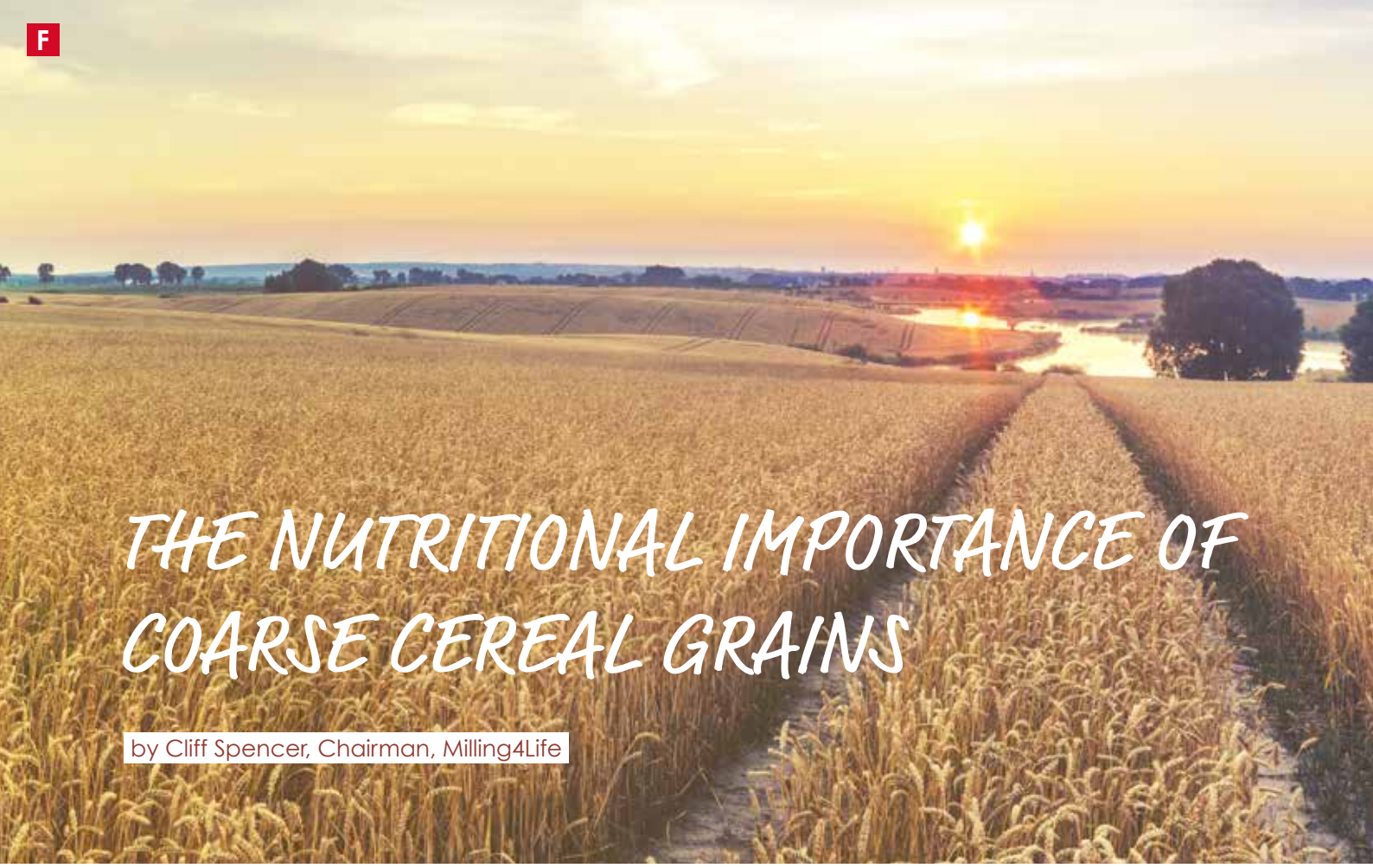


THE NUTRITIONAL IMPORTANCE OF COARSE CEREAL GRAINS

by Cliff Spencer, Chairman, Milling4Life

I have recently promoted some lesser-known cereal crops for use by millers and their major milling feedstock supply potential in developing countries. I described the agricultural, environmental and climatic reasons for millers pursuing the development of these feedstocks.

Now to consider their positive and all-important nutritional aspects.

Cereal grains consist of three major parts, and different nutrients reside in these parts.

There is the bran – the outer layer of the grain containing fibre, omega-3 fatty acids, vitamins and dietary minerals, the endosperm – the main part of the grain consisting mainly of starch, and the germ – the smallest part of the grain, containing vitamin Ee, folate, thiamine, phosphorus and magnesium.

Cereal is typically a low-fat, nutrient-dense food with many essential vitamins and minerals and delivers important nutrients and essential vitamins such as iron, B vitamins and zinc.

Currently, important cereals such as rice, wheat and maize are particularly important to humans because of their role as staple food crops in many areas of the world. Rice is the most valuable agricultural crop in the world but it is second to maize (corn) in the quantity of cereal products produced.

However coarse grains are food cereal grains other than wheat and rice and they also are used for animal feed and brewing. As previously described these coarse grains are warm-season cereals valued for their food, feed and fodder uses in various parts of the world. They are largely grown in the semi-arid tropical regions of Asia and Africa; under rain-fed farming systems with little external inputs and with current grain yield levels being low.

Coarse cereals include maize, sorghum, oats, barley, pearl millet and other minor millets such as Finger, Kodo, Proso, Foxtail, Little and Barnyard millet. These grains are rich in dietary energy, vitamins, several minerals (especially micronutrients such as iron and zinc), insoluble dietary and phytochemicals with antioxidant properties.

Indeed, these coarse cereals dubbed as 'poor man's crops', have remained neglected with respect to their appropriate position in the commercialised food system, and the required investment in research and development.

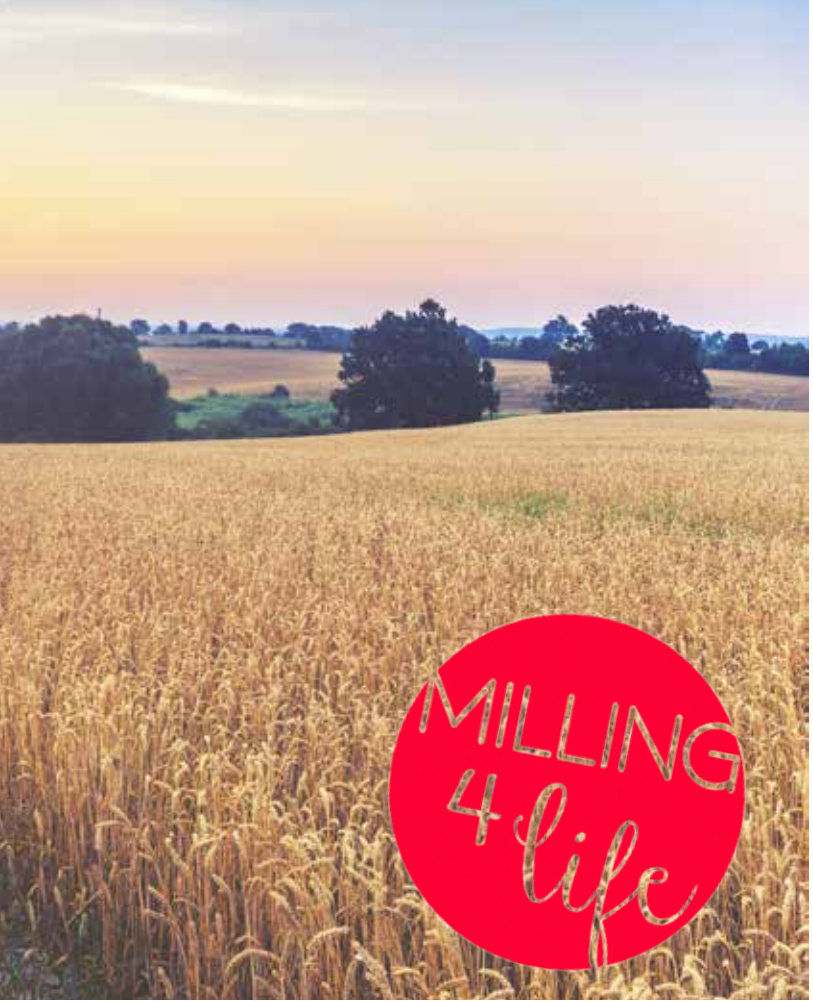
Now with the increasing concerns about adverse changes in environmental quality and its consequent negative effects on food and nutritional security they are demanding industry attention. Link this with the need for increasing food production per unit resource investment for an ever increasing population, and these coarse grains have good prospects of penetrating the food baskets of a wider range of consumers, both rural and urban, poor and rich and in developed and developing economies.

Research and development on potential uses of these coarse cereal grains is bringing out the potential of these grains for being used as formulated foods and these coarse cereals have of late even been designated as nutricereals. They are rich in compounds that help against several chronic diseases like ischemic strokes, cardiovascular diseases, cancers, obesity and type II diabetes.

Composition of some of the major cereals including coarse cereals and millets is presented in Table 1. They are nutritionally comparable or even superior to major cereals such as wheat and rice, owing to their higher levels of protein with more balanced amino acid profile (good source of methionine, cystine and lysine).

The amino acid profile of major coarse cereals is given in Table 2.

These coarse cereal grains are laden with phytochemicals including phenolic acids, tannins, anthocyanins, phytosterols, avenenathramides and policosanols. They possess higher antioxidant properties in vitro than staple cereals and fruits by different purported pathways. There are also some anti-nutritional factors that may be reduced by certain processing treatments so the skill of the miller will be paramount in bringing these underutilised crops and their superior products to market.



Several epidemiological studies show that these cereals are helpful in reducing several kinds of chronic diseases like cancers, cardiovascular diseases, type II diabetes and various gastrointestinal disorders.

Being coarse in nature, they cannot replace our staple cereals, but can be used in different proportions with rice and wheat to formulate various nutritional products. They can be used to make porridges, biscuits, cakes, cookies, tortillas, bread, probiotic drinks, ladoo, ghatta, flakes and several fermented foods.

As an aside, these coarse cereals also have good potential in manufacturing bioethanol, paper, oil and biofilms.

Coarse these grains may be, but they are very sophisticated in their properties and potentials!

Cancer

Cancer is a leading cause of death throughout the world according to World Health Organisation (WHO) estimates.

Several in vitro and in vivo studies reveal that coarse cereals contain various components such as β-glucans, lignans, antioxidants and phytosterols which play important roles in prevention of breast, prostate, colo-rectal and other cancers. Dietary sitosterol (SIT) may offer protection from chemically induced colon cancer and lignins selectively increase growth of bifidobacteria, which have anticancer potential or enhance formation of short chain fatty acids (SCFA) such as acetate, butyrate and propionate.

Butyrate reduces cancer cell survival by inducing apoptosis and inhibiting proliferation in tumour cells. Thus butyrate acts on secondary chemoprevention by reducing the number of cells in cancerous lesions and thereby slowing or inhibiting formation of malignant tumours.

The possible mechanisms of action of lignan as an anti-carcinogen may be due to direct binding to the carcinogen resulting in excretion through faeces, lowering the pH of the tract or specific action of butyrate when fermented by colonic bacteria.

Table 1: Nutrient composition of sorghum, millets and otehr cerels (per 100 g edible portion, 12% moisture)

Food	Protein (g)	Fat (g)	Ash (g)	Crude Fibre (g)	Carbo -hydrate (g)	Energy (kcal)	Ca (mg)	Fe (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)
Rice (brown)	7.9	2.7	1.3	1	76	362	33	1.8	0.41	0.04	4.3
Wheat	11.6	2	1.6	2	71	348	30	3.5	0.41	0.1	5.1
Maize	9.2	4.6	1.2	2.8	73	358	26	2.7	0.38	0.2	3.6
Sorghum	10.4	3.1	1.6	2	70.7	329	25	5.4	0.38	0.15	4.3
Pearl Millet	11.8	4.8	2.2	2.3	67	363	42	11	0.38	0.21	2.8
Finger millet	7.7	1.5	2.6	3.6	72.6	336	350	3.9	0.42	0.19	1.1
Foxtail millet	11.2	4	3.3	6.7	63.2	351	31	2.8	0.59	0.11	3.2
Common millet	12.5	3.5	3.1	5.2	63.8	364	8	2.9	0.41	0.28	4.5
Little millet	9.7	5.2	5.4	7.6	60.9	329	17	9.3	0.3	0.09	3.2
Barnyard millet	11	3.9	4.5	13.6	55	300	22	18.6	0.33	0.1	4.2
Kodo millet	9.8	3.6	3.3	5.2	66.6	353	35	1.7	0.15	0.09	2
Oats	17	6	2.6	11	66	390	54	4.7	0.22	0.12	3.2

Table 2: Essential amino acids in cereals and millets (g/100 g of protein)

Amino Acids	Finger millet	Kodo millet	Proso millet	Foxtail millet	Barnyard millet	Wheat	Rice
Isoleucin	4.4	3	8.1	7.6	8.8	3.3	3.8
Leucine	9.5	6.7	12.2	16.7	16.6	6.7	8.2
Lysine	2.9	3	3	2.2	2.9	2.8	3.8
Methionine	3.1	1.5	2.6	2.8	1.9	1.5	2.3
Cystine	2.2	2.6	1	1.6	2.8	2.2	1.4
Phenyl alanine	5.2	6	4.9	6.7	2.2	4.5	5.2
Tyrosine	3.6	3.5	4	2.2	2.4	3	3.9
Threonine	3.8	3.2	3.2	2.7	2.2	2.8	4.1
Tryptophan	1.6	0.8	0.8	1	1	1.5	1.4
Valine	6.6	3.8	6.5	6.9	6.4	4.4	5.5
Histidine	2.2	1.5	1.9	2.1	1.9	2.3	2.4

Oat fibres also act as a prebiotic in the colon and hence are effective in colorectal cancer. Sorghum consumption is consistently correlated with low incidences of esophageal cancer in various parts of the world including several parts of Africa, Russia, India, China, Iran, etc. and the phenol content of sorghum was correlated with its antioxidant activity.

Cardiovascular diseases (CVD)

According to World Health Organization (WHO) estimates CVD accounts for 30 percent of all deaths globally. Coarse cereals have antioxidant and cholesterol lowering properties, and hence, lower the risk of Coronary Heart Diseases (CHD).

Fibres, phytosterols, β-glucans and policosanols have anti-cholesterolemic properties whereas flavonoids and anthocyanins have antioxidant properties. Policosanols are reported to reduce plasma LDL-cholesterol levels by suppressing 3-hydroxy 3-methylglutaryl- CoA (HMG CoA) reductase activity and increasing LDL receptor uptake by cells. Oat bran reduces total serum cholesterol in hypercholesterolemic subjects by as much as 23 percent with no change in high density lipoprotein (HDL) cholesterol.

There is an average reduction of 11 percent in the plasma total on consumption of 140g of rolled oats . The FDA claim for oats determined that an effective daily intake of β-glucan for controlling serum cholesterol level is three grammes. This can differ among different individuals and depends upon initial cholesterol content of the subject.

However, guinea pigs fed with 58 percent low tannin sorghum proved more beneficial in lowering cholesterol than rolled oats, wheat or pearl millet. Consumption of 3 or 6 g β-glucan in barley diet resulted in significant reduction in total cholesterol content among mildly hypercholesterolemic individuals as compared to control groups.

However, there was no significant effect on HDL cholesterol and triacyglycerol concentration.

Diabetes

A high intake of cereal fibre has consistently been associated with a lower risk of diabetes. Foods low in glycemic index (GI) help in weight management, as they promote satiety. Several intervention studies have found that energy-restricted diets based on low-GI foods produce greater weight loss than those based on high-GI foods.

A decrease in peak and average increase in glucose and insulin was observed in non-Insulin dependent diabetes mellitus (NIDDM) subjects when they are fed with extruded breakfast cereal enriched with β-glucan (~15% dwb). It has been shown that the viscosity of β-glucan could account for 79–96 percent of the changes in plasma glucose and insulin response to 50 g glucose in a drink model.

Weight management

Numerous studies have linked higher intake of dietary fibre to improved management of body weight. It has been conclusively demonstrated that lean men and women have significantly higher fibre intake compared to obese males and females.

Higher fibre intake is associated with lower body mass index (BMI) in both men and women. Oats, barley and other coarse cereals being a rich source of fibres provide high satiety value, decrease the appetite and hence help in weight management. Numerous reports on reduced weight gain of animals (rats, pigs, rabbits, poultry) fed on high tannin sorghum are also available.

The mechanisms by which tannin reduces nutritive value include binding of food proteins and carbohydrates or binding of digestive enzymes including sucrase, amylases, trypsin, chymotrypsin and lipases thus inhibiting their activity. Inhibition of intestinal brush-border bound amino acid transporters by sorghum tannins is also reported.

So millers, there is much to gain from developing these crops and food/health products and huge potential benefits to engage and help build success in developing countries.