Perspective: Closing the Dietary Fiber Gap: An Ancient Solution for a 21st Century Problem[1,2]

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ABSTRACT

An important gap exists between the daily amounts of fiber recommended in the human diet (28–42 g/d) and that which is actually consumed (median intake, 12–14 g/d). In fact, <5% of Americans meet the recommended intake for dietary fiber, and the magnitude of the gap is large, approximately a 50–70% shortfall. Because considerable evidence indicates that dietary fiber affects normal physiologic function and the onset of chronic diseases and their progression, the fiber gap represents an opportune target at which dietary interventions can be directed. This perspective considers whether a scientific basis exists for the current lack of emphasis on pulse crops, that is, grain legumes (common bean, chickpea, lentils, and garden pea) as a concentrated, inexpensive, and widely available source of dietary fiber. Attention is directed to this topic because the fiber gap has existed for decades with little improvement despite nutrition labeling, consumer education about the value of whole-grain cereal crop-based products, and the introduction of many fiber-enriched foods. The time is long overdue to identify additional approaches that have the potential to close the dietary fiber gap. To this end, the potential role of pulse crops in remediating this gap is examined. *Adv Nutr* 2016;7:623–6.

Keywords: dietary fiber, dietary fiber gap, dietary intake, pulse crops, cereal crops

Introduction

The carbohydrate polymers of plants in the human diet that cannot be hydrolyzed by the endogenous enzymes in the small intestine are referred to as dietary fiber (1). Dietary fiber has many characteristics, some of which have been reported to affect physiologic function (2). In addition, increasing the amount of fiber in the diet is associated with reduced risk of several chronic diseases (3, 4). However, inadequate dietary fiber intake is widespread with <5% of all Americans meeting recommended intake amounts (5), and similar deficits exist globally. Low dietary intake and the pandemic rates of obesity and associated chronic diseases, that is, type 2 diabetes, cardiovascular and cerebrovascular diseases, and several types of cancer, have prompted a resurgence of interest in dietary fiber intake and human health (5–8). Moreover, because an internationally accepted consensus definition of dietary fiber has emerged (9), and a validated, integrated method of dietary fiber analysis that complies with that definition has been developed, that is, AOAC 2011.25 (10), the opportunity exists to minimize technical differences between laboratories in analysis and interpretation of food composition data. This will facilitate the translation of what is known into forward-thinking public health guidance. Our perspective focuses on sources of dietary fiber, as naturally occurring in food, that is, category 1 of the new consensus definition (9), and whether a scientific basis exists for the current lack of emphasis on pulse crops as reflected by the absence of their mention in planning efforts to close the gap in dietary fiber (5–8). Although the new Dietary Guidelines for Americans do recommend foods such as pulses, they do not specifically mention them for fiber, an important omission because pulses are an affordable, widely available, and concentrated source of dietary fiber. To address this issue, 2 sources of foods are considered, namely, cereal crops, which are a primary focus of efforts to increase dietary fiber consumption over the past few decades, and pulse crops, which are one of the most concentrated whole-food sources of dietary fiber (**Table 1**).

Establishing a Basis for Comparing Dietary Fiber Content between Food Crops

Although the major fractions of total dietary fiber are insoluble, soluble, and oligosaccharides, the specific chemical components that contribute to these fractions are briefly considered to facilitate an understanding of differences between food crops in the characteristics of the fiber they contain. A list of chemical components of dietary fiber in

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TABLE 1 Dietary fiber, protein, and kcal per 100-g portion (as eaten) of pulse and cereal crops

Crop[1]	Bean[2] (common)	Lentils[3]	Chickpea[4]	Pea[5] (garden)	Wheat[6]	Rice[7] (brown)	Corn[8] (sweet)	Bean[9] (soy)	Peanut[10]
Energy, kJ	599	486	686	351	1054	514	402	590	1330
Protein, g	9.0	9.0	8.9	5.4	12.6	2.7	3.4	12.4	13.5
Lipid, g	0.7	0.4	2.6	0.2	3.5	1.0	1.5	6.4	22.0
Fiber, g	9.0	7.9	7.6	5.5	6.0	1.6	2.4	4.2	8.8
Fiber, g/100 kJ	1.5	1.6	1.1	1.6	0.6	0.3	0.6	0.7	0.7

[1] Values for food composition taken from USDA Nutrient Database for Standard Reference: Release 28.
[2] Bean, pinto, mature seeds, cooked, boiled. Database reference number 16043.
[3] Lentils, mature seeds, cooked, boiled. Database reference number 16070.
[4] Chickpea, mature seeds, cooked, boiled. Database reference number 16057.
[5] Pea, green, cooked, boiled. Database reference number 11305.
[6] Bread, whole wheat, commercially prepared. Database reference number 18075.
[7] Rice, brown, long grain, cooked. Database reference number 20037.
[8] Corn, sweet, yellow, cooked, boiled. Database reference number 11168.
[9] Soybeans, green, cooked, boiled. Database reference number 11451
[10] Peanuts, all types, cooked, boiled. Database reference number 16088.

foods, and the fractions associated with each chemical component from the AOAC 2011.25 method are listed (**Table 2**), when that information is available. In this classification matrix, dietary fibers are grouped according to their chemical structure. The groups are as follows: glucose polymers with α-1,4 linkages (resistant starch), β linkages (glucans), and polymers that mainly consist of mannose (mannans), fructose (fructans), xylose (xylans), and galacturonic acid (pectins). The chemical components of dietary fiber that are considered fermentable and/or viscous are also noted.

Cereal and Pulse Crops

Most cereal crops are members of the grass or Graminacea family. The FAO designates crops in this family as cereal crops if they are harvested for their dry seed or grain (11). Species of the grass family members harvested for forage or silage or grazed are classified as fodder crops. FAO lists 17 cereal grains. Of these, wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and maize (*Zea mays* L.) are the predominant staple cereal crops. Pulse crops are members of the botanical family Fabaceae, also referred to as Leguminosae. FAO defines pulses as grain legumes (12) and excludes the immature pods of common bean and garden pea and oil seed legumes such as soy beans (*Glycine max* L.) and peanuts (*Arachis hypogaea* L.). Because the dietary fiber and lipid composition of pulses and oil seed legumes differ markedly (Table 1), it is important to distinguish between these 2 categories of legumes. Of the pulse crops recognized by FAO, the following 4 are considered to be the dominant types of pulses consumed: common bean (*Phaseolus vulgaris* L.), chickpea (*Cicer arietinum* L.), garden pea (*Pisum sativum* L.), and lentils (*Lens culinaris* L.), and they have more than twice the concentration of dietary fiber as either cereal grains or oil seed legumes (Table 1).

Comparison of Pulse and Cereal Crops

No studies were identified that compared cereal crops with pulse crops when each crop was prepared in a similar manner with the use of the recently published consensus method, AOAC 2011.25, for dietary fiber analysis. Therefore, the work of Dodevska et al. (13) was adapted for use in **Table 3**, recognizing that it is likely that those data underestimate soluble fiber because the values are based on AOAC 985.29. The results presented indicate that the components of the plant cell wall that contribute to dietary fiber are found in both cereal and pulse crops, with few exceptions. Similarly, storage forms of carbohydrate such as resistant starch, fructans, and galactans included in the new CODEX definition of dietary fiber are also found across these crop species,

TABLE 2 Summary of chemical characteristics of dietary fiber in foods[1]

	Dietary fiber characteristic				
Main components	Insoluble dietary fiber	Soluble dietary fiber	Fermentable	Viscous	Polymer type
Cellulose	HMW				Glucan
Lignin	HMW				Monolignol
Resistant starch		HMW[2]	X	X	Type 1, 2, 3, 4
Hemicelluloses	HMW	HMW[2]	X	X	Xylan, galactan, araban, mannan, others
Pectins	HMW	HMW[2]	X	X	Galacturonic acid
Arabinoxylans		HMW[2]	X	X	Xylan
β-Glucans		HMW[2]	X	X	Glucan
Gums		HMW[2]	X	X	Mannan
Mucilages		HMW[2]		X	
Inulin		LMW	X		Fructan
Fructooligosaccharides (nystose, kestose)		LMW	X		Fructan
Galactooligosaccharides (raffinose family)		LMW	X		Raffinose family

[1] HMW, high molecular weight; LMW, low molecular weight; X, the main component has the identified characteristic.
[2] Soluble in aqueous solution but precipitates in 80% ethanol (vol:vol).

TABLE 3 Dietary fiber components in cooked cereals and pulses (g/100 g dry matter)[1]

Crop	Fructans	Arabinoxylan	Cellulose	β-Glucan	Resistant starch	Dietary fiber[2]
Wheat	2.9 ± 0.8	5.9 ± 0.4	2.5 ± 0.4	0.6 ± 0.04	1.3 ± 0.2	12.9 ± 2.1
Corn, sweet	1.1 ± 0.1	1.4 ± 0.1	1.9 ± 0.3	ND	3.1 ± 0.6	8.1 ± 1.0
Rice, whole meal	2.2 ± 0.2	0.5 ± 0.04	1.6 ± 0.2	0.4 ± 0.1	0.5 ± 0.2	7.0 ± 0.8
Bean	1.4 ± 0.2	2.2 ± 0.3	6.0 ± 0.5	ND	4.8 ± 0.3	18.2 ± 1.6
Lentils	1.5 ± 0.3	1.0 ± 0.1	5.4 ± 1.3	ND	2.1 ± 0.2	12.5 ± 2.0
Pea	1.2 ± 0.1	1.1 ± 0.2	8.1 ± 0.5	ND	6.3 ± 0.1	19.6 ± 2.3

[1] Values are means ± SDs. n = 3 independent determinations. Data shown from reference 13. ND, not detectable.
[2] Dietary fiber by AOAC 985.29.

although galactans dominate in pulse crops; whereas fructans, mannans, and xylans are the predominate oligosaccharides in cereals. It appears that the differences that exist in dietary fiber amount and type between pulse and cereal seeds arise from differences in their anatomy and physiology. From a chemical perspective, these differences influence the amount of the various dietary fiber components present in each crop species. In general, the qualitative differences, that is, the presence or absence of specific chemical components observed in cereals and pulses, are small and fail to provide a rationale for de-emphasizing pulse crop consumption to close the fiber gap, given the concentration of dietary fiber that they contain per kilocalorie. Rather, the data suggest that eating pulse crops in addition to cereal grains has the potential to markedly increase dietary fiber intake because pulse crops are ≥2-fold higher in dietary fiber than cereal grains. Moreover, pulses are generally eaten as a whole food, whereas cereal grains are used as ingredients in making other foods, for example, whole-grain bread, which dilutes the amount of fiber actually consumed. The recommendation to eat pulse crops in addition to cereal grains resonates well with recent discussions about how to close the dietary fiber gap, the tenets of which include the following: all fibers fit, mixes of fiber are better tolerated, and no clear evidence exists that one type of dietary fiber, for example, soluble compared with insoluble, is better than another for health promotion and disease prevention (5–8).

Impact of Pulse Consumption on Dietary Fiber Intake

To illustrate the impact of pulse crop consumption, 2 studies were examined in which national dietary intake databases from the United States and from Canada were used to characterize food consumption in individuals who either consumed pulses or who were nonusers (14, 15). It was observed that intake of cereal grains (in servings/d) was similar across nonconsumers and consumers of pulses (Table 4). However, in individuals who consumed pulses, dietary fiber was significantly increased. In the highest quartile of pulse consumption, dietary fiber intake was 31 g/d in the Canadian population and 36 g/d in the US population. Evidence from the AARP cohort indicates that such levels of intake would yield important benefits relative to the onset and/or progression of chronic diseases (4). Currently, no upper limit of dietary fiber intake is considered unsafe, so concerns about detrimental effects would largely depend on individual levels of tolerance of high dietary fiber patterns of food consumption.

Achieving Success by Shifting Focus within an Existing Food Guidance Paradigm

One of the observations that emerges from reviewing the various dietary guidance recommendations used by national committees and international organizations is that there are inconsistencies between groups that draft dietary guidelines about where to include recommendations for pulse consumption (16, 17). Confusion also exists about what pulses are called; for example, legumes, which allows their consumption to be confused with soy products or peanuts, or their immature parts (fleshy pods) or vegetables that includes many other foods listed as vegetables, which vary considerably in both fiber and protein content. In an effort to be clear and practical, we advance the idea of presenting dietary guidance in a format that emphasizes a long-standing, as it were, "ancient" relation that can be traced back to the origins of agriculture as detailed in (18). Specifically, cereal and pulse crops should be consumed in combination. Moreover, from the work of Bressani (19), an existing WHO metric can be highlighted (20), namely that these crops be consumed in a serving's ratio of 2:1, cereal:pulse grain, which is considered optimal relative to protein quality.

TABLE 4 Dietary fiber intake of pulse crop by consumers and nonconsumers

Dietary fiber intake	Nonconsumers[1]	High consumers[1]	Nonconsumers[2]	High consumers[2]
Cereal grains, servings/d	6.5	6.4	5.8	6.3
Pulse grains, g/d	0	277	0	294
Protein, g/d	80	106	85	101
Fiber, g/d	14	36	17	31
Fiber, g/4184 kJ	7.0	13.6	8.5	13.8

[1] Data shown are from reference 14.
[2] Data shown are from reference 15.

Pulses are not only a concentrated source of dietary fiber but also of dietary protein. In fact, consumption of foods in the recommended 2:1 ratio of cereal grains to pulses renders a protein source of high biological value at an extremely affordable cost (19). In addition, pulse crops are excellent sources of vitamins such as folate and of minerals, particularly magnesium, potassium, and iron, which are considered underconsumed nutrients by the USDA.

Summary

Important efforts are under way to close the fiber gap in the human diet (5–8). To succeed in conquering 21st century grand challenges and the looming specter of the physical, psychosocial, and financial burden of chronic disease (21), the scientific literature indicates that closing the dietary fiber gap will contribute to this objective in a substantive manner. We propose that closing the fiber gap can be achieved by explicit endorsement of an ancient concept: consume cereal and pulse crops in combination as dietary staples, in adequate amounts every day. This strategy is consistent with guiding principles of the initiative to close the fiber gap, including that a mixture of fibers increases benefit and tolerance, recognizing that no clear evidence suggests that one type of dietary fiber, for example, soluble compared with insoluble, is better than another.

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