



Quinoa – The Health Food - A Boon for Vegans and Vegetarians

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Quinoa and its Origin

Quinoa (pronounced as 'Keen-wa') is an annual seed producing grain crop. It is a pseudo-cereal that is botanically related to Spinach - *Chenopodium quinoa* (Figure 1). It is a wheat-free alternative to starchy grains which is rich in several important nutrients that come forward as a super-food for vegans and vegetarians that lack various nutrients such as essential amino acids, minerals, etc., in their normal, animal product - free diet. It takes less time to cook and comes in different varieties having different taste.



Figure 1: A typical Quinoa Plant at flowering stage
(C.F. – Bazile Didier) [1].

Quinoa is originally a native crop of the Andean region of north-west South America, but due to an increase in World trade, its cultivation has spread to more than 70 countries around the world.

It has been grown in South America (Peru, Bolivia and Chile) for thousands of years. Earlier, about 5.2-7 years it was used to feed livestock, later 3-4 thousand years ago it entered the human diet, mainly in Peru and Bolivia. Now, owing to its nutritional content, health benefits, adaptability to different climates and low-cost of cultivation, it is emerging as a preferred food item over wheat and rice.

Nutritional content

Quinoa is naturally gluten-free. One cup of cooked quinoa, weighing 185 grams (g), contains:

- 222 calories
- 8.14 g of protein
- 5.2 g of fiber
- 3.55 g of fat, of which 0.42 g is saturated
- 39.4 g of carbohydrate
- Magnesium - 30 percent recommended daily allowance (RDA)
- Manganese - 30 percent RDA
- Folate - 19 percent RDA
- Phosphorous - 28 percent RDA
- Copper - 18 percent RDA
- Iron - 15 percent RDA
- Zinc - 13 percent RDA
- Potassium - 9 percent RDA

One cup also contains more than 10 percent of the RDA of the vitamins B-1, B-2, and B-6, and traces of vitamin E, B3, and calcium.

Additionally, quinoa contains a healthy dose of fatty acids: "About 25 percent of quinoa's fatty acids come in the form of oleic acid, a heart-healthy monounsaturated fat, and about 8 percent

comes in the form of alpha-linolenic acid (ALA), the omega-3 fatty acid most commonly found in plants".

Melinda Lund, M.S., R.D., a registered dietitian and medical nutrition therapist

Zinc and human health

Zinc is known to play a critical role in normal functioning of body and is integrated with several enzyme systems. Adequate dietary intake of zinc has been shown to exert ameliorating effect on the skin, and this attenuates the likelihood of restricted linear growth in young children. Neuro-behavioral disturbances among infants and repeated infections are common among zinc-deficient people of all ages. Pregnant women with zinc deficiency are at the risk of complicated pregnancy outcomes [2]. This is further complicated by the fact that Zinc deficiency is one of the major factors limiting the yield of agricultural crops. This necessitated the need to fortify Black Rice with Zinc using Zinc oxide nanoparticles. It is believed that Black Rice augmented with Zinc would not only ameliorate the health of the marginalized sections of the Indian populace but also pave the way to improve the agricultural yield thereby sustainably improving the carrying capacity of the arable land [3].

Content of essential amino acids (EAA) in Quinoa in comparison to the values recommended by FAO (in grams per 100 grams of protein)

	FAO Recommendation	Quinoa
Isoleucine	3.0	4.9
Leucine	6.1	6.6
Lysine	4.8	6.0
Methionine	2.3	5.3
Phenylalanine	4.1	6.9
Threonine	2.5	3.7
Tryptophan	0.66	0.9
Valine	4.0	4.5

Table 1: Amino acid content of Quinoa (C.F. - M.J. Koziol) [4].

Types of quinoa

There are over 120 different varieties of Quinoa as defined by the Whole Grains Council but the most common Quinoa colours found across grocers and markets are white (also considered ivory or yellow quinoa), red and black (Figure 2).



Figure 2: Varieties of Quinoa white, red and black (C.F. - Alia Hoyt).

Nutritional values among the three types are almost similar, with minor differences such as black quinoa having the lowest fat and iron value.

	White Quinoa	Red Quinoa	Black Quinoa
Calories	355	380	370
Fat	6g	7.2g	3.3g
Protein	13g	14g	11g
Iron	90%	50%	20%

Table 2

Quinoa also has high content of two types of flavonoids (anti-oxidants) quercetin and kaempferol. Allowing the seeds to sprout seems to increase the antioxidant content even further.

Where taste is concerned, red and black varieties tend to have an earthier flavor with black having an additional sweeter taste as compared to the white variety. When cooked, white quinoa appears fluffier, whereas both red and black quinoa tend to be a bit more crunchy in texture.

Where is quinoa grown in India?

In India, as farmers and people are becoming more aware and receiving food and agricultural education, crops having improved quality and nutritional value have increased both in productivity and consumer demand. Mainly, the States of Andhra Pradesh, Uttarakhnad and Rajasthan are emerging as the main cultivators of Quinoa in India.

Various conditions but some key breeding objectives in Quinoa cultivation

- Seed yield
- Heat tolerance
- Resistance to downy mildew
- Low saponin content
- Drought tolerance
- Early maturity
- Pre-harvest sprouting resistance
- Nutritional value and flavour

Cooking protocol of Quinoa

Ingredients

- 1 cup quinoa, (194g)
- 2 cups water, (480ml)
- 1/2 teaspoon kosher salt, (3g)
- Vegetables (optional). Most common vegetables added are carrot, peas, beans and broccoli. Addition of Cashew nuts or peanuts adds flavour.

Instructions

- Place quinoa in a medium-sized bowl and cover with cold water. Soak for 2 minutes.
- Transfer soaked quinoa to a fine-mesh sieve. Rinse quinoa under running cold water for 30 seconds until water runs clear.
- Shake the sieve to remove excess water.
- Transfer rinsed quinoa to a medium-sized pot fitted with a lid. Add vegetables according to the taste.
- Add 2 cups of cold water and salt to the pot.
- Bring water to a boil over high heat.
- Once the water boils, immediately reduce heat to medium-low.
- Cover pot and simmer until quinoa absorbs all of the water and is tender about 15 to 20 minutes. If the quinoa still looks wet, continue to cook, checking every 5 minutes.
- Turn off heat and let stand, covered 5 to 10 minutes. Fluff with a fork to separate the grains.

Note

Toasting Option: Once quinoa is rinsed, it can be sautéed in 2 tablespoons olive oil or any other vegetable oil over medium heat for a few minutes before adding in water add salt. This will accentuate the slightly bitter and nutty flavors of the quinoa.

Average production per acre of land

According to Mr. Manoj Upadhyaya (Pune), in India it is available for Rs. 1800 -2000/kg. 2 kg seeds are required for 1 acres quinoa farming. Quinoa is a self-resistant crop and less prone to insect or microorganism attack. "At the moment it is free from pest but may be Indian insect will start stacking the crop soon, then 'gomutra' and 'neem leaves extract' can be used as preventive measures".

Yield per acre is about 450 kg but may range from 600-700 kg/acre.

Strategies to enhance the yield and value addition to the seeds is promised by interaction with Symbiotic fungus *Piriformospora indica* (*Serendipita indica*) and ZnO nanoparticles singly and/or in combination.

P. indica is a plant beneficial fungus that supports plant growth during its mutualistic symbiotic relationship by root colonization which results in early flowering, higher seed yield, alteration in the secondary metabolites, and adaptation to abiotic and biotic stresses. *P. indica* - infested roots also show antioxidant capacity. The fungus also induces systemic disease resistance in plants.

Mass multiplication of *P. indica* on cheap, reproducibly and reliable Jaggery (Gur) as sole Carbon energy source and *P. indica* fungus showing fluorescent pear shaped spores (Figure 3).



Figure 3: Cultivation of *Piriformospora indica* on eco-friendly medium containing 4% jaggery (obtained from *Saccharum officinarum*) (944/DEL/2012 patent).

Treatment with ZnO Nanoparticles.

Synthesis of nano zinc materials

ZnO nanorods were prepared by a mechanical-assisted thermal decomposition process. Zinc acetate dihydrate $[\text{Zn}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}]$ was used as precursor for synthesis of zinc oxide nanorods. In the synthesis process, zinc acetate dihydrate (5 g) was ground in a mortar and pestle for 45 min then loaded into an alumina crucible, which was then heated in a programmable muffle furnace (at ramp rate of 4 C/min) at 275°C for 4 h to obtain ZnO nanopowders. The obtained powders were then washed twice with distilled water, followed by drying in an oven at 80°C for 8 hours.

The nanoparticles were spherical, oblong and rod in shape (Figure 4). The diameter varied from 9.6-25.5 nm in size [5].

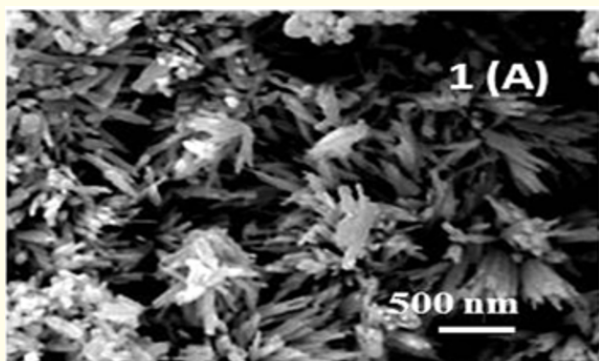


Figure 4: Scanning electron microscopy (SEM) micrograph of pure ZnO nanorods.

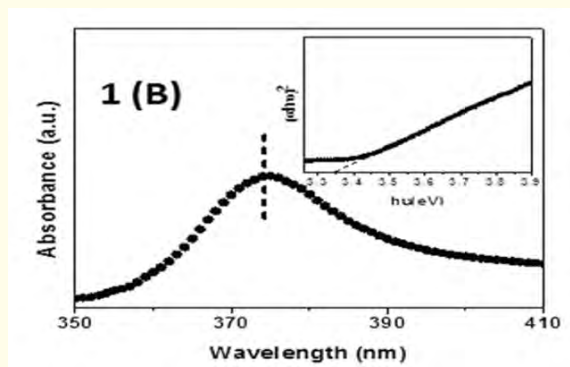


Figure 5: Tauc's plot and UV-Vis absorption spectra of pure ZnO nanorods.

Figure 6 Indicates the morphology of the spores with and without treatment with ZnO nanoparticles as observed under confocal microscope (Model Nikon A1).

For confocal based analysis of *P. indica* spores the technique adopted by Hilbert et al. 2013 with slight modifications was used. 0.002% freshly prepared Tween twenty solution was autoclaved and stored at 4°C. 1ml of the solution was added to *P. indica* culture plate and spores were scraped out with the help of spreader and collected in 2ml micro-centrifuge tubes followed by centrifugation at 5000 G for 15 minutes. The plate was collected and mixed with 1ml autoclaved distilled water while the supernatant was discarded. The spores were stained with WGA Alexa 488 conjugated dye. Approximately, 5 μl of the dye (10 μg per ml conc) was used for staining 500 μl of spores and was subjected to confocal microscopy. The images were captured using confocal microscope (Model Nikon A1) under magnification of 40X. The confocal setting WGA – Alexa 488 conjugated dye was as follows:

- Excitation – 488nm, emission 515
- The shelf life of ZnO embedded fungal spores is prolonged due to presence of nanomaterials.

Comparative analysis

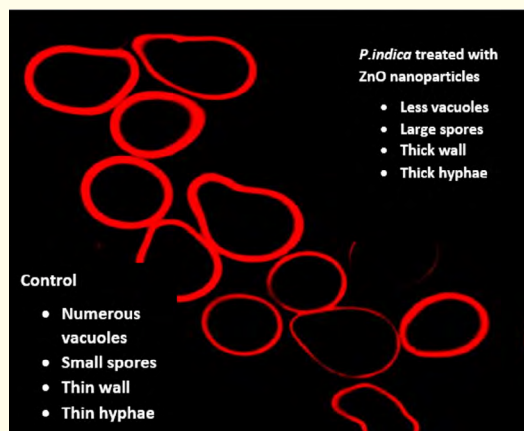


Figure 6: Morphology and essential characteristics of *Pindica* spores with and without ZnO particle treatment.

Ongoing research

The experiments on interaction of Zinc oxide (ZnO) nanoparticles and the beneficial fungus) with quinoa seeds are in progress under temperature and environment control greenhouse condi-

tions. With a sole objective to enhance the yield and value addition to the seeds (flavonoids quercetin and kaempferol). The aim is also focused on keeping the crop disease free [6-20].

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