85,0	70,9
Males, 19-50 years: P-50 Food Intake of target group = 439,0 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,362	192,4	153,9
Vit. B-12	0,008	N.D.	0,003	149,3	124,4
Iron (NaFeEDTA)	15,0	28,8	6,585	63,9	48,1
Zinc	30,0	45,0	13,170	112,9	94,1
Males, 51-65 years: P-50 Food Intake of target group = 430,2 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,355	188,6	150,8
Vit. B-12	0,008	N.D.	0,003	146,3	121,9
Iron (NaFeEDTA)	15,0	27	6,453	62,6	47,1
Zinc	30,0	45,0	12,907	110,6	92,2
Males, +65 years: P-50 Food Intake of target group = 360,0 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,297	157,8	126,2
Vit. B-12	0,008	N.D.	0,002	122,4	102,0
Iron (NaFeEDTA)	15,0	25,2	5,400	52,4	39,4
Zinc	30,0	45,0	10,799	92,6	77,1
Females, 10-18 years: P-50 Food Intake of target group = 338,0 g/day					
Vit. B-9 (Folate)	1,0	0,7	0,279	148,2	118,5
Vit. B-12	0,008	N.D.	0,002	114,9	95,8
Iron (NaFeEDTA)	15,0	18	5,070	29,6	15,6
Zinc	30,0	28,0	10,141	84,5	70,4
Females, 19-50 years: P-50 Food Intake of target group = 346,8 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,286	152,0	121,6

Nutrient	Addition level to flour, mg/kg	Adjusted upper limit, mg/day	Daily intake of micronutrients in the composition of fortified wheat flour		
			mg/day[a]	% EAR/day	% RNI/day
Vit. B-12	0,008	N.D.	0,002	117,9	98,3
Iron (NaFeEDTA)	15,0	23,4	5,202	39,3	17,7
Zinc	30,0	45,0	10,404	127,4	106,2
Females, 51-65 years: P-50 Food Intake of target group = 342,4 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,282	150,1	120,1
Vit. B-12	0,008	N.D.	0,002	116,4	97,0
Iron (NaFeEDTA)	15,0	25,2	5,136	100,9	45,5
Zinc	30,0	45,0	10,273	125,8	104,8
Females, +65 years: P-50 Food Intake of target group = 307,3 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,254	134,7	107,7
Vit. B-12	0,008	N.D.	0,002	104,5	87,1
Iron (NaFeEDTA)	15,0	21,6	4,610	65,3	40,8
Zinc	30,0	45,0	9,219	112,9	94,1

Notes:

[a] - These values are calculated taking in consideration the micronutrient losses during storage and distribution, as well as during cooking.

EAR = Estimated Average Requirement is the daily intake which meets the nutrient requirements of 50% apparently healthy individuals in an age- and gender-specific population.

RNI = Recommended nutrient intake is the daily intake which meets the nutrient requirements of almost all (97.5%) apparently healthy individuals in an age- and gender-specific population.

* N.D. = Not determined

Annex 2 – High-extraction wheat flour fortification characteristics and daily intake of micronutrients by population groups in the composition of fortified wheat flour, in Pakistan

Pakistan: High-extraction wheat flour fortification

Nutrient	Addition level to flour, mg/kg	Adjusted upper limit, mg/day	Daily intake of micronutrients in the composition of fortified wheat flour		
			mg/day[a]	% EAR/day	% RNI/day
Children, 1-3 years: P-50 Food Intake of target group = 115,2 g/day					
Vit. B-9 (Folate)	1,0	0,3	0,095	134,6	107,7
Vit. B-12	0,008	N.D.	0,001	113,1	87,0
Iron (NaFeEDTA)	15,0	4,7	1,728	69,4	29,8
Zinc	30,0	7,0	3,455	50,0	41,6
Children, 4-6 years: P-50 Food Intake of target group = 146,3 g/day					
Vit. B-9 (Folate)	1,0	0,4	0,121	128,3	102,6
Vit. B-12	0,008	N.D.	0,001	99,5	82,9
Iron (NaFeEDTA)	15,0	7,2	2,195	84,7	34,8
Zinc	30,0	12,0	4,389	54,9	45,7
Children, 7-9 years: P-50 Food Intake of target group = 183,7 g/day					
Vit. B-9 (Folate)	1,0	0,5	0,152	107,3	85,9
Vit. B-12	0,008	N.D.	0,001	83,3	69,4
Iron (NaFeEDTA)	15,0	10,1	2,755	75,2	31,0
Zinc	30,0	12,0	5,510	59,0	49,2
Males, 10-18 years: P-50 Food Intake of target group = 286,4 g/day					
Vit. B-9 (Folate)	1,0	0,7	0,236	125,5	100,4
Vit. B-12	0,008	N.D.	0,002	97,4	81,1
Iron (NaFeEDTA)	15,0	19,8	4,296	34,4	24,5
Zinc	30,0	28,0	8,592	60,3	50,2
Males, 19-50 years: P-50 Food Intake of target group = 311,3 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,257	136,4	109,1
Vit. B-12	0,008	N.D.	0,002	105,8	88,2
Iron (NaFeEDTA)	15,0	28,8	4,670	45,3	34,1
Zinc	30,0	45,0	9,339	80,0	66,7
Males, 51-65 years: P-50 Food Intake of target group = 305,1 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,257	136,4	109,1
Vit. B-12	0,008	N.D.	0,002	105,8	88,2
Iron (NaFeEDTA)	15,0	28,8	4,670	45,3	34,1
Zinc	30,0	45,0	9,339	80,0	66,7
Males, +65 years: P-50 Food Intake of target group = 255,3 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,211	111,9	89,5
Vit. B-12	0,008	N.D.	0,002	86,8	72,3
Iron (NaFeEDTA)	15,0	25,2	3,829	37,2	27,9
Zinc	30,0	45,0	7,658	65,6	54,7
Females, 10-18 years: P-50 Food Intake of target group = 239,7 g/day					
Vit. B-9 (Folate)	1,0	0,7	0,198	105,1	84,0
Vit. B-12	0,008	N.D.	0,002	81,5	67,9
Iron (NaFeEDTA)	15,0	18	3,596	21,0	11,1
Zinc	30,0	28,0	7,191	59,9	49,9
Females, 19-50 years: P-50 Food Intake of target group = 245,9 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,203	107,8	86,2

Nutrient	Addition level to flour, mg/kg	Adjusted upper limit, mg/day	Daily intake of micronutrients in the composition of fortified wheat flour		
			mg/day[a]	% EAR/day	% RNI/day
Vit. B-12	0,008	N.D.	0,002	83,6	69,7
Iron (NaFeEDTA)	15,0	23,4	3,689	27,9	12,5
Zinc	30,0	45,0	7,378	90,3	75,3
Females, 51-65 years: P-50 Food Intake of target group = 242,8 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,200	106,4	85,1
Vit. B-12	0,008	N.D.	0,002	82,6	68,8
Iron (NaFeEDTA)	15,0	25,2	3,642	71,6	32,2
Zinc	30,0	45,0	7,284	89,2	74,3
Females, +65 years: P-50 Food Intake of target group = 217,9 g/day					
Vit. B-9 (Folate)	1,0	1,0	0,180	95,5	76,4
Vit. B-12	0,008	N.D.	0,001	74,1	61,7
Iron (NaFeEDTA)	15,0	21,6	3,269	46,3	28,9
Zinc	30,0	45,0	6,537	80,0	66,7

Notes:

[a] - These values are calculated taking in consideration the micronutrient losses during storage and distribution, as well as during cooking.

EAR = Estimated Average Requirement is the daily intake which meets the nutrient requirements of 50% apparently healthy individuals in an age- and gender-specific population.

RNI = Recommended nutrient intake is the daily intake which meets the nutrient requirements of almost all (97.5%) apparently healthy individuals in an age- and gender-specific population.

* N.D. = Not determined

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Acknowledgement: This document was made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contests are the responsibility of the Kazakh Academy of Nutrition (KAN) and GAIN and do not necessarily reflect the views of USAID or the United States Government.