Comparative ANN-TLBO and RSM Optimisation Approach for Bioactive Potential of Microwave Convective Dried Mango (*Mangifera indica*) †

Tanmay Sarkar, Molla Salauddin, Sudipta Kumar Hazra and Runu Chakraborty *

Department of Food Technology and Biochemical Engineering, Faculty of Engineering and Technology, Jadavpur University, Jadavpur, Kolkata 700032, India; email@gmail.com (T.S.); email@gmail.com (M.S.); email@gmail.com (S.K.H.)

* Correspondence: crunu@hotmail.com

† Presented at the 1st International Electronic Conference on Food Science and Functional Foods, 10–25 November 2020; Available online: https://foods_2020.sciforum.net/.

Abstract: Mango (*Mangifera indica*) is a rich source of antioxidants like phenolic acids and flavonoids. Polyphenol oxidase (PPO) and peroxidase (POD) enzyme oxidises mono and/or diphenols, thus the antioxidant potential diminished. For cost effective and sustainable preservation of this sub-tropical climacteric fruit, microwave convective dehydration is a prospective choice. Drying operation deactivates PPO and POD. Microwave convective drying was done at 100–300 watt of power level, temperature range of 40–80 °C, total soluble solid content of 20–30 °B and puree load of 0.4–0.6 g/cm^2 to investigate the effect of process parameters on total phenolic content (TPC) of the final product. Response surface methodology (RSM) was employed to optimise the TPC value. Further, artificial neural network (ANN) with the back propagation-feed forward modelling approach was adopted for the experimental results obtained, teaching-learning based optimisation (TLBO) was then employed to acquire the optimised drying condition for sample with maximum TPC value. The optimised process condition obtained from both the method was virtually compatible. From RSM analysis the maximum TPC value of 13.36 mg GAE/100 g was observed at 170.27 watt power level, 57.84 °C oven temperature, 0.60 g/cm^2 of puree load and 29.05 °B of total soluble solid content. Whereas, from ANN-TLBO technique 14.29 mg GAE/100 g of TPC was attained for the combination of drying parameters as follows: 175.08 watt, 57.15 °C, 0.60 g/cm^2 and 29.25 °B. The ANN-TLBO approach predicted better optimised result (TPC value) in comparison to the RSM method.

Keywords: food processing; bio-catalysis; polyphenol; ANN; enzyme

1. Introduction

Mango is a widely cherished sub-tropical fruit, full of antioxidants like phenolic acids, flavonoids and carotenoids. Mango leather is produced by drying of mango pulp [1]. The polyphenol oxidase (PPO) and polyphenol peroxidase (POD) enzyme degrade the phenolic compounds thus reducing its antioxidant potential. Microwave convective (MWC) drying is an emerging technique in developing countries in this era of industrial revolution 4.0. Heat and microwave radiation may deactivate the PPO and POD, thus increase the phenolic content in dried sample. The MWC should be optimised to produce mango leather with higher phenolic content with lower cost of production. Response surface methodology (RSM) and artificial neural network (ANN) are widely used for food production. Though teaching-learning based optimisation (TLBO) is considered in this research for the first time in fruit processing for optimisation of process parameters in MWC.

2. Materials and Methods

Samples were prepared as per our previous work Sarkar et al., 2020 [2] but using microwave convective (MWC) dryer instead of hot-air drying. Central composite design was adopted for MWC with power level in the range of 100–300 W, temperature from 40 to 80 °C, total soluble solid from 20 to 30 °B and pulp amount 0.4 to 0.6 g/cm³ (Table 1). Sample extract preparation and estimation of total phenolic content (TPC) was done following our previous work Hazra et al., 2019. Response surface methodology (RSM) and ANN-TLBO was conducted using Design Expert 7.0.0 and MATLAB 2018a.

Table 1. Central composite design was adopted for microwave convective drying of mango.

Parameters	-1 Level	+1 Level	-alpha	+alpha
Temperature (°C)	40	80	20	100
Puree load (g/cm³)	0.4	0.6	0.3	0.7
Brix (°B)	20	30	15	35
Power level (W)	100	300	0	400
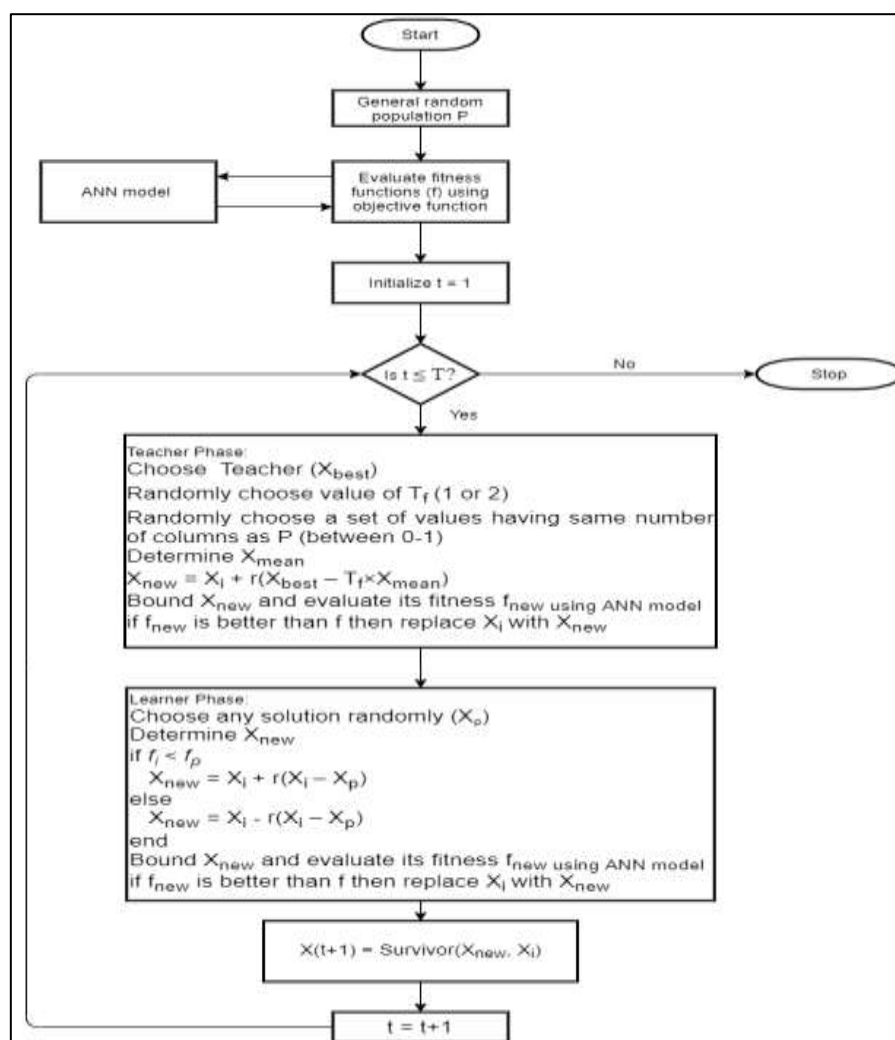
Figure 1. Flowchart of TLBO optimization.

3. Results and Discussion

From the model developed (non-linear) it was evidenced that amount of pulp being used affected the TPC value most followed by temperature of MWC, total solid and power level. The interactive effect of temperature and pulp amount followed by interaction between pulp amounts

and total solid, puree load and power level affected the TPC results. The R^2 value appeared from RSM was 0.8560, model was significant ($p < 0.01$) and lack of fit was insignificant ($p > 0.01$).

ANN model was built with feed forward back-propagation type of network, trainlm was the training function, learngdm was the learning function, performance was measured by mean squared error, optimum number of layers was 5, numbers of neurons were 7 and transig was used for transfer function (Stalin et al., 2019). The coefficient of correlation for predicted versus actual values was 0.9136 the proposed ANN model is represented in Figure 2.

For TLBO, student size was 40, factor of teaching was 1–2 and best value for last 50 generations was the criteria. For best teacher the set of parameters which provide maximum TPC was considered as "best teacher value", thereafter mean of entire parameters were calculated. After teaching phase, inputs responsible for maximum TPC values were considered for improved inputs. Whereas, the maximum TPC value achieved from the input set was considered as the student phase performance. The maximum TPC value achieved by ANN-TLBO was 14.29 mg GAE/100 g for the optimised input set of 175.08 watt, 57.15 °C, 0.60 g/cm^2 and 29.25 °B.
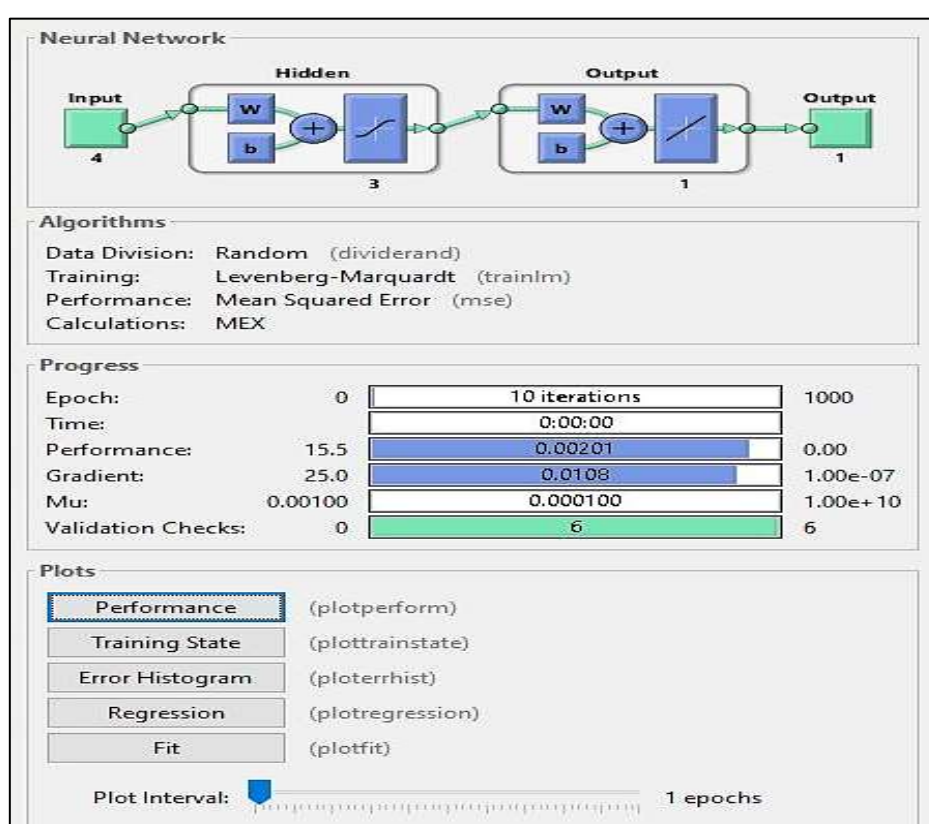

Figure 2. ANN model.

4. Conclusions

The inhibition or deactivation of polyphenol oxidase was there resulting in higher TPC content along with availability of free polyphenols during the microwave convective drying. Using RSM optimization the highest TPC value was observed 13.36 mg GAE/100 g for the combination of 57.84 °C (MWC dryer temperature), 29.05 °B (total soluble solid content), 170.27 watt (microwave power level) and 0.60 g/cm^2 (pulp amount). The maximum TPC value of 14.29 mg GAE/100 g was found using ANN-TLBO for the combination of drying parameters as follows: 175.08 watt, 57.15 °C, 0.60 g/cm^2 and 29.25 °B. More robust model with higher coefficient of correlation was achieved by ANN-TLBO technique than that of RSM.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Sarkar, T.; Chakraborty, R. Formulation, Physicochemical Analysis, Sustainable Packaging-Storage Provision, Environment Friendly Drying Techniques and Energy Consumption Characteristics of Mango Leather Production: A Review. *Asian J. Water Environ. Pollut.* **2018**, *15*, 79–92, doi:10.3233/AJW-180046.
2. Sarkar, T.; Nayak, P.; Chakraborty, R. Storage Study of Mango Leather in Sustainable Packaging Condition. *Mater. Today Proc.* **2020**, *22*, 2001–2007, doi:10.1016/j.matpr.2020.03.177.
3. Sarkar, T.; Salauddin, M.; Hazra, S.K.; Chakraborty, R. A Novel Data Science Application Approach for Classification of Nutritional Composition, Instrumental Colour, Texture and Sensory Analysis of Bael Fruit (*Aegle Marmelos* (L) Correa). *Int. J. Intell. Netw.* **2020**, *1*, 59–66, doi:10.1016/j.ijin.2020.07.003.
4. Stalin, B.; Kumar, P.; Ravichandran, M.; Kumar, M.; Meiyanathan, M. Optimization of Wear Parameters Using Taguchi Grey Relational Analysis and ANN-TLBO Algorithm for Silicon Nitride Filled AA6063 Matrix Composites. *Mater. Res. Express* **2019**, *6*, doi:10.1088/2053-1591/ab3d90.