Characterization of bio- active compounds in Neglected Underutilized Species for Nutritional Security

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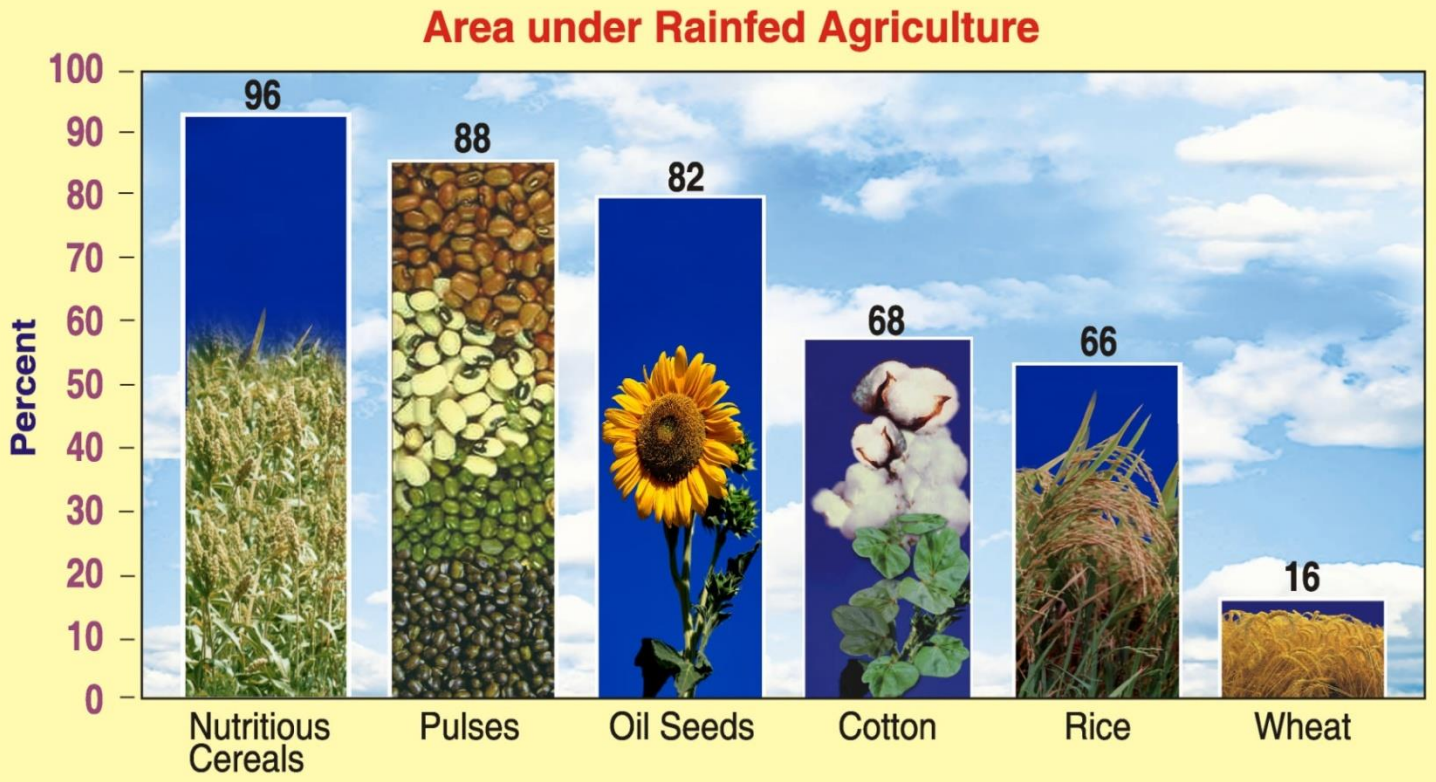
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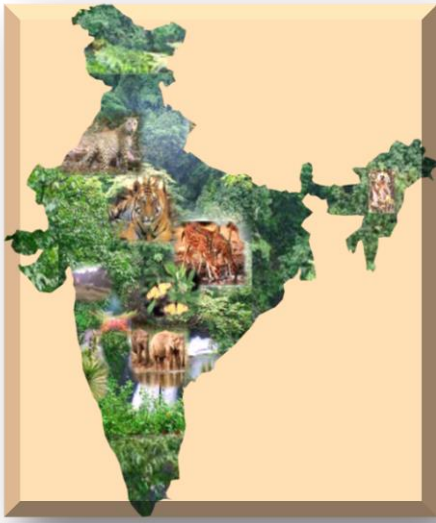
Agriculture Situation In India

- 65% of net sown area in India is rainfed (92 m ha)
- Contributes 42% of food
- Supports 40% of population
- Feeds two out of three cattle



INDIA - A GENE RICH CENTER

- 17,500 species of higher plants
- 583 crop plant species cultivated
- Home land of 167 crop plant species
- 334 wild species of crop plant relatives
- 1256 species in 245 genera and an estimated 370 endemic Grass species
- Over 2,000 different plant ornamental species mainly orchids (1,234) and impatiens (241).
- 1,532 edible plant species used in tribal areas
  - 145 species of roots and tubers
  - 521 of leafy vegetables
  - 101 of buds and flowers
  - 647 of fruits
  - 118 of seeds and nuts





Food security in 20th Century- Intl. Agriculture & green revolution

‘A gift from USA to the developing countries’

- US initiative to improve agriculture in Mexico – 1944
- US initiative to improve agriculture in India – 1956
- Intl. Agri. Res. Centers– 1960 onwards
- High yielding wheat and rice varieties developed

❖Green Revolution’

USAID Director William Gaud coined the term in 1968 after watching India’s success.



A special stamp on wheat revolution in 1968 in India

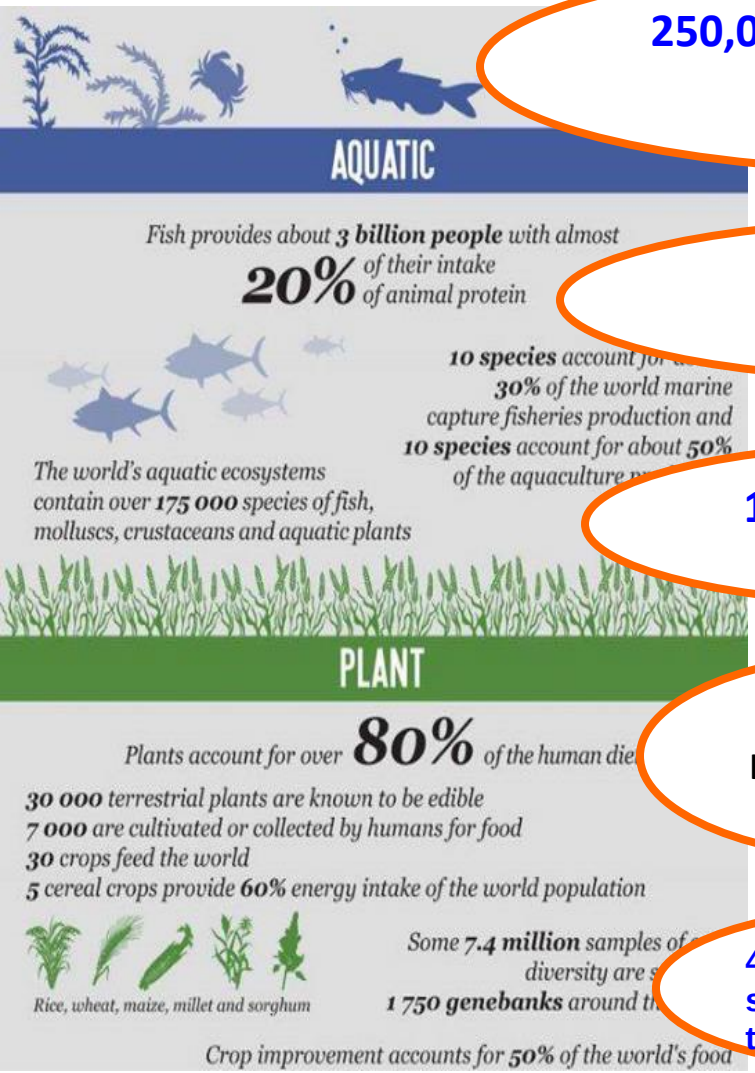




High yielding wheat and rice varieties in 1960s



N.E. Borlaug
Nobel Peace Prize



250,000 Plant species known so far

80,000 are edible

150 cultivated on large scale

30 plant species provide 95% of the total calorie

4 plant species sharing 60-70% of the total calorie

Rice, Wheat, Maize and Potato

Major crops species in use out of large number available to mankind

Genetic erosion due to narrow crops base and crops species replacements / extinctions

--- who knows in future due to global climatic changes these four species will also be wiped off and we may end up with nothing or may be some new unknown species become our staple foods





Current scenario of our food basket and crops diversity









Agricultural species that are not among the major staple crops

often come under the heading of ‘neglected and underutilized

sp nes cal





NUS differ from staple crops in fundamental ways. They tend to be managed with traditional systems, use informal seed sources and involve a strong gender element.

Their processing can be laborious, grading and packaging primitive and the products marketed locally with limited involvement of large enterprises.

Having long been neglected by mainstream agriculture for a variety of agronomic, genetic, economic, social and cultural reasons, today these crops are receiving increasing recognition because of their potential role in mitigating risk in agricultural production systems.



Grain amaranth



Buckwheat



Chenopod

Pseudocereals



Finger millet



Foxtail millet



Proso millet



Barnyard millet

Small millets

Loosing ground – Why??????????

- Changing cropping patterns (shift towards cash crops (off-season), which have well developed door step market)
- Changing food habits and life styles of the peo young generation



- Lack of alternative uses/products
- Food and pharmaceutical industry not exploiting for its bioactive contents may be because of lack of published research data
- Lack of awareness about its food value among farmers and urban societies (in today's context deliberate ignorance)









Necessity and Features of Traditional Crops and Varieties

- Very high tolerance to biotic and abiotic stresses
- Longer viability and low cost of cultivation
- Known to be resilient to Climate Change
- Broadens the species portfolio for food security and development
- Receive attention by national agricultural and biodiversity conservation policies, research and development
- Cultivated and utilized relying on indigenous knowledge







Nutritional composition (per 100 g)

Food grain	Protein (g)	Carbohydrate (g)	Fat (g)	Dietary fibre (g)	Mineral matter (g)	Calcium (mg)	Phosphorus (mg)	Fe (mg)
Finger millet	7.3	72.0	1.3	18.8	2.7	344	283	3.9
Kodo millet	8.3	65.0	1.4	15.0	2.6	27	188	12.0
Proso millet	12.5	70.4	3.1	14.2	1.9	14	206	10.0
Foxtail millet	12.3	60.9	4.3	14.0	3.3	31	290	5.0
Little millet	7.7	67.0	4.7	12.2	1.5	17	220	6.0
Barnyard millet	6.2	65.5	2.2	13.7	4.4	11	280	15.0
Amaranth	16.5	61.4	5.7	20.6	2.8	180	535	9.2
Buckwheat	12.5	58.9	2.1	29.5	2.1	61	394	4.7
Chenopod	14.6	64.2	5.2	14.2	2.7	33	457	5.5
Wheat	11.8	71.2	1.5	12.9	1.5	34	124	3.5
Rice	6.8	782	0.5	5.2	0.6	45	113	1.8

Grain Amaranth



- Amaranthus is a typical *C4 grain* plant.
- The protein is of an unusually high quality
- Amaranth grain is particularly high in Lysine
- Amaranth grain is free of Gluten
- The tocopherol fraction of amaranth oil contains cholesterol-lowering properties
- Cultivated from 100 m to 3000 m amsl



AmA1 gene : Albumin gene transgenic potato, Rice : Pusa Basmati, IR 72

Chakraborty et al (2000) Proc Natl Acad Sci U S A March 28; 97(7): 3724–3729

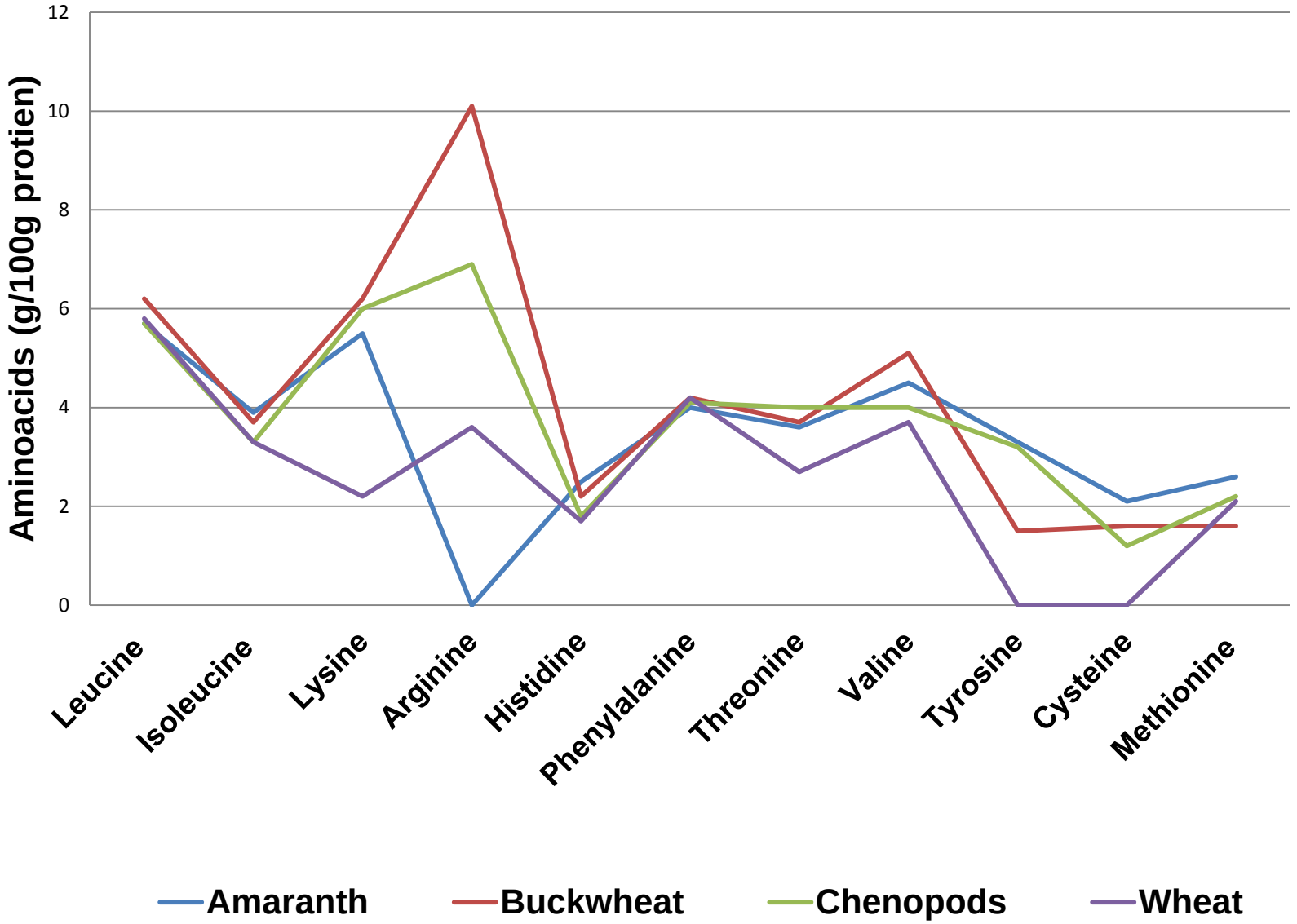
Evaluation of Grain amaranth elite lines for quality traits (%)

Varieties	Palmitic	Stearic	Oleic	Linoleic	Linolenic
Annapurna S	20.98	2.58	20.65	54.82	0.97
Durga	20.72	2.57	19.95	55.90	0.85
PRA-1	20.92	3.30	21.58	53.18	1.02
PRA-2	22.41	2.49	16.71	57.39	1.00
PRA-3	20.29	2.97	24.73	50.95	1.06
Annapurna	20.52	3.12	23.25	52.13	0.98
GA-1	22.37	3.10	16.24	57.27	1.02
GA-2	19.55	3.17	27.22	49.00	1.06
GA-3	20.63	2.71	21.53	54.13	1.00
BGA-2	20.27	2.78	23.73	52.33	0.90
VL-101	22.00	2.80	16.48	57.78	0.94
VL-102	20.93	3.06	20.49	54.59	0.93
VL-44	20.18	3.23	23.04	52.62	0.94
Swarna	20.81	2.87	22.04	53.35	0.93

Evaluation of Grain amaranth elite lines for quality traits

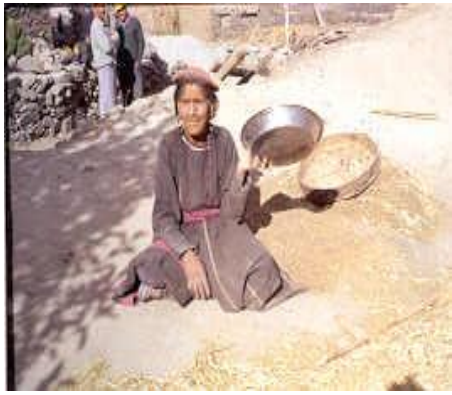
Variety	Protein (%)	Oil (%)	Total phenolics (µg/g)
GA 1	16.14	6.4	1193.750
GA 2	15.53	7.5	593.750
GA 3	13.15	6.75	1170.833
Annapurna Sel.	14.95	7.97	2003.125
Durga	12.80	8.44	1989.583
PRA 2	13.73	7.26	1851.042
PRA 3	11.31	7.15	2234.375
VL 44	13.43	7.66	1670.833
VL 101	14.53	7.42	1839.583
VL 102	13.88	8.65	1438.542
PRA 1	11.56	9.08	1708.333
Swarna	10.76	9.31	1615.625
BGA 2	14.64	7.79	1191.667
Annapurna	13.50	9.31	1737.500

Amino acid composition of pseudocereals as compared to wheat



Buckwheat in India

- It is grown from 500 to 3500 m elevation mainly for green at lower elevations and for grain at higher elevations, Popular as "*kuttu ka atta*" in plains of India and eaten during fast



- The brew made of buckwheat is known to have medicinal properties particularly the one made from bitter buckwheat and locally called as *pechuwi, chang, ghanti* etc.



- During winters, tribal people used the paste of bitter buckwheat flour to cover raw mutton of goats and sheep as it protects meat from microbial attack.



- Little awareness on the nutraceutical value among local and elite folks of India .

Nutritional and Food value Buckwheat (Ogla and Phaphra)

- Very rich in protein and amino acid lysine (deficit in wheat, rice and maize)
- Virtually fat free and seeds contain 1.5-3.7% total lipids
- Rutin, a flavonol glycoside (quercetin-3-0-rutinoside, important ingredient
  - keep capillaries and arteries strong and flexible thus results in a decreased incidence of vascular complications
  - effective preventative measure against high blood pressure or hypertension
  - shown effect in lowering the level of blood sugar
- contains choline, which facilitates the working of the liver
- contains considerable amount of vitamins B1 and B2, potassium, magnesium, calcium, phosphate, zinc and iron are abundant



Fagopyrum tataricum



Fagopyrum esculentum



Potential medicinal and nutritional uses of buckwheat

Product/compound	Effect	Reference
Rutin	**Strengthens capillaries and so helps in arteriosclerosis or high blood pressure**	**Campbell (1997)**
Tartary buckwheat flavonoid (TBF)	**Chemopreventive activity and may have therapeutic role for human leukemias**	**Ren et al. (2001)**
Buckwheat protein	**Suppresses gallstone formation and cholestrol level by enhancing bile acid synthesis**	**Tomotake et al. (2000)**
Buckwheat flour	**Diabetes, obesity, hypertension and constipation**	**Li et al. (2001)**
Buckwheat protein product	**Lowers plasma cholestrol and raises fecal neutral sterol**	**Kayashita et al. (1997)**
Buckwheat polyphenols	**Ameliorate spatial memory impairment**	**Pu et al. (2004)**
Buckwheat concentrate	**Diabetes**	**Kawa et al. (2003)**
Antimicrobial peptides Fa-AMP1 and Fa-AMP2	**Toxic to plant pathogenic fungi, gram-positive and –negative bacteria**	**Fujimura et al. (2003)**
Phenolic antioxidants in buckwheat honey	**Protects humans from oxidative stress**	**Schramm et al (2003)**

Status of Buckwheat Germplasm in India

Indigenous collections– 832

Species	No. of accs.
Fagopyrum esculentum	278
F. tataricum	464
F. sagittatum	12
F. Cymosum	14
F. tataricum ssp. *himalianium*	38
F. tataricum ssp. *emerginatum*	26





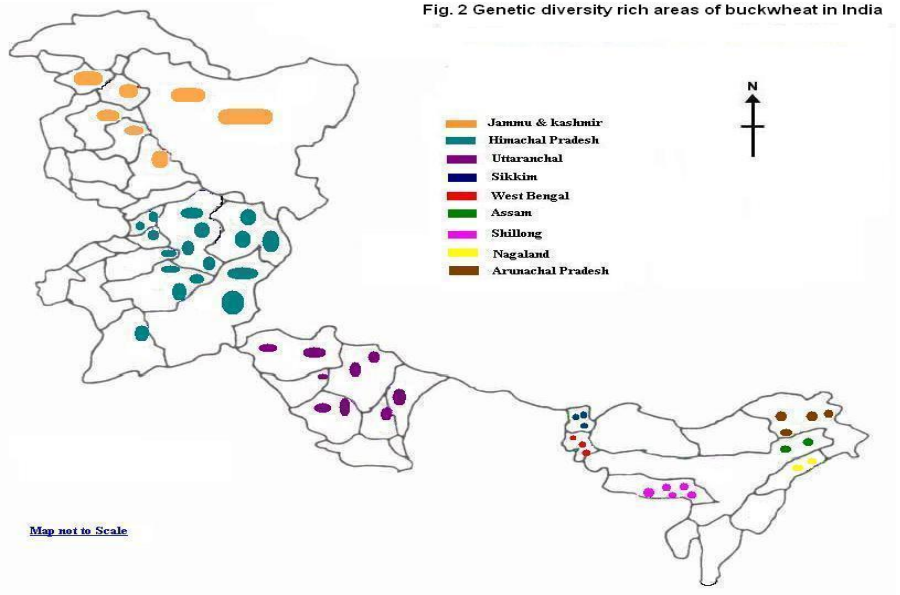
The native germplasm has also been enriched by introducing 154 germplasm accessions from different countries representing USA (44), Canada (38) Nepal (21), Japan (22), Italy (12), Russia (13), Poland (3) and Germany (1)



Seed variability in *F. esculentum*



Seed variability in *F. tatricum*



Genetic diversity rich areas of buckwheat in India

Evaluation of buckwheat elite lines for quality traits

Accession no.	Protein (%)	Oil (%)
IC-42426	16.772	5.442
IC-109314	14.671	4.348
IC-109728	14.932	6.127
IC-18864	13.75	2.429
IC-109729	13.869	3.788
IC-14889	14.952	6.436
IC-17371	15.451	2.368
IC-202226	15.252	3.12
IC-258233	13.954	3.676
IC-274425	12.338	4.717
IC-274427	14.004	1.746
IC-341659	13.925	5.706
EC-288737	14.379	1.624
EC-323730	15.809	1.692
SANGLA-B-5	14.336	4.994
SANGLA-B-129	15.978	4.727
SANGLA-B-214	15.829	4.964
PRB-1	14.87	4.037
HIMPRIYA	15.47	5.266
SHIMLA-B-1	13.663	6.458

Evaluation of buckwheat elite lines for quality traits

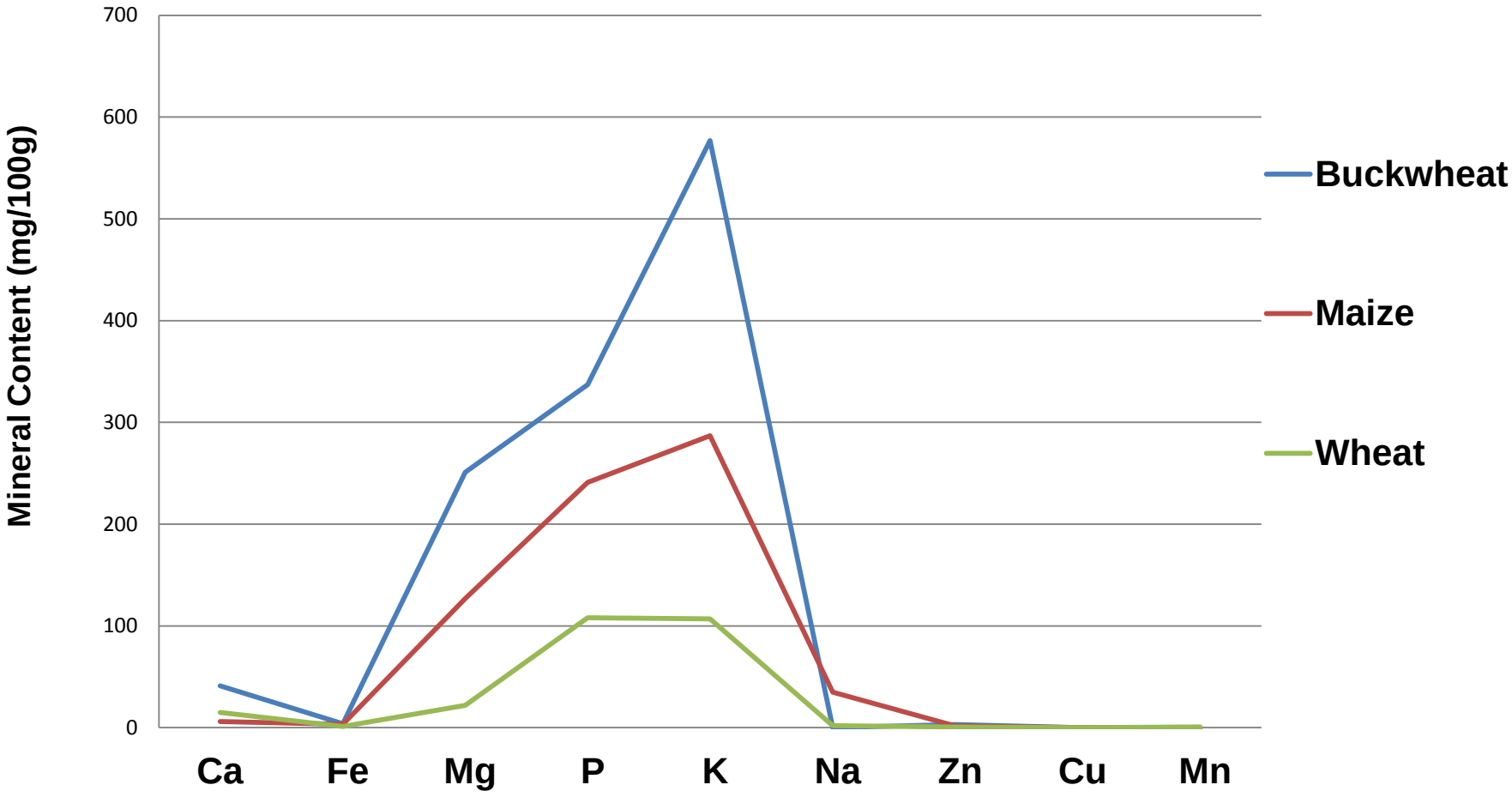
Characters	Range		Mean
	Min.	Max.	
Methionine (g/100g protein)	0.84	1.68	1.24
Tryptophan (g/100g protein)	0.89	1.74	0.97
Oxalate (mg/100g)	67	117	93.5
Free fatty acids (mg/g)	2.85	12.90	6.28
Total phenols (mg/100g)	79	227	193.52

Minerals, trace elements and heavy metals contents of *F. esculentum* and *F. Tataricum* on concentration basis (ppm)b

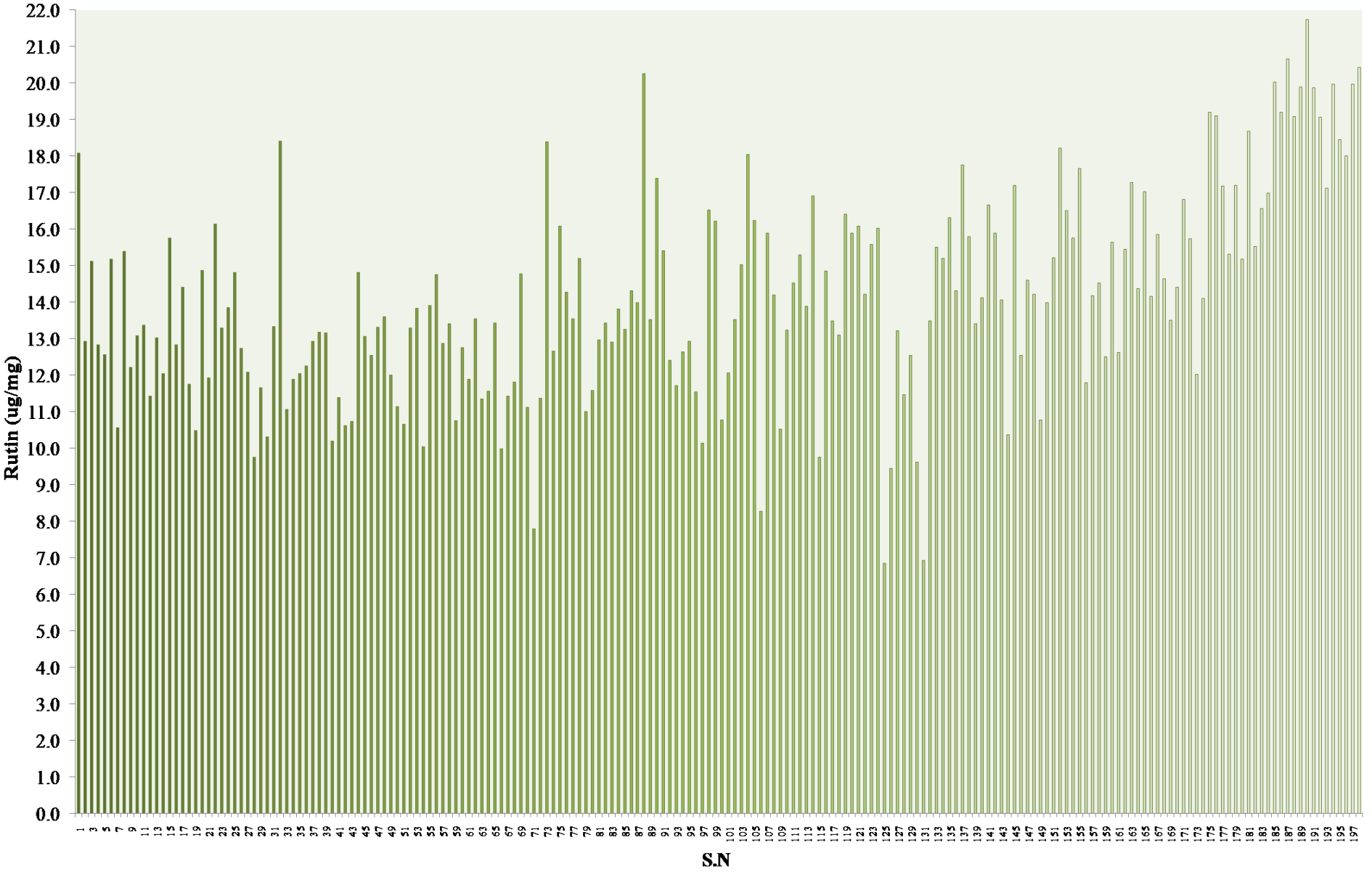
Analytes	*F. Esculentum*	*F. tataricum*
K	2409.7±1.23a	3132.91±0.40b
P	2307±1.04a	1541±0.48b
Mg	1817.1±1.66a	1230±0.43b
Ca	748.3±0.51a	505.48±0.40b
Na	126±0.36a	314.62±0.25b
Mn	12.79±0.45a	10.19±0.42b
Fe	2.208±0.01a	15.92±0.45b
Cu	3.779±0.38a	1.332±0.34b
Ti	0.932±0.03a	0.236±0.02b
Sr	0.778±0.01a	0.513±0.03b
Ni	0.698±0.01a	0.651±0.04a
Cr	0.534±0.02a	0.246±0.02b
Mo	0.496±0.01a	0.168±0.04b
Li	0.181±0.001a	N.D.b
Co	0.126±0.001a	N.D. b
Pb	0.100±0.05a	N.D.b

N.D. Not defined. Mean values within each row followed by different letter are significantly different at $p < 0.05$.

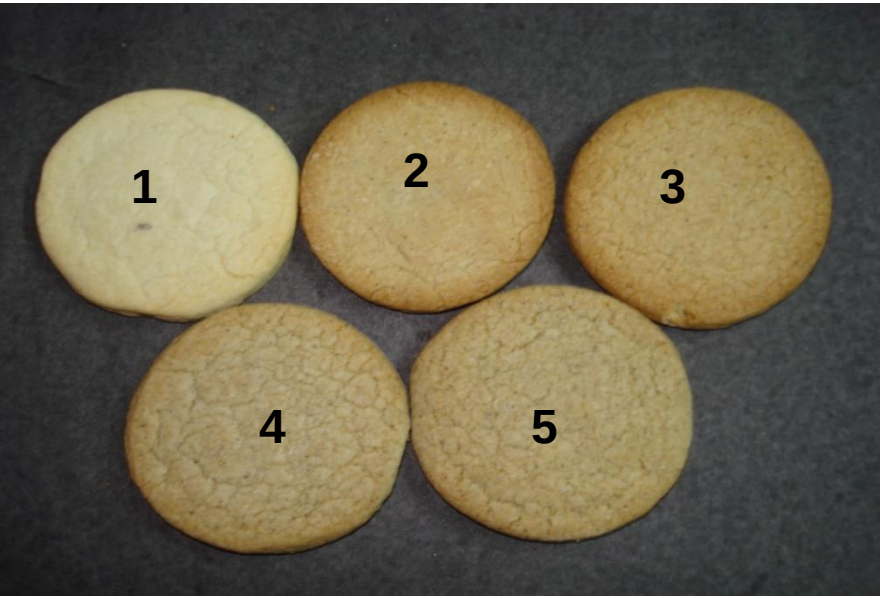
Comparison of mineral content of buckwheat with wheat and maize



Rutin Content Variation Among 200 Accessions of *F. tataricum*



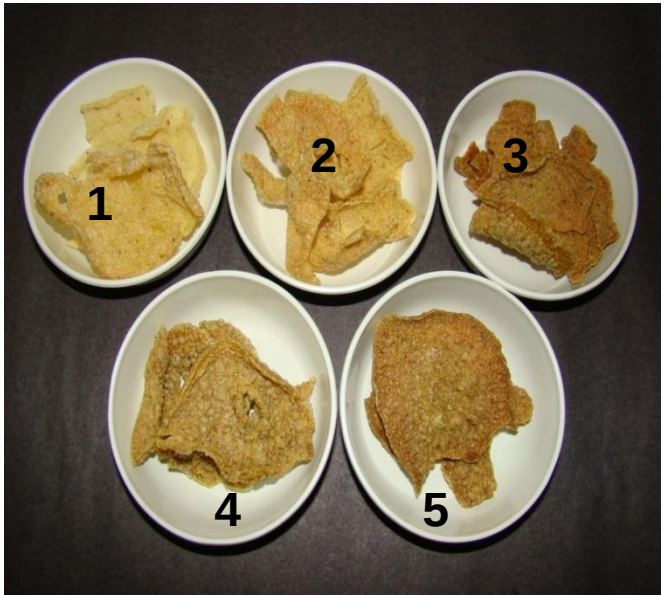
Value Addition in Buckwheat



1: Control (Pure wheat)
2: 10%, (buckwheat)
3: 20%, (-do-)
4: 30%, (-do-)
5: 40% (-do-)

Physical appearance of (A) raw and (B) fried *papad*

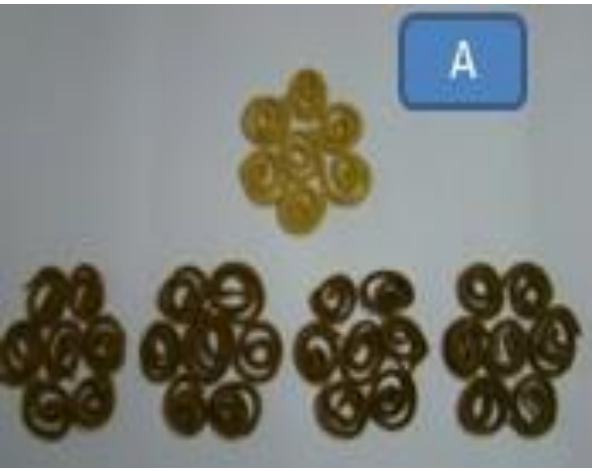




1: Control (Pure rice)
2: 25%, (buckwheat)
3: 50%, (-do-)
4: 75%, (-do-)
5: 100% (-do-)

Physical appearance of supplemented curls of buckwheat with rice flour

Raw



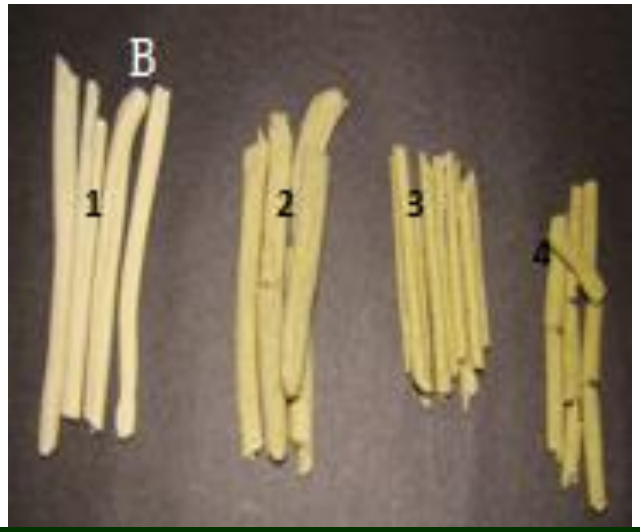
Deep Fried



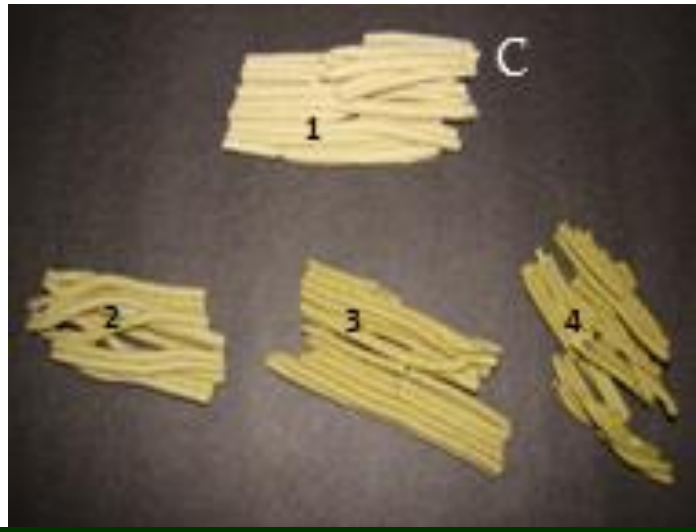
1: Control (Pure rice)
2: 25%, (buckwheat)
3: 50%, (-do-)
4: 75%, (-do-)
5: 100% (-do-)



Pasta



Spaghetti



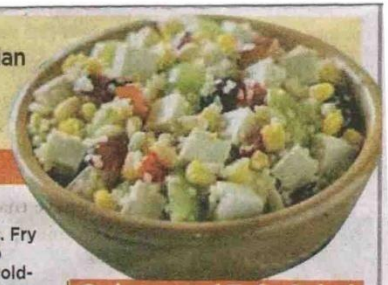
Noodles

Physical Appearance of Supplemented buckwheat with pure wheat flour

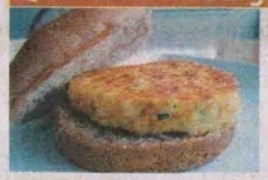
Quinoa – Crop of Andean origin getting popular in Europe and Western World due to its very high nutritive value

It is one of the few crops which contain all essential amino acids

Quinoa often has a bitter after-taste. Nutritionist Uma Lakshmi says that for the Indian palate, quinoa's bland taste may not be very appealing. Hence, it can be be mixed with other grains or added to other food items.



Quinoa Millet Burger



INGREDIENTS

1/2 cup of rinsed quinoa
1 cup millet flour
2 tbsp coconut oil
1 medium red onion, minced
2 cloves of garlic, crushed
3 cups of spinach, chopped
2 carrots, peeled and minced
1/2 bell pepper, seeds removed and minced
2 stalks of celery, minced
1 tbsp cumin
1/2 tsp ground pepper
Salt to taste

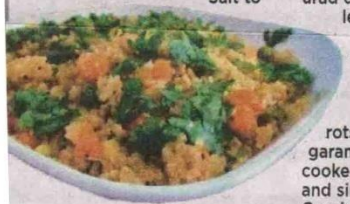
PREPARATION

Boil quinoa for 15 minutes. Fry garlic and onions in 1 tbsp coconut oil till they turn golden brown. Add spinach, carrots, bell peppers and celery. Cook for 2 minutes. Take the quinoa and sprinkle some cumin and pepper. Adjust seasoning.
Place contents into a mixing bowl and add the flour to the veggie quinoa mix. Stir well and set aside.
Heat a pan on high and add the rest of the coconut oil. Make patties from the mixture in the bowl. Cook each bun of the burger on both sides until brown and crispy. Put the patty inside the bun. Quinoa burger is ready.

Quinoa Upma

INGREDIENTS

1 cup cooked quinoa
1/2 cup steamed green peas
1/4 tsp turmeric powder
1/4 tsp garam masala
1/4 tsp mustard seeds
1/4 tsp cumin
1/4 tsp channa and urad dal
Pinch of asafoetida
Salt to taste
Coriander for garnishing
1/2 cup sliced, steamed carrots
2 green chillies
1 cup onions and curry leaves



PREPARATION

Boil quinoa. Heat 1 tbsp oil in a heavy-bottomed pan; add mustard seeds, cumin, channa dal, urad dal, asafoetida and curry leaves. Once the dals become golden brown, add in onions and salt. Saute until the onions are translucent. Stir in the green chillies, carrots and peas. Add the garam masala. Add the cooked quinoa, cover the pan and simmer for 5 minutes. Garnish with coriander.

Quinoa and Tofu Salad

INGREDIENTS

2 cups of water
3/4 tsp salt,
1 cup quinoa, rinsed well
1/4 cup lemon juice
3 tablespoons olive oil
2 cloves garlic, minced
1/4 tsp freshly ground pepper
1 6-or 8-ounce package diced and baked smoked tofu,
1 small yellow bell pepper, diced
1 cup grape tomatoes, halved
1 cup diced cucumber
1/2 cup chopped fresh parsley
1/2 cup chopped fresh mint

PREPARATION

Bring water and 1/2 teaspoon salt to a boil in a medium saucepan.
Add quinoa and return to boil by letting it be for 15 minutes. After reducing to a simmer, cover and cook until the water has been absorbed. This should take 15 to 20 minutes. Spread the quinoa on a plate to cool.
Meanwhile, whisk lemon juice, oil, garlic, the remaining 1/4 teaspoon salt and pepper in a large bowl.
Add the cooled quinoa, tofu, bell pepper, tomatoes, cucumber, parsley and mint; toss well to combine.
The healthy salad is ready to be enjoyed.

Miracle grain ideal for AP

The plants can survive the severe heat and do not need too much water

KANIZA GARARI and LASYA NADIMPALLY | DC
HYDERABAD, JUNE 12

Quinoa is a food to replace cereals that has taken the world market by storm. Its successful growth in the Andhra Pradesh Academy of Rural Development is a cause for cheer for India.
With quinoa prices skyrocketing in the world market, the successful experiment shows that there is hope for farmers to look at another crop during the severe summer months.
The crop was cultured in the laboratory in February and small offshoots planted in March. The growth since then has been phenomenal, and despite the severe summer, the crop has borne the grain.
Three different varieties have been planted in medium soil and as the plant has a weak stem, it requires a stick to support it. Some saplings planted under a tree have grown higher than those in direct sunlight but the crop is taking time to bear the grain. The time-period from sapling to maturity is calculated as 150 days.
"For the extreme temperatures of AP, the full growth of quinoa under direct sunlight means a lot," explained project in charge Ratna Chary.
Another important feature is that the plant does not require too much water.
"For this crop, 200 mm rainfall in a year is enough. This means that it can be grown in drought-like conditions. While watering the plant, we had to provide a separate drainage channel so that excess water flows away otherwise the plant would not survive," explained director general of the Centre for Development Studies K. Chandramouli.
It does not require too much of manure but requires a good amount of organic pesticide in terms of neem Cake.
"The infestation of white flies is a problem with all leafy plants. Good quantity of neem cake applied in the soil keeps flies," said Mr Chary.

PRECAUTIONS

- Plant must be protected from 17 species of insects or pests.
- Viruses found on spinach or beet roots are also observed in these plants.
- Weed control is essential before and after plantation.
- If planted during heavy rains, the plant is likely to suffer from bacterial and fungal diseases.

QUINOA FACTS

- There are a total of 360 quinoa varieties
- Easy growth and good harvest has been found in 160 varieties
- In India, three varieties have been tried: E 507338, E 507339 and IC 411824.
- The UN General Assembly declared 2013 as the International Year of Quinoa.



Quinoa plant that was sowed in Academy for Rural Development.

NUTRITIONAL VALUE FOR EVERY 100 g

Calories:	120 calories
Total fat:	1.9%
Cholestrol:	0mg
Potassium:	172 mg
Sodium:	7mg
Total carbohydrate:	21gm
Protein:	4.4 gm

- Quinoa is very rich in protein, amino acids and fibre. Some nutritionists say that it contains protein value equivalent to meat. Also, the fat content is just about around 1.9% and
- It contains phytoestrogen that prevents osteoporosis and functional disorder during menopause.
- Quinoa contains iron and it helps keep red blood cells healthy.
- It contains lysine, which is essential for

Quinoa is sold for ₹1,500 per kg in city

DC CORRESPONDENT
HYDERABAD, JUNE 12

In Hyderabad it is being imported and sold in only 2 stores. The prices have tripled in the world market from 2006 to 2013.

The growing enthusiasm for consuming the health food quinoa has hiked the prices of the grain worldwide. In Hyderabad, at present it is imported and sold at a whopping price of ₹1,500 per kg in only two supermarkets in Banjara Hills. The situation in Hyderabad is reflected in the rest of the country and the world. The 'wonder grain', as it's called, is much sought-after for its high health properties — rich protein content, fibre, calcium and amino acids.
Quinoa is increasingly popular in the United States, Europe, China and Japan. But the grain is not grown there and is imported from Central and South America — Mexico, Peru, Chile, Ecuador and Bolivia, where the soil and climate is suitable and it is grown on the mountain slopes, plateaus and valleys. These places are the only areas where quinoa is grown commercially.
Due to the huge demand, the prices have tripled in 2006 to 2013. In 2011, the average crop value was $3,115 per ton with some varieties selling for as much as $8,000 per ton. The difference in this demand-supply chain is what pegs quinoa at such a high price. So, quinoa is not commercially grown in most other parts of the world that want to consume it. Many people opt to buy red rice which is way cheaper than quinoa, because of the affordability quotient.
Director general of Center for Development Studies, K. Chandramouli says, "The demand of quinoa has suddenly increased among vegetarians. The first crop will be planted in Anantpur district in July and after that we hope that it can be made

Finger millet (mandua, koda)

Its protein has high biological value with good amounts of tryptophan, cystine, methionine amino acids

Rich source of minerals such as calcium, phosphorus, potassium and iron

Considered to be one of the best seed for brewing. Indeed, finger millet has much more of this "saccharifying" power than does sorghum or maize: only barley, the world's premier beer grain, surpasses it

It is safer food for diabetic patients as its slow digestion keeps low blood sugar levels



Pearl millet – storehouse of energy

Pearl millet contains more calories than wheat, probably because of it's higher oil content of 4.2% which is 50% polyunsaturated- the reason it does wonders for growing children and pregnant women

It is rich in B vitamins, potassium, phosphorus, magnesium, iron, zinc copper and manganese ; compared to maize,40% richer in amino-acids lysine and methonine

It is a gluten free grain and is the only grain that retains it's alkaline properties after being cooked which is ideal for people with wheat allergies

Pearl Millet flour mixed with wheat flour is used for making baking products like breads, cakes, muffins, cookies, and biscuits.







STATUS OF GENETIC RESOURCES

Crops	Total in India	Western Himalaya
Finger millet	7070	1588
Foxtail millet	2421	236
Barnyard millet	1196	439
Proso millet	926	385
Amaranth	8568	4685
Buckwheat	1235	1068
Chenopod	185	168
Total	21601	8569

What is needed to be done

- **Research and development to create add value options (post harvest and industry)**
- **Promotion of on-farm conservation and cultivation in public-private mode**
- **Need to develop market network including development of seed chain through agriculture state department**
- **Systematic collection and evaluation for advanced quality and agronomic traits**



THANKS