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REVIEW ARTICLE

Moringa oleifera as a food fortificant: Recent trends and prospects

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Abstract *Moringa oleifera* tree is referred to as a miracle tree due to its rich source of certain macro and micro nutrients of great importance in human nutrition. The chemical composition of the different parts of the *Moringa* tree may vary depending on cultivar and source. *M. oleifera* leaf, seed and flower have found numerous applications in food. In this review we firstly summarized the present knowledge on the use of *M. oleifera* as a food fortificant in amala (stiff dough), ogi (maize gruel), bread, biscuits, yoghurt, cheese and in making soups. The knowledge gap in the reported research was provided and possible future applications of *M. oleifera* in foods as well as the need for a well-structured and planned experimental design were suggested.

Contents

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1. Introduction

Moringa Oleifera is universally referred to as the miracle plant or the tree of life. The *Moringa* plant derives this name based on its uses, particularly with regard to medicine and nutrition. It is a plant native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan (Fahey, 2005). *M. Oleifera* is the most widely cultivated among the 13 species of the *Moringaceae* family and it is exceptionally nutritious with a variety of uses. Almost all the parts of this miracle tree have been found to be very useful. Leaves are used as forage, tree trunk for making gums, flower nectar in honey and powdered seeds for water purification Fuglie (1999). *M. Oleifera* leaf has been used as an alternative food source to combat malnutrition, especially among children and infants (Anwar et al., 2007). *M. Oleifera* leaves are reported to contain substantial amounts of vitamin A, C and E (Hekmat et al., 2015). The leaves of *M. Oleifera* have also been found to contain appreciable amounts of total phenols, proteins, calcium, potassium, magnesium, iron, manganese and copper (Hekmat et al., 2015). *M. Oleifera* leaves are also good sources of phytonutrients such as carotenoids, tocopherols and ascorbic acid (Saini et al., 2014b, 2014d). These nutrients are known to scavenge free radicals when combined with a balanced diet and may have immunosuppressive effects (DanMalam et al., 2001). Besides the leaves, the flowers and fruits of *M. Oleifera* have also been found to contain appreciable amounts of carotenoids (Saini et al., 2014e).

In many parts of the world including Africa, the use of *M. Oleifera* as a food fortificant is on the increase. For instance, both fresh and dried *Moringa* leaves are included in meals in African countries such as Ghana, Nigeria, Ethiopia, East Africa and Malawi (Agbogidi and Ilondu, 2012). Many studies have shown the potential use of different parts of *M. Oleifera* in food applications such as in making soups (Babayeju et al., 2014), weaning foods (Arise et al., 2014), amala, a stiff dough made from yam and plantain flour (Karim et al., 2015, 2013), herbal biscuits (Alam et al., 2014), bread (Chinma et al., 2014), cake (Kolawole et al., 2013) and yoghurt (Hekmat et al., 2015). The use of this nutrient rich plant in fortifying foods is getting much attention. This review firstly summarizes the present knowledge on the use of *M. Oleifera* as a food fortificant. It then provides knowledge gap with a view to provide suggestions for potential applications in foods.

1.1. Nutritional value of M. Oleifera

M. Oleifera tree is a plant rich in a number of nutrients such as proteins, fibre and minerals (Jongrungruangchok et al., 2010; Moyo et al., 2011) that play important role in human nutrition. Many of the reported studies have shown that *M. Oleifera* leaves are exceptionally high in protein compared to other leaves consumed as food. The nutritional value of *M. Oleifera* leaves may vary with cultivar and source. For instance, Jongrungruangchok et al. (2010) observed variations in the protein (approx. 19–29%) and fibre (16–24%) contents of *M. Oleifera* leaves grown in 11 different provinces in Thailand. The protein content of the leaves reported by these authors is similar to those reported in Brazil (28%) (Teixeira et al., 2014) and South Africa (approx. 30%) (Moyo et al., 2011). The calcium, iron and potassium contents of the leaves were also found to show substantial variations (Jongrungruangchok et al., 2010). Yang et al. (2006) working with four cultivars of *Moringa* reported that *M. oleifera* had the highest amount of β-carotene, ascorbic acid (Vitamin C), α-tocopherol (Vitamin E) and iron. Fresh leaves of *M. Oleifera* have been found to be good sources of carotenoids such as trans-lutein (approx. 37 mg/100 g), trans-β-carotene (approx. 18 mg/100 g) and trans-zeaxanthin (approx. 6 mg/100 g) (Saini et al., 2014d). These authors similarly reported relatively high amounts of ascorbic acid (271 mg/100 g) and tocopherols (36.9 mg/100 g) in the fresh *M. Oleifera* leaves (Saini et al., 2014d). *M. oleifera* leaves have also been found to contain significant amount of essential amino acid and are rich in alpha linoleic acid (Moyo et al., 2011). The leaves are known to be excellent source of a wide range of dietary antioxidants (Moyo et al., 2012; Qwele et al., 2013; Saini et al., 2014d, 2014e; Yang et al., 2006). According to Yang et al. (2006), *M. oleifera* leaves have significantly higher antioxidant contents when compared to fruits such as strawberries known for high antioxidant contents. Other authors have similarly reported the antioxidant potential of the leaves of *M. Oleifera* (Saini et al., 2014b, 2014d). Other studies showed that *M. Oleifera* plant may find application in livestock industry for improving meat quality in terms of chemical composition, colour and lipid stability (Nkukwana et al., 2014a, 2014b, 2014c; Qwele et al., 2013). A recent study showed that iron from *M. Oleifera* can overcome iron deficiency and modulate the expression of iron-responsive genes better than conventional iron supplements (Saini et al., 2014a). Similarly, Saini et al. (2016) found that the relative bioavailability of folate from *M. Oleifera* leaves using rat model was very high (approx. 82%) suggesting that the *M. Oleifera* leaves can be a potential source of dietary folate. It is also important to mention that the *M. Oleifera* leaves, flower and tender pods are potential sources of polyunsaturated fatty acids, which may have some beneficial effects in *M. Oleifera* based products (Saini et al., 2014c). Many of the aforementioned nutritional benefits of *M. Oleifera* suggest that these plants can serve as a functional ingredient in the food and allied industries.

1.2. Purpose of food fortification

Food fortification involves the addition of essential nutrients such as vitamins and minerals to staple foods to improve their nutritional value. In most cases, fortification can lead to rapid

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