Silicon supplementation improved the nutritional potential and sensory properties of drought-stressed lentil seeds as revealed by a novel sensory analysis using non-invasive biometrics from consumers

Sajitha Biju[1]
Sigfredo Fuentes[1], Claudia Gonzalez Viejo[1], Damir Torrico[2] and Dorin Gupta[1]

[1] The University of Melbourne
[2] Lincoln university, New Zealand

Lentil is one of the most important nutritionally rich pulse crops in the world. Despite having a prominent role in human health and nutrition, it is very unfortunate that global lentil production is adversely limited by drought stress, especially in Mediterranean and sub-tropical countries, causing a huge decline in yield and productivity. Furthermore, drought stress can also affect the nutritional profile of lentil seeds. The mineral silicon (Si) is an essential element for plants (especially under stresses) and a general component of the human diet found mainly in plant-based foods. This study investigated the effects of Si on nutritional (nutrients, antinutrients and antioxidants) and sensory properties of cooked seeds obtained from two lentil genotypes (ILL 6002-drought tolerant) and ILL 7537-drought sensitive) grown in Si-supplied, drought-stressed environment. The sensory properties of cooked seeds (stir-fried and boiled) obtained from lentil plants grown under different drought stress treatments were evaluated using 51 panellists (35 females and 16 males; 20 to 50 years). A novel sensory analysis using an integrated camera system coupled with the Bio-Sensory application was employed to evaluate the unconscious and self-reported responses of the participants. Appearance, color, aroma, flavor, texture and overall liking of samples were rated using a 9-point hedonic scale (1=dislike extremely to 9=like extremely). Biometric measurements (unconscious responses) were acquired from video data acquisition and infrared thermography to obtain a series of physiological (heart rate and skin temperature changes, respectively), emotional and behavioural responses from facial expression analysis (neutral, happy, sad, angry, surprised, scared, disgusted, and contempt, gaze direction and head orientation) from participants during the sample assessments. The facial expressions and emotional responses to different samples were analysed using FaceReader™ 7.1 software. Significant enhancements in the concentration of nutrients (protein, carbohydrate, total dietary fibre and Si) were found in the lentil seeds along with increase in the antioxidants (ascorbate, phenol, flavonoids and total antioxidant activity). Significant reductions in antinutrients (trypsin inhibitor, phytic acid and tannin) were also recorded ($P \leq 0.05$), irrespective of cooking methods. The results also showed a higher acceptability for lentil seeds obtained from Si treated drought stressed plants with higher flavour, softness and aroma, along with good texture in the stir-frying cooking method. The emotional and physiological responses captured using non-invasive biometrics also lead to similar findings and supported the results from self-reported responses. Principal component analysis explained 88.5% of total data variability along with the covariance matrix ($P \leq 0.05$), showing significant correlations ($R=0.6$-1) between the nutritional properties of seeds and sensory responses of consumers with the biometric data. Overall, this study demonstrated that Si supplementation of drought-stressed plants can improve the nutritional properties and sensory characteristics of seeds. Thus, this study not only offers an innovative approach in sensory analysis coupled with biometric techniques to accurately assess consumer's preference and liking towards tested

samples, but also, in the future, would help in making a predictive model for sensory traits and nutritional components in lentil seeds using machine learning modelling techniques.