R-2683
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REVIEW ARTICLE Agricultural Reviews, Volume Issue : ()

Quality Assessment of Different Agricultural Produce under Organic as Well as Inorganic Production System: A Review

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10.18805/ag.R-2683

ABSTRACT

The urgent need to grow more food to feed the growing population has led to intensive farming with a lot of negative impacts on soil health as well as the ecosystem. To mitigate the negative impacts of conventional farming, the concept of organic farming has resurfaced. However, separate study of conventional and organic farming does not give a comparative assessment between two production system. The compensation of yield loss under organic farming could only be overlooked through enhancing the quality of produce. Good quality produce is just as important as quantity, yet quantity is typically prioritized. There is a myth that organically grown produce is superior and tastier than conventionally grown produce, yet this isn't always the case. So, it's high time to screen out the specific nutrient/ vitamin or any other quality parameter that can be enhanced through organic farming. So that agro-technique for organic fortification can be developed for the future researchers. Almost 71 research experiment were carefully studied and tried to assess the impact on organic farming on quality of produce. In developed and developing countries the area is increasing with an average growth rate of 20-25 %. Organically grown produce enhanced the mineral content especially phosphorous, and iron in rice, increased the protein content of maize by 8 to 19%, lysine content in wheat by 25-30%, ash and crude fat content in millets and oats and many more. Besides, improving physical appearances such as kernel length, elongation ratio of cereals, the cooking time has been greatly reduced in organic than inorganic production system. Even, the crude protein and oil contents greatly increased in the oilseed crops in organic production system over inorganic. However, variable response was reported in case of tuber crops, as quality parameters as well as organoleptic taste between conventional as well as organic farming system remained insignificant. However, few researchers reported significant increase in tuber dry matter content (20.92%) as well as quality traits for processing of tubers under organic farming system. Likewise, the oleoresin (5.26%) and essential oil (3.96%) contents of zinger rhizomes and curcumin (5.3%) and essential oil contents (4.2%) of turmeric greatly increased in organic production system over inorganic.

Key words: Conventional, Nutrients, Organic, Protein, Quality.

Globally the area under organic farming is gradually increasing because of its tremendous positive effect on soil health, quality of produce, and reducing the health hazards in humans and animals caused by the levels of pesticide residues. Organic agriculture is a huge production management system that promotes agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes production by using, wherever possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system (FAO/WHO Codex Alimentarius Commission, 1999). Despite the high cost and low productivity of organic produce in comparison to traditional agriculture, people's preference for healthy and quality produce from organically grown crop has been progressively rising both in developed and developing countries with an annual average growth rate of 20-25 % (Ramesh *et al.,* 2005). This might be due to many drawbacks associated with inorganic farming such as increase in soil acidity and bulk density, decrease in water holding capacity (Bhuyan *et al.,* 2018) and microbial density etc. The soil physical properties like bulk density and porosity greatly decreased and availability of nutrients to soil greatly increased after incorporation of *dhaincha* as green manuring crop in rice (Ahmed *et al.,* 2020).

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How to cite this article: Begum, M., Goswami, J., Dubey, P.K., Ahmed, P., Kandali, G.G. and Dutta, D. (2024). Quality Assessment of Different Agricultural Produce under Organic as Well as Inorganic Production System: A Review. Agricultural Reviews. 1-8. doi: 10.18805/ag.R-2683.

Submitted: 13-12-2023 **Accepted:** 03-09-2024 **Online:** 18-12-2024

Organic nutrient management is of utmost importance not only for the growth and development of the crop but also for the maintenance of soil health as well as the quality of the produce. Nowa days liquid organic fertilizers which are mostly used in organic farming greatly increased the crop yield as well as quality of produce without deteriorating the soil properties (Patel *et al*., 2016a; Akhila *et al*., 2017a). More often organically produced foods are supposed to be tastier and healthier than those which are conventionally grown (Premuzic *et al.,* 1998). The major challenge with organic farming systems is to maintain the quality of the produce without hampering the yields (Tilman *et al.,* 2002).

Quality of organically grown cereals

Cereals *viz*. rice, wheat, maize, barley, rye, and oat occupy considerable area and production globally providing almost one-half of total nutrition energy for human and animal populations. Henceforth, the assessment of the nutritional quality of these crops under organic production is necessary to affirm its outcome on human health. When we talk about the quality of produce it mainly includes macro as well as micro (trace) elements, protein, starch content, and amino acids in cereals. Many factors like selection of variety, nutrient management practices being followed source and type of nutrients, initial soil condition etc. governed the quality of produce.

However, Bordoloi *et al*. (2019) opined that the type of variety does not play a significant role and all local/ traditional cultivars can be selected for organic cultivation which was contradictory with the results obtained from Sarmah *et al*. (2022). The cultivar Kola joha recorded more Fe (39.73 mg 100 g^{-1}), Zn (4.07 mg 100 g^{-1}) and Mn (6.76) contents than the Keteki Joha, whereas the former reported less amount of crude protein, Ca, and Mg content than the later. Similarly, Bora *et al*. (2014) reported that the source or type of manure influenced the yield of rice, but the milling and cooking quality remained unaffected (Davari and Sharma, 2010; Rao *et al.,* 2013). Application of neem leaf manures@ 60 kg ha^{-1} augmented the amylase (23.86%) and protein content (7.70%) of the grain as compared to the other organic nutrient sources such as farm yard manure, sheep manure, and poultry manure, each applied @ 60 kg ha^{-1} in scented rice (Rao *et al.,* 2013). The supply of potassium through different organic sources also significantly affected the grain quality of scented rice (Das *et al.,* 2018) and it was further reported that application of 100% RDK through enriched compost recorded significantly higher grain length (7.18 mm), protein content (8.13%) as well as aroma in *badashbhog* variety of scented rice. Apart from this, organically grown basmati rice had better cooking quality manifested by a higher elongation ratio (1.64), swelling rate (0.73) and lesser kernel hardness (8.44 kg/grain) (Joshi *et al.,* 2019). The grain hardness adversely affects water absorption and delays the cooking process. Thus, it can be inferred that organically grown rice needs less time for cooking as compared to inorganic rice. Even the organically grown rice was tastier than the inorganic rice with better protein and phosphorous contents (Surekha *et al.,* 2013 and Joshi *et al.,* 2019). Significant improvement in protein (Biswas *et al.,* 2016, Pal *et al.,* 2019) and amylase contents in aromatics rice (Rao *et al.,* 2014) under organic management were reported by many researchers. Contrastingly, Joshi *et al*. (2019) reported that crude fat and copper contents in grains of basmati rice were higher when applied with inorganic fertilizer than in organic nutrient management. They also conducted detailed assessment of grain quality parameters of rice grown under organic and inorganic production system (Fig 1). Other nutrients such as manganese, cobalt, and zinc contents also did not improve under organic nutrient management in rice. This was in contradiction to the results obtained by Mishra *et al*. (2004) who reported an increase in the Fe content of rice due to different organic sources.

The increase in protein content and protein yield with the application of organic nitrogen might be due to higher uptake of nutrients, particularly nitrogen, and subsequent

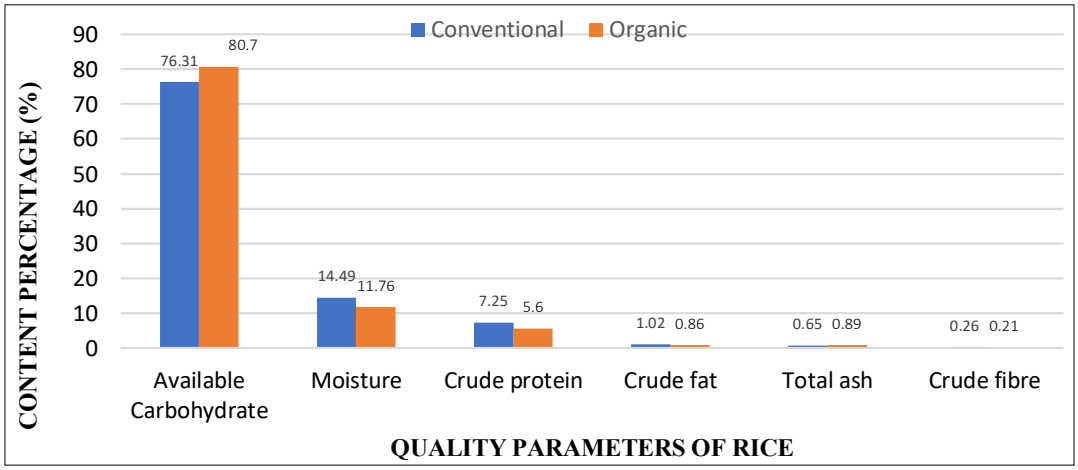

Fig 1: Grain quality parameters of rice grown under organic and inorganic production system (Joshi *et al.*, 2019).

increase in its concentration in the grains, which might have modified the proportion of grain constituents. Accumulation of protein in seeds may also be increased due to the continuous nitrogen supply and its translocation in seed buds and optimal nutrition. It is known that protein content imparts strength to the grain which in turn results in higher head rice recovery (Yadav *et al.,* 2016).

An over-view of the nutritional quality of wheat grains in response to organic and conventional nutrient management, indicated that the grain hardness, protein content, amino acid composition, mineral content and baking quality remained insignificant (Paul *et al.,* 2007). Protein content which is a desirable trait of wheat for bread or pasta making was greatly reduced when *T. aestivum and T. durum* were grown organically, but a remarkable increase in *Zn* concentration of the grain was observed in organic management than that of conventional practice (Shivay *et al.,* 2010). Lower protein content under organic cultivation as compared to conventional farming was reported in earlier findings (Jones *et al.,* 2010). The low amount of nitrogen supply under organic might be responsible for the reduction in protein content under the organic production system. Besides this, significant improvement in ash, dry matter, crude protein, and crude fat content was noticed under organically grown wheat (Denis *et al.,* 2011) and lysine content was increased by 25-30%. Conversely, Paul *et al*. (2013) reported that the protein content of wheat grain was greatly reduced under organic cultivation (9.5%) as compared to conventional method (12.7%). Therefore, varieties with high protein content as well as sedimentation values should be recommended for organic farming purposes to compensate for the relatively low protein content of the grain (Konvalina *et al.,* 2009).

Because of the presence of an ample amount of linolenic acid and unsaturated fatty acid, maize is considered a good feed for both humans as well as animals (Okoroafor *et al.,* 2013). The quality of organically grown maize depends upon the type of cultivars. Under the same organic management practices, extra early cultivars such as Vivek Hybrid-9 and Vivek QPM-9 produced more protein content than the other medium and late-maturing cultivars (Jat *et al.,* 2019). Crude protein is considered an important quality parameter in cereals like maize. Kanatas *et al.* (2020) reported that incorporation of green manure crops under organically grown maize increased the protein content by 8 to 19%. Maize hybrids were significantly affected by organic sources of application. Organic fertilizer sources improved the quality of maize hybrids. Application of poultry and farmyard manure increased the protein and oil contents compared to biochar and chemical fertilizers. It has been shown that protein content is substantially impacted by nitrogen content that is present in sufficient quantities in the organic sources used, especially in poultry and farmyard manure. The rise in protein levels may be related to an increase in leaf N content, which during the growth of the crop is rapidly converted to protein and transported to grain for protein synthesis (Nagavani and Subbian, 2014). An increase in the oil content of maize with the application of poultry manure was reported by Aldal'in (2017). An increase in the oil content due to the application of organic sources could be attributed to the synthesis of more glycosides. The increase in overall protein content was due to a consistent increase in different fractions of protein. The protein is formed by different amino acids which are constituted in higher amounts owing to nitrogen application in split doses during all the growth stages of the crop. It is expected that the slow release of nitrogen from poultry litter has directly contributed to the grain protein content. Therefore, the availability of nitrogen during grain filling stage is necessary to improve the protein content. The application of poultry litter promoted an increase in the potassium, calcium, iron and zinc contents in maize grain (Aldal'in, 2017). This might be attributed to the supplement of micronutrients by the manure and also due to the organic acids produced during the decomposition of the soil minerals.

Millets are important cereals that play an important role in the food and nutritional security of developing countries particularly the semi-arid tropics of Asia, Africa especially in India because of their nutritional superiority and higher water economy as compared to the major cereals (Sujatha *et al.,* 2016). Organic nutrient management has a considerable influence on the quality of minor millets. Mirjana *et al*. (2014) reported that the ash content of organic produced barely was higher than the conventional one. Likewise, the crude fat content of organically grown oats, rye and other millets was greater in organic nutrient management. In oats, the organic production system increased the test weight of the grains. However, the fiber content remained lower by 5.8% over the conventional practice (Spasova and Menkovska, 2009).

Quality of organically grown pulses

Pulses play a vital role in human diet which supplies many vitamins as well as minerals to human health. But, because of lack of high yielding varieties the production of pulses is less as compared to other cereal and oilseed crop. Here, necessity of organic nutrient management raised as the quality of the crop is the matter of concern.

Green gram is extensively grown leguminous crops in India, but, extensive and continuous use of chemical fertilizers to this crop has led to reduction in the crop yield accompanied by adverse effects on soil health. Thus, the concept of organic farming has been developed which is known for improving the crop quality as well as soi health. Akhila *et al*. (2017b) reported that application of 2% *Kappaphycus alverezii* seaweed sap and 1% enriched banana pseudostem sap significantly increased the growth and quality of green gram. The application of 100% RDN through NADEP compost significantly increased protein content of grain (20.30%) but, significantly reduced the total

sugar (4.93%) as well as non-reducing sugar (2.44%) contents in green gram as compared to 50% RDN as well as 4 t/ha through NADEP compost (Patel *et al*. 2020). Kumar *et al*. (2022) reported that the combination of vermicompost + ghanajeevamrutha, FYM + ghanajeevamrutha, FYM +vermicompost based on 100% RDP (Recommended dose of Phosphorus) along with Rhizobium + PSB treatments recorded higher seed index (10.25) and protein content (22.7%) in black gram when compared to control. This can be attributed to the higher availability of nitrogen, a major constituent of amino acids, which act as a building block of protein (lysine). Shariff *et al.* (2015) reported that soil application of RDP (Recommended Dose of Phosphorus) along with FYM, vermicompost and glyricidia as leaf manure in equal proportions and a foliar spray of panchagavya @ 3% at flower initiation stage and 15 days after flowering improved the seed quality of green gram in terms of protein content (22.64%). The foliar spray of panchagavya @ 3% increased the protein content up to 23.11% which can be attributed to the enzymatic activity of nitrate reductase and glutamate synthase. Application of 33.33% Bio-compost (BC) + 16.7% vermi-compost (VC) + 33.33% castor cake (CC), increased the bolting point (6.17%), TSS (12.40%), Pyruvic acid (5.65 µM/g) in onion, while 16.7% Bio-compost (BC) + 33.33% VC + 33.33% CC significantly increased the neck thickness (12.80) as compared to other treatments (Patel *et al.,* 2016). The improvement in quality parameters of crop through different organic sources might be due to presence of different essential nutrients, growth-promoting hormones and growth-regulating substances which effectively regulates various metabolic functions for the synthesis of proteins and thus improving the quality of the produce.

Quality of organically grown oilseed crop

Rapeseed and mustard are considered as important oilseed crops throughout the world. Adoption of different organic nutrient management practices greatly enhanced the oil content in mustard as compared to inorganic. Out of the different nutrient sources; the combined application of cattle dung and poultry manure comparatively recorded higher oil content (38.44%) than the inorganic fertilized (37.54%) and control treatment (36.82%) (Bhaskar, 2020). Application of FYM and Zn increased the glucosinolate level in mustard seeds, but seed treatment with azotobacter reduced the glucosinolate content (Pal and Singh, 2019). Paramasivam *et al*. (2006) reported that sole application of composted poultry manure, composted pressmud or vermicompost as N equivalent did not improve the oil and protein content in groundnut seed, but combined application of these organic sources along with panchagavya spray @ 3 % significantly improved the quality of groundnut seeds. Besides this, crude protein content in sesame increased upon application of poultry manure + rice husks (Vayipuri *et al.,* 2003). In sunflower, foliar application of Panchagavya in combination with other organic manures significantly increased the oil content of seeds (Somasundaram, 2003). The application of biogas slurry of 3 milch animals and spray of Panchgavya @ 3 % increased the soluble protein of sunflower (Somasundaram *et al.,* 2007).

In many crops although the yield of organically grown crops was not up to that mark, but in case of soybean, yield was 5-13% higher in organically grown crop than that of recommended dose of fertilizers (Aher *et al.,* 2019). In an earlier research, Aher *et al*. (2015) also reported the positive effect of organic manure application on the performance of soybean and other crops in black soils. Kuotso and Singh (2021) reported that application of poultry manure @ 3 t ha^{-1} + forest litter @ 0.25 t ha^{-1} increased the protein and oil content in soybean. Higher protein content in the above treatment might be due to the fact that greater amount of nitrogen is supplied by poultry manure and since nitrogen is the constituent of amino acids which is known to be building block of protein. Similarly increase in the oil content might be attributed to balanced nutrition and supply of organic nutrients seems to be involved in an increased conversion of primary fatty acids metabolites to end products of fatty acid resulting in higher oil content in seeds.

Quality of organically grown tuber crops

The demand for organic potato products is gradually increasing (Willer and Youssefi, 2007) although the production of organically grown potato is quite low as compared to inorganic. Begum (2020) reported that the yield of potatoes in organic farming is quite low (18.59 t ha^{-1}) as compared to inorganic farming (29.03 t ha^{-1}). The quality parameters of potato such as carbohydrate, starch, reducing sugar and tuber dry matter percentage of organically produced crop did not vary with that grown under conventional method. Equivalent performance of organic and inorganic farming systems with regards to tuber quality *viz*., phenolic compound and starch content was also reported by Brazinskiene *et al*. (2014) and Ezekiel *et al*. (2013). The differences were insignificant even for the organoleptic taste (Asakaviciute and Razukas, 2020). On the other hand, few researchers reported significantly higher tuber dry matter content of organically grown potatoes as compared to conventional farming (Albino *et al.,* 2008, Gilsenan *et al.,* 2010 and Kazimierczak *et al.,* 2019). But higher levels of nitrogen through chemicals in conventional cultivation has led to a higher protein-carbohydrate ratio resulting in a decline in the carbohydrate content (Salunke and Desai, 1998).

Contrastingly, higher vitamin C (Hajšlová *et al.,* 2005) and phenolic compounds have been reported under organically grown potatoes (Keutgen *et al.,* 2019). Begum *et al*. (2021) also reported that application + spraying of banana pseudo stem sap @ 2% at 15, 30 and 45 DAP + mulching with water @ 6 t ha^{-1} significantly increased tuber quality by increasing the crude protein (18.02 %), starch (18.02 %) and vitamin C (18.15 mg 100 g^{-1}) contents over

control. The organic N nutrition with organic manures along with biofertilizers proved significantly superior with respect to quality parameters of potato. Maximum starch content was recorded under organic sources of nitrogen along with biofertilizers, especially due to higher concentration of potassium in poultry manure, which might have modified the proportion of tubers constituents with respect to starch (Yadav *et al.,* 2016).

On the contrary, the presence of nitrates compounds, precursors of carcinogenic nitroso amines in the human digestive system (Guziur *et al.,* 2000) have been reduced greatly in organic potatoes than the conventionally produced tubers (Lombardo *et al.,* 2012). Application of bio-fertilizers like *Mycorrhiza* and *Azospirillum* to potato also reduced the nitrate and nitrite contents in potato tubers (Abou-Hussein *et al.,* 2002). Apart from this, P, Mg, and Na were higher in the tubers of organically grown crop and it produced sufficient amount of dry matter (19%) for processing of french fries without impairing the texture of the fries (Haase *et al.,* 2007).

The sweet potato (*Ipomoea batatas* L.) plays an important role in the human diet due to presence of ample amounts of vitamins and minerals antioxidants, carotenoids, anthocyanins and phenolic compounds (Vizzotto *et al.,* 2018). Sweet potato is gaining popularity for its nutritional benefits combating the malnutrition and food security. The source of nutrient significantly influenced the quality of sweet potato. Atuna *et al*. (2018) reported that sweet potato grown with poultry manure @ 10 t/ha significantly increased β-carotene content (14.14-19.13 mg/ 100 g), while the soil treated with compost@ 10/ha significantly increased the sucrose (14.86±0.50%) and glucose (5.19±0.20%) than control. Integrated application of 100% RD of NPK along with 4 t/ha of cow dung significantly increased the dry matter content of sweet potato over control as well as sole organic treatment like application of poultry @ 6 t/ha and (Nyarko *et al.,* 2022).

Quality of organically grown spices

Organic production in spice crops has gained significant importance due to its environmental and health benefits. As consumer awareness about food safety and sustainability grows, the demand for organically produced spices has surged. Organic farming methods, which avoid synthetic chemicals and emphasize natural inputs, enhance soil health, biodiversity, and ecological balance. Application of panchagavya @ 4% improved the quality parameters *viz*., ascorbic acid (34 mg 100 g^{-1} of the fruit), TSS (9.2 g lit^{-1}) and total fenolics (0.697 mg g^{-1}) of black pepper fruit grown in Tamil Nadu (Sritharan *et al.,* 2010). Kadam *et al*. (2020) reported an improvement in the quality of turmeric, especially with regards to curcumin content under organic production. They found that application of organic nutrient sources like farmyard manure, vermicompost, and press mud cake has yielded curcumin equivalent to that obtained through inorganic fertilizers (5.19 %). Replacement of recommended dose of fertilizers with FYM @ 50%, vermicompost and neem cake each @ 25% had significantly increased the curcumin (5.3%) and essential oil (4.2%) contents over the inorganic fertilizers (200:100:100 kg N: P_2O_5:K_2O ha^{-1}) (Kumar *et al.,* 2016). A similar increase in the curcumin content of turmeric in response to organic nutrient management was reported by several workers (Velmurugan, 2008 and Nanda *et al.,* 2012). Ginger (*Zingiber officinale* Rosc.) is another high value spice crop adopted for cultivation in both tropical as well as subtropical regions. Many studies have emphasized that organic nutrient management has a profound influence in the improvement of rhizome quality. Boniface *et al*. (2019) revealed that different organic soil amendments *viz.*, 50% rural compost + 50% poultry manure increased the oleoresin content (5.26%), essential oil (3.96%) and crude fiber (4.95%) in the rhizome. Jyotsna *et al.* (2013) also reported similar findings in ginger. Application of NADEP compost @ 5 t ha^{-1} or vermicompost @ 2.5 t ha^{-1} greatly increased the number of pods $plant^{-1}$ (29.03; 8.48), number of seeds pod^{-1} (14.80;14.26), protein content in the seeds (17.11;6.72), and hence seed yield (1093 kg/ha;1083 kg/ha) (Lunagariya et al. ,2018). They also reported that soil application of enriched banana pseudostem sap @ 5 L ha^{-1} significantly increased the seed protein content in fenugreek (17.11%) as well as seed yield (1093 kg/ha) as compared to soil drenching of Panchagavya @ 20 L /ha^{-1} and Jeevamruta @ 200 L ha^{-1}.

CONCLUSION

Thus it can be inferred that organic nutrient management helps to build healthy soil that is rich in organic matter and provide all the nutrients that the plants need besides improving the quality and taste of the final produce. Unlike conventional farming, organic farming with a small carbon footprint and plays a major role in the conservation of the nature. Organically grown products are having high level of nutrients and it is free from pesticide residues. Therefore, It was recommended that instead of focusing solely on highly marketable produce, future research should prioritize on quality best produce . Besides this, post harvest quality evaluation is needed for those products consumed after processing.

Conflict of interest

All authors declared that there is no conflict of interest.

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