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Effect of Ethyl Oleate Treatment on Drying of Bitter Gourd

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Abstract. Bitter gourd (*Momordica charantia L.*) is famous for its nutritional and medicinal value and is widely recommended in daily diet. Despite of many advantages, it has not been explored to its potential because of its bitter taste. Proper processing and value addition options of this vegetable is necessary. Drying with appropriate pre-treatments can extend the shelf life and availability of the product for consumption throughout the year. Chemical treatment has been used to improve drying characteristics of many vegetables. The bitter gourd samples were treated with ethyl oleate and subsequently blanched under microwave and tray dried. The drying time could be decreased from 150 to 110min by ethyl oleate treatment and microwave blanching. The effective diffusivity increased from 8.92 $x10^{-8}$ to $9.73x10^{-8}$. The rehydration ratio also improved from 4.88 to 5.21. It also decreased the shrinkage ratio while drying. Ethyl oleate treatment followed by microwave blanching can improve the drying characteristics and quality of bitter gourd for better consumer acceptance and storability.

Keywords. Bitter gourd, blanching, drying characteristics, ethyl oleate, pre-treatment,

1. Introduction

Bitter gourd (*Momordica charantia* L.) is one of the antioxidant-rich vegetables in *curcurbitaceae* family which is cultivated and consumed worldwide. It is known with many local names like *Karela* (India), *bitter melon* (United States), *ampalaya* (Philippines), *peria* (Indonesia, Alysia), *kugua* (China), and *mara* (Thailand) (Tan *et al.*, 2013). Philippines, India, China, Taiwan and Vietnam are the largest producers of bitter gourd in the world. In India, Andhra Pradesh, Odisha, Bihar, and Chhattisgarh are the major bitter gourd producing states. The bitter gourd has many nutritional and medicinal properties. The bitterness of the vegetable is due to the alkaloid momordicine (Cantwell *et al.*, 1996). It is rich in vitamins A and C, beta-carotene, phosphorous and iron. It is also known for its medicinal properties such as anti-diabetic, anti-cancer, anti-tumor. It is an excellent source of antioxidants. Drying and canning are the two commercial methods adopted to prolong the shelflife of bitter gourd (Sagar, 2013). Drying of bitter gourd is associated with browning and loss of antioxidants and vitamins. The proper pretreatment along with drying can improve the product quality and shelf-life. Many researchers studied the effect of blanching on bitter gourd (Kulkarni *et al.*, 2005; Sagar, 2013). The effect of ethyl oleate is studied on apricot (Doymaz, 2004), mulberry (Davoodi & Nikkhah, 2014), grapes (Pangavhane *et al.*, 1999), ginger (Deshmukh *et al.*, 2013) and red pepper (Doymaz & Pala, 2002). But the combined effects of ethyl oleate and blanching on bitter gourd has not been reported till date. Effect of three pretreatments *viz.* microwave assisted blanching (MB), ethyl oleate dipping (EO) and ethyl oleate treated and subsequent microwave blanching (EOMB) on drying characteristics were investigated.

2. Materials and Methods

2.1 Sample preparation

Bitter gourds (*ver.* pusa hybrid) were procured from the local vegetable market. These were then washed and packed in poly ethylene pouches and stored at 4ºC. Before the experimentation, the bitter gourds were taken out and cooled down to the ambient temperature. The initial moisture was determined by AOAC (1990) method. The average initial moisture was found to be 92±1% (wb). Samples were sliced into 3.5±0.2 cm diameter and 0.5±0.1 cm thickness manually. These samples were used for pretreatments and drying.

2.2 Pretreatments and drying

The sliced bitter gourds without any pretreatment were used as control samples and rest of the samples were divided into three groups and various combinations of pretreatments were applied (Table 1).

Table 1. Details of pretreatments

Pretreatments	Methodology
Not Pretreated (NOP)	Sliced bitter gourds were dried without any pretreatment
Ethyl oleate dipping (EO)	Sliced bitter gourds were dipped in ethyl oleate solution (2% EO and 4% K_2CO_3 v/v) for 1 min at room temperature
Microwave Blanching (MB)	Microwave blanched for 600 W for 135 seconds
Ethyl oleate treated microwave blanching (EOMB)	Samples were dipped in EO solution and microwave blanched at 600W for 135 seconds

The samples were blanched and then dipped in cold water to bring down the temperature to ambient level. Surface moisture was removed by muslin cloth. The pretreated samples were tray dried at three different temperatures 50±1ºC, 60±1ºC and 70±1ºC at 0.8m/s parallel flow of air velocity. The samples were dried in a single layer. Sample weight were taken at every five minutes interval until it reaches the equilibrium moisture content (EMC). The dried samples were packed in low density polyethylene pouches and stored in desiccator for further analysis.

2.3 Moisture ratio, effective diffusivity, shrinkage and rehydration ratio

Moiture ratio (MR) of the samples were determined using Eq. 1 (Motevali *et al.*, 2012).

$$MR = \frac{M_t - M_e}{M_0 - M_e} \qquad (1)$$

Where, M_t=moisture content at time (t) ; M_o=initial moisture content ; M_e=equilibrium moisture content

The values of M_e is relatively small to that of M_t or M_o. So, the term M_e is negligible and the simplified (Eq.2) is used to determine the moisture ratio (Aghbashlo *et al.*, 2009).

$$MR = \frac{M_t}{M_0} \qquad (2)$$

Moisture diffusivity was determined following Fick's law of diffusion (Eq.3) with slab boundaries assumption. The effective diffusivity was determined by plotting Ln (MR) against drying time. The slope of the striaght line gives the effective diffusivity of sample.

Activation energy was calculated using Arrrhenius equation (Eq.4) and plotting the graph Ln (D) w.r to 1/T. The slope of the equation was taken as the activation energy (Motevali *et al.*, 2012).

$$Ln(MR) = \ln\frac{8}{\pi^2} - \frac{D\pi^2}{4L^2} \qquad (3)$$

Where, D=drying time(min) ; L=half thickness (cm)

$$D = D_0 \exp(\tfrac{-E_a}{RT}) \qquad (4)$$

Where, Do=pre-exponential factor; R=universal gas constant (8.314 J/mol K); T=temperature(K); Ea=activation energy (KJ/mol).

Shrinkage ratio was determined using Eq. 5 by measuring the sample volume before (V_i) and after drying (V_f) (Abasi *et al.*, 2009).

$$\text{Shrinkage ratio} = \frac{V_i - V_f}{V_i} X100 \qquad (5)$$

Rehydration ratio was calculated following standard procedure using Eq.6. Dried sample (5g) were taken in beaker and placed in hot water bath maintained at 80ºC for 10 mins. The samples were taken and surface moisture was removed and weighed. The ratio of gained weight after rehydration (R_f) to the intial weight (Ri) gives the rehydration ratio (Abasi *et al.*, 2009)

$$\text{Rehydration ratio} = \frac{R_f}{R_i} X100 \qquad (6)$$

2.4 Statistical analysis

All the results were statistically analysed using STATISTICA (Ver-8, Statsoft Inc.,USA). The data were analysed for two-way ANOVA at $P \leq 0.05$ at the confidence level of 95%.

3. Results and Discussion

3.1 Effects of pretreatments on moisture ratio of bitter gourd

The moisture ratio of the controlled and pretreated bitter gourd samples dried at three different temperatures are shown in Fig 1-3. The drying time was reduced as the drying temperature was increased. Bitter gourd dried at 50, 60 and 70ºC without any pretreatment (NOP) took longer drying time of 270, 210 and 170 min repsectively. Microwave assisted blanching (MB) of bitter gourd decreased the drying time significantly ($P<0.05$) to 240, 180 and 150 min dried at 50, 60 and 70ºC respectively. This is due to the penetration of electromagnetic waves altering the cell wall structure and forming the pores in the tisssues thus enabling increased water diffusion from interior to surface during drying (Abano & Amoah, 2015). Ethyl oleate (EO) treatment further decreased the drying time significantly ($P<0.05$) to 230, 170 and 130 min dried at 50, 60 and 70ºC respectively. This is due to the dipping of sliced bitter gourd in EO solution rupturing the waxy layer around the sample and creating pores which improves moisture removal at a faster rate than the MB samples (Doymaz, 2004). Both MB and EO samples were found to have higher drying rate at the intial stage which decreases gradually. EOMB samples could be dried faster with decreased drying time of 190, 130 and 100 min at 50, 60 and 70ºC respectively. This is due to dipping the samples in EO and subsequently blancing under microwave. The drying time was maximum (270min) for NOP samples dried at 50ºC. It was minimum (100 min) for EOMB samples dried at 70ºC. EOMB treatment could reduce the over all drying time by 91%.

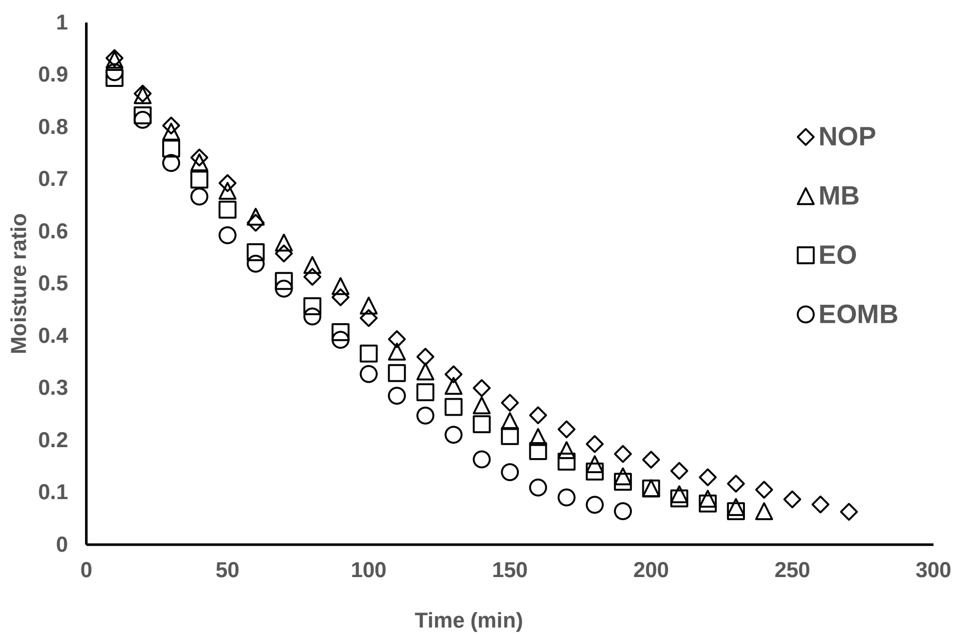

Figure 1. Drying curve for NOP, MB, EO, EOMB at 50ºC

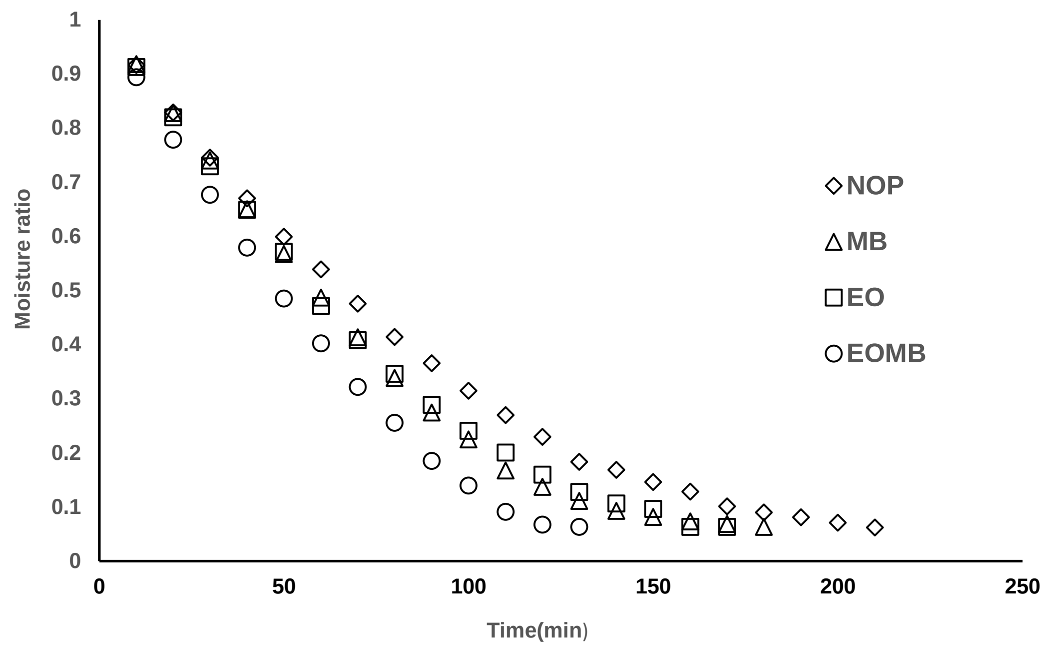

Figure 2. Drying curve for NOP, MB, EO, EOMB at 60ºC

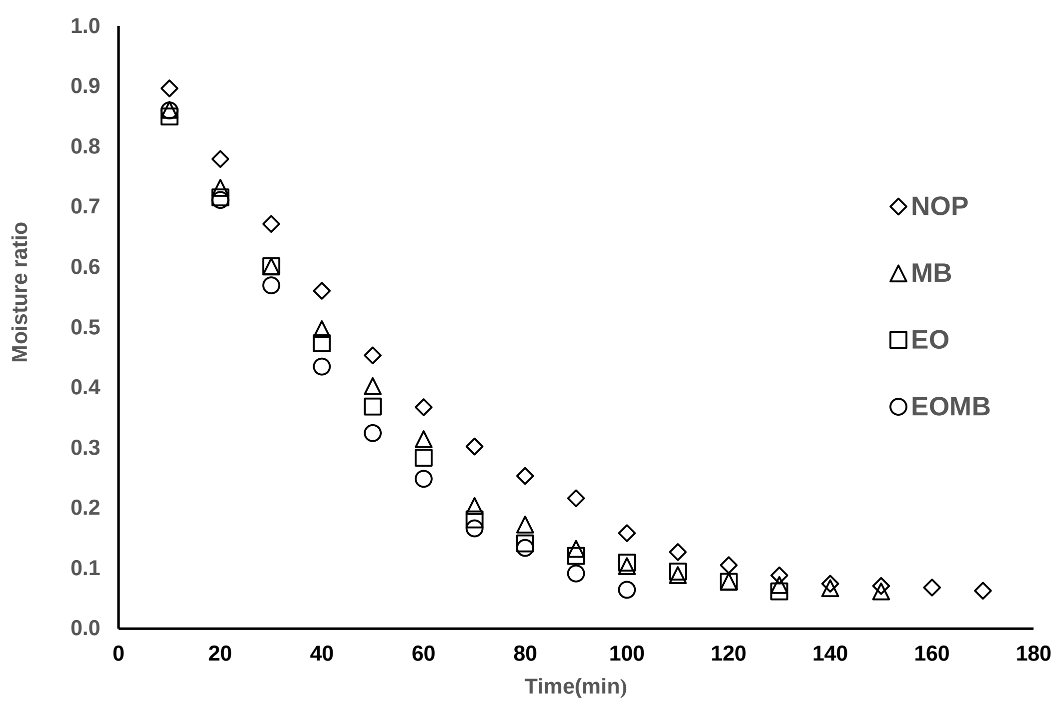

Figure 3. Drying curve for NOP, MB, EO, EOMB at 70ºC

3.2 Effects of pretreatments on moisture diffusivity

The effective diffusivity (D_{eff}) of the bitter gourd during drying was determined using Fick's second law of diffusion for drying temperature of 50, 60 and 70 ºC (Fig 4-6). Drying of the samples followed a falling rate period indicating interior moisture diffusion (Chen *et al.*, 2013). EOMB treatment increased D_{eff} from 2.65 $x10^{-8}$ to $7.48x10^{-8}$ at 70ºC. NOP sample had the lowest D_{eff} (2.65 $x10^{-8}$ to $4.85x10^{-8}$) even if the drying temperature was increased from 50 to 70ºC. The MB treatment increased the D_{eff} values from 3.11 $x10^{-8}$ to $5.51x10^{-8}$ with increased drying temperature from 50 to 70ºC . This may be due to the cell wall disruption during microwave blanching which increases effective moisture diffusivity (Patricia *et al.,* 2011). EO treatment further increased the effective diffusivity from 3.14 $x10^{-8}$ to 6.06 $x10^{-8}$ with increase in drying temperature from 50 to 70ºC. D_{eff} values were found to be maximum in EOMB pretreated samples. This may be due to the combined effect of microwave and EO. ANOVA of the drying data suggests that there was significant differences ($P<0.05$) among all the pretreatements.

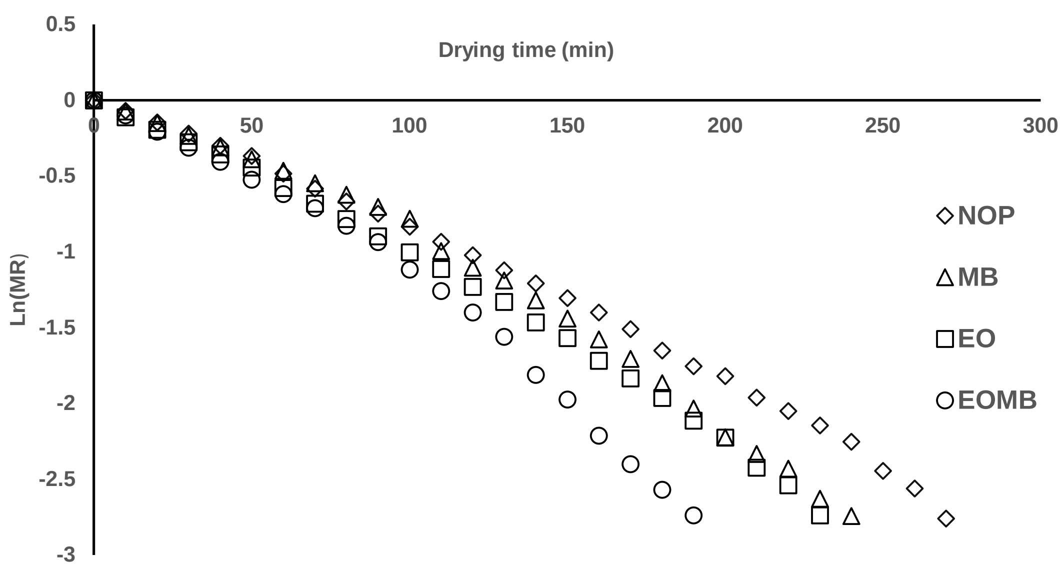

Figure 4. Effective diffusivity of NOP, MB, EO and EOMB at 50ºC

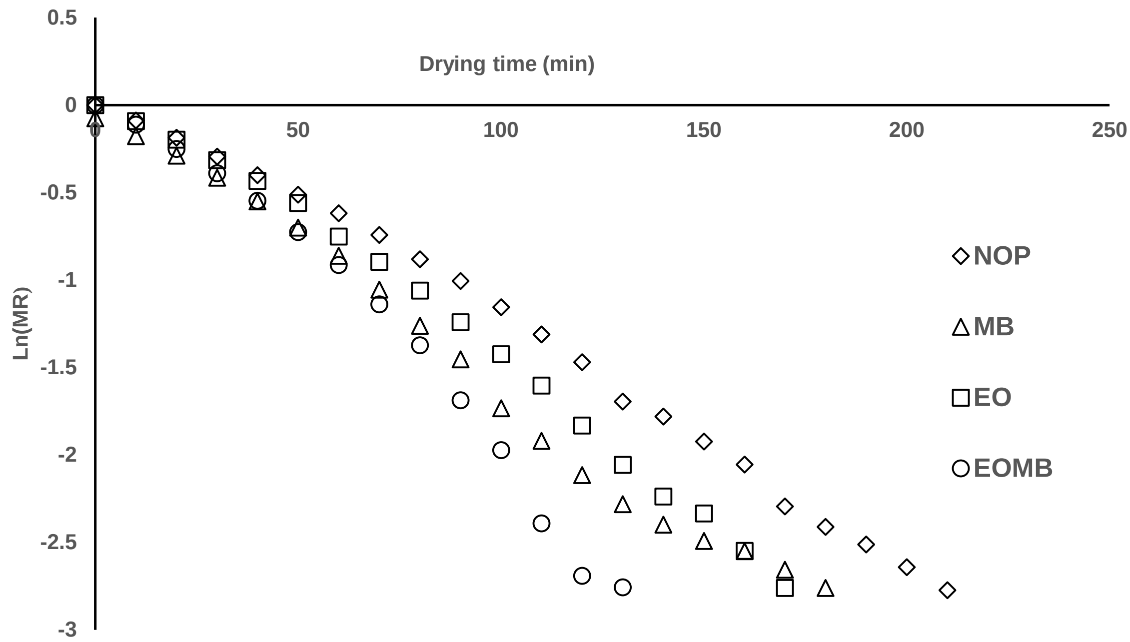

Figure 5. Effective diffusivity of NOP, MB, EO and EOMB at 60ºC

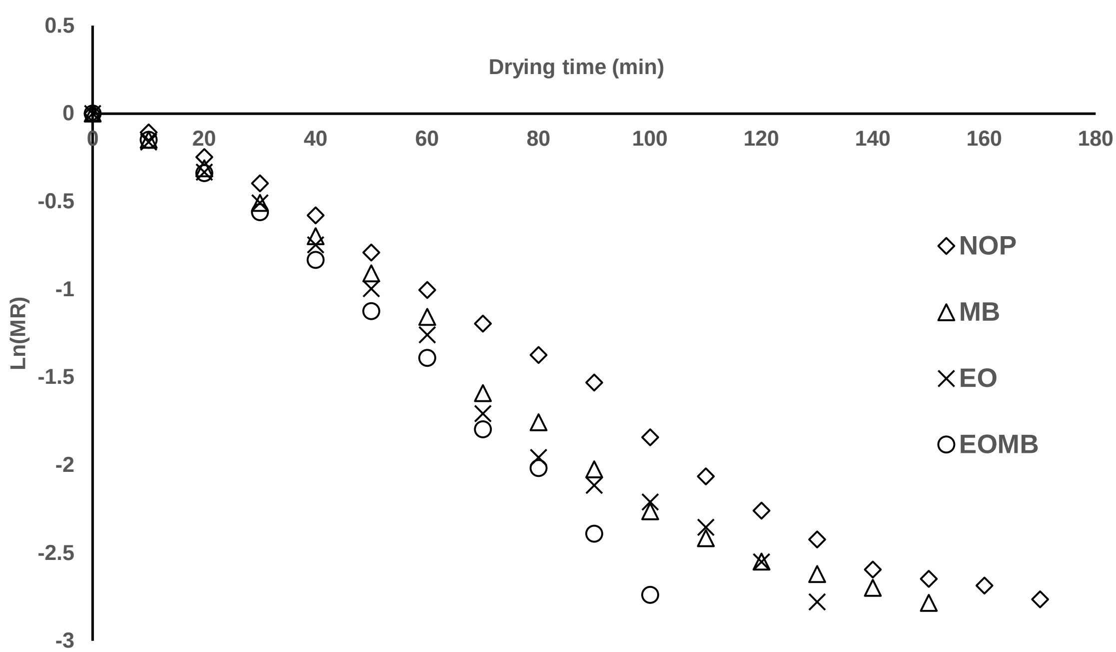

Figure 6. Effective diffusivity of NOP, MB, EO and EOMB at 70ºC

3.3 Effects of pretreatments on shrinkage and rehydration ratio

Shrinkage and rehydration ratio are the two important drying characteristics. These two values have significant role in quality, appearance and consumer acceptance of dried samples. The shrinkage and rehydration ratio of bitter gourd samples dried at various temperature are shown in Fig 7 and 8. The shrinkage ratio was lowest at 50 ºC and highest at 70ºC. NOP samples were having highest shrinkage ratio (80%) at 70ºC. EOMB treated samples had lowest shrinkage (46%) at 60ºC.

EOMB treatment increased the rehydration ratio. It was maximum (5.16) for drying at 70ºC. The NOP samples had lesser rehydration ratio (4.23) as compared EOMB samples. EO treatment does not change the structure of tissues even after drying (Doymaz, 2007)

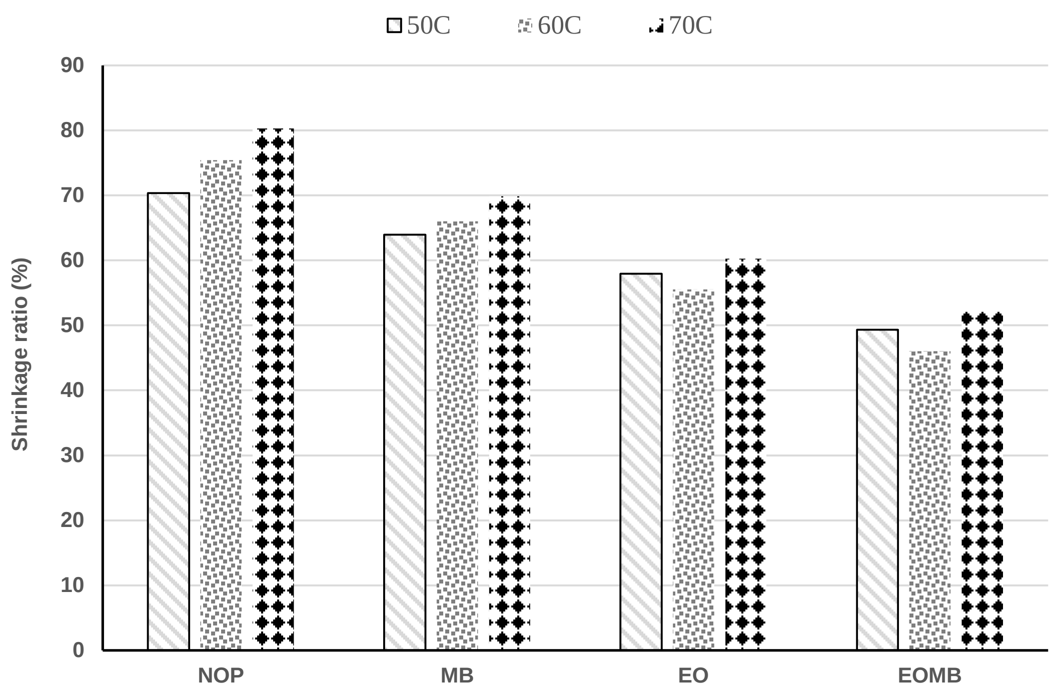

Figure 7. Shrinkage ratio of NOP, MB, EO and EOMB at 50, 60 and 70ºC

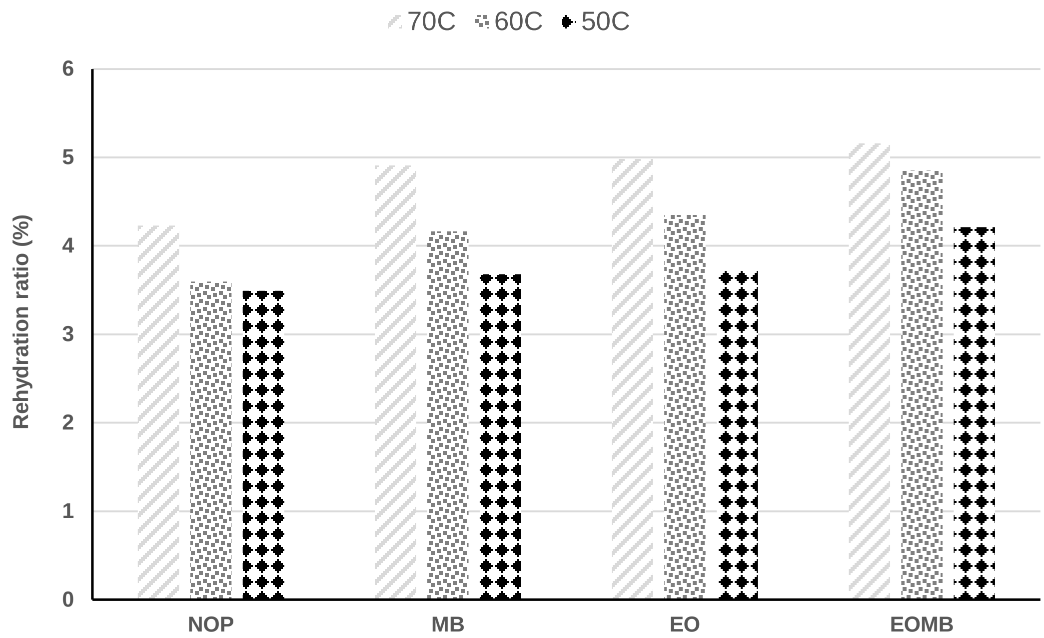

Figure 8. Rehydration ratio of NOP, MB, EO and EOMB at 50, 60 and 70ºC

4. Conclusion

The combined effect of ethyl oleate and microwave blanching significantly ($P<0.05$) reduces the drying time by almost 90% for bitter gourd samples. This is good for designing any processing operations of this vegetable in large scale value addition. Effective diffusivity was increased from 2.65×10^{-8} to 7.47×10^{-8}. The maximum activation energy was 30.5 KJ/mol. The shrinkage and rehydration properties were also good for EOMB treated sample of bitter gourd. Ethyl oleate treatment followed by microwave blanching can improve the drying characteristics and quality of bitter gourd for better consumer acceptance and storability.

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