UNIVERSITY OF CAMBRIDGE

Foxtail millet: could the sustenance of our ancestors become a health food and contribute to food diversity in the future?

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Food security:

"when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life"

(WHO, World Food Summit 1996)

"The issue of food security is an outdated concept – we face the issue of food accountability"

Angela Raven Roberts, at the 2nd Annual Food Security Conference, University of Oxford 2013

Food sovereignty:

A people's right to define their own agricultural and food policy

(Declaration of Nyeleni, 2007)

Food diversity

“an indicator of food security”

(Hoddinott & Yohannes, 2002)

Rice, wheat, maize and potatoes account for over 50% of calories consumed by the human population

Orphan crops – stuck in a vicious circle. If there is no international market, no research is carried out on these crops…

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Crop diversity decline 'threatens food security'

By Mark Kinver
Environment reporter, BBC News

A growing reliance on crops such as wheat helps feed a growing population - but at what cost?

Fewer crop species are feeding the world than 50 years ago - raising concerns about the resilience of the global food system, a study has shown.

The authors warned a loss of diversity meant more people were dependent on key crops, leaving them more exposed to harvest failures.

Higher consumption of energy-dense crops could also contribute to a global rise in heart disease and diabetes, they added.

The **study appears in the journal PNAS**.

"Over the past 50 years, we are seeing that diets around the world are changing and they are becoming more similar - what we call the 'globalised diet'," co-author Colin Khoury, a scientist from the Colombia-based International Center for Tropical Agriculture, said.

Related Stories

Key crops head to 'doomsday vault'

Uncertainty hampering food security

Climate 'drives crop pest spread'

FOGLIP
(Food Globalisation In Prehistory)

- Researching the initial phase of food globalisation – the spread of starchy cereal crops wheat, barley, broomcorn millet and foxtail millet as well as buckwheat

- How early did the globalisation of these crops take place?
- What were the routes of spread?
- What impact did this have on early societies?

- Interdisciplinary approach: archaeobotany, stable isotope analysis, genetic analysis of ancient and modern plant material

Millets

- Millets are an important functional group of small-grained cereal crop species in the Panicoideae and Eragrostidaeae subtribes of the grasses
- They are cultivated in the semi-arid subtropics

- Pearl millet
- Finger millet
- Proso millet
- Foxtail millet
- Fonio
- Barnyard millet
- Kodo millet
- Little millet
- Teff




- Over 95% of millet production is in developing countries!

Perception of millets

- Catch crop, can be grown to “fill the gap” if yield from main crop (such as rice) is poor

- To a small extent grown in the US, Australia and Europe, where its main use is as fodder

- In Chinese and Japanese cultures: associations with famine

“This country is no better than a scattering of millet, a place where hearts know only sadness”

(from *The tale of the Heike*, an epic poem about the Genpei War 1180-1185)

Health benefits of millet

Table C8.1 Nutrients in white rice and minor millets

Food (100 g)	*Energy (Kcal)*	*Protein (g)*	*Fat (g)*	*Fiber (g)*	*Carbohydrate (g)*	*Phosphorous (mg)*	*Calcium (mg)*	*Iron (mg)*
Rice (*Oryza sativa*)	346	6.4	0.4	0.2	79.0	143.0	9.0	1.0
Common millet (*Pennisetum glaucum*, "Bajra, Cambu")	361	11.6	5.0	1.2	67.5	296.0	42.0	8.0
Italian millet (*Setaria italica* "Thenai")	331	12.3	4.3	8.0	60.9	290.0	31.0	2.8
Proso millet (*Panicum miliaceum* "Pani-varagu")	341	12.5	1.1	2.2	70.4	206.0	14.0	0.8
Finger millet (*Eleusine coracana* "Ragi")	328	7.3	1.3	3.6	72.0	283.0	344.0	3.9
Little millet (*Panicum sumatrense* "Samai")	341	7.7	4.7	7.6	67.0	220.0	17.0	9.3
Kodo millet (*Paspalum scrobiculatum* "Varagu")	309	8.3	1.4	9.0	65.9	188.0	17.0	0.5

Source: Modified from Gopalan et al., 2004

- Slow release of sugar: good for diabetes patients
- Lack of gluten: suitable for people with coeliac disease
- In Tanzania millet consumption it is recommended for AIDS patients – its health benefits make the drugs more effective

Ecological advantages of millets

- Able to withstand limited rainfall and poor soil fertility
- Rich in **genetic diversity** - compared to wheat, rice and maize, which is linked to:

Phenological diversity, useful in farming areas where timing of the rainy season is unpredictable

Resistance to common crop diseases

C_4 plant – less affected by rising CO_2 levels

LETTER

doi:10.1038/nature13179

Increasing CO_2 threatens human nutrition

Samuel S. Myers[1,2], Antonella Zanobetti[1], Itai Kloog[3], Peter Huybers[4], Andrew D. B. Leakey[5], Arnold J. Bloom[6], Eli Carlisle[6], Lee H. Dietterich[7], Glenn Fitzgerald[8], Toshihiro Hasegawa[9], N. Michele Holbrook[10], Randall L. Nelson[11], Michael J. Ottman[12], Victor Raboy[13], Hidemitsu Sakai[9], Karla A. Sartor[14], Joel Schwartz[1], Saman Seneweera[15], Michael Tausz[16] & Yasuhiro Usui[9]

Dietary deficiencies of zinc and iron are a substantial global public health problem. An estimated two billion people suffer these deficiencies[1], causing a loss of 63 million life-years annually[2,3]. Most of these people depend on C_3 grains and legumes as their primary dietary source of zinc and iron. Here we report that C_3 grains and legumes have lower concentrations of zinc and iron when grown under field conditions at the elevated atmospheric CO_2 concentration predicted for the middle of this century. C_3 crops other than legumes also have lower concentrations of protein, whereas C_4 crops seem to be less affected. Differences between cultivars of a single crop suggest that breeding for decreased sensitivity to atmospheric CO_2 concentration could partly address these new challenges to global health.

experiments contribute more than tenfold more data regarding both the zinc and iron content of the edible portions of crops grown under FACE conditions than is currently available in the literature. Consistent with earlier meta-analyses of other aspects of plant function under FACE conditions[14,15], we considered the response comparisons observed from different species, cultivars and stress treatments and from different years to be independent. The natural logarithm of the mean response ratio (r = response in elevated $[CO_2]$/response in ambient $[CO_2]$) was used as the metric for all analyses. Meta-analysis was used to estimate the overall effect of elevated $[CO_2]$ on the concentration of each nutrient in a particular crop and to determine the significance of this effect (see Methods).

We found that elevated $[CO_2]$ was associated with significant decreases in the concentrations of zinc and iron in all C_3 grasses and le-

My PhD – researching the genetic basis of flowering time diversity in foxtail millet

Apart from being one of the world's most ancient domesticated crops, foxtail millet (*Setaria italica*) now has a sequenced genome (Bennetzen et al, 2012)

At the McDonald Institute, we have 623 accessions of foxtail millet from across Eurasia, encompassing a lot of the diversity in this species.

I am looking at flowering time as a key adaptive trait; understanding the genetic basis of this adaptation allows us to understand the crop diversification and spread in the past and plan for farming in the future!

Experimental method: association of phenotype and genotype data.

Phenotyping

Growth chamber
Greenhouse
Field study

Genotyping

Sequencing of candidate genes
KASP markers
Genotyping by Sequencing

Conclusions and prospects for future collaboration:

Millet crops have potential to help address the problem of food security and major health issues of the 21st century. Crucially – they are best suited to grow in regions which are most affected – placing emphasis on eating local produce.

Genetic resources are being generated for the new model species foxtail millet. This will facilitate research of the Panicoideae subfamily of grasses.

There is still too little information on the nutritional properties of foxtail millet (and indeed other millets). This is a potential area for collaboration, given our seed collections and the phenotype and genotype information we already have for a diverse range of accessions.

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