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PHYSICOCHEMICAL AND COLOUR PROPERTIES CHANGES IN FRUITS AND VEGETABLES DURING DRYING PROCESS: A REVIEW

HITESH SINGH WASKALE
Department of Mechanical Engineering, Indira College of Engineering and Management, Pune Savitribai Phule Pune University, India

MAHESH GANPAT BHONG
Department of Mechanical Engineering, Indira College of Engineering and Management, Pune Savitribai Phule Pune University, India

ABSTRACT
The shelf life of eatable needs to be high so it can be consumable after a long period of time. Various methods for increasing the shelf life of food include drying method which primary reduce the moisture contain in food and restrict the growth of fungi and decrease it decomposition rate. Drying leads to change in physicochemical properties of food and its colour. This review paper aims to study the various physicochemical parameters changes which take place during drying period and colour variation base on hunter colorimetric system.

INTRODUCTION
The demand of preserve eatables increase during World War II. The troops deploy in field needs fresh and healthy food to eat which has good nutrition value. Many company out form during that period providing the requirement of army. Casserole and Eggs are some of the starting tin can product which has high shelf life and also able to maintain the nutrition value. [1] Nutrition bar [2]provided by United State Army under Meal, Ready to eat [3] was one of the best eatables containing all the required nutrition for a solider.
During processing of food, it's physicochemical and nutrition level gets change which affects the appearance and the quality of food product. Many research have been conducted worldwide aiming to understand the variation of such properties and to maintain the nutrition level of food. Food drying is one of the food processing process which removes the moisture from food and increase its shelf life. It use a heat source and fan or blower for force convection to circulate air over food and reducing its moisture contain. This process restrict the growth of bacteria and increase the life of food. The moisture reduction make food light in weight and easy to transport. [4] Most commonly hot air drying is used for drying eatables as it reduce the packaging cost and storage as the final product has low volume to weight ratio. [5] Moreover, the shelf life of eatables having low moisture contain is more as compare to those eatables which has high moisture contain. [6] Some food are highly sensible to temperature and there nutrition value get reduce during drying process. Functional properties like oxidation value, shrinkage, loss of colour and texture are important to consider during drying of fruits and vegetables. [7]
Hot air drying (AD) leads to degradation of flavor, colour and nutrition value because of its high temperature operational process whereas Microwave drying (MD) and infrared radiation (ID) result in more promising result in terms of colour and flavor preservation during drying process. Freeze drying (FR) yields high quality dried product but it consume high energy. [8]Many researcher had used L*a*b colour space [9] to measure the colour value of fresh fruits and vegetables and processed ones. L*a*b colour space as compare to RGB colour space and CYMK colour space has uniform colour distribution and perception of colour which is easy to human eye to read and understand. [10] This review paper focus on different drying technique used to remove moisture, change in colour and physicochemical properties of fruits and vegetables.

IMPORTANT CONCEPT
A. PHYSICOCHEMICAL PROPERTIES
Physicochemical properties of food are important to design the food processing, storage and handling system. [11] This properties include moisture, protein, fat, fiber and ash contain in food.

1) Moisture
It is most common measure quantity in processed food as there are legal standard of moisture contain in food. [12] Moisture in food is the amount of water present in food. The quantity of moisture effect the chemical and physical aspect of food. [13]
2) Protein
Protein are basically long chain of amino acid found in fruits and vegetables. [14] They are structurally classified in four groups as primary, secondary, tertiary and quaternary. During drying process the fruits and vegetables are expose to high temperature result in denaturation of proteins structure. The α-helix and β-sheet structure of protein get disturbed and attained random structure. [15]
3) Fat
Fat are fatty acid belonging to carboxylic acid group which are solids at room temperature. [16] This acids are very unstable in nature and react actively to oxygen and form reactive aldehydes. [17] To reduce the oxidation of fatty acid, antioxidant are added. Vitamin C are naturally occurring antioxidant in fruits and vegetables. Processed food generally added with synthesis antioxidant like TBHQ (tertiary butylhdroquinone), BHA (butylatedhydroxyanisole) and BHT (butylatedhydroxytoluene). [18]
4) Fiber
The fiber are classified in two types, soluble and insoluble. [19] The soluble fiber are pectin and gum found inside the plant cell of fruits and vegetables whereas the insoluble fiber are found in the cell wall of cellulose and lignin. [20] Both this soluble and insoluble fiber form crude fiber which are generally knows as dietary fibers. [21] Crude fiber is the total amount of fiber in food which is plant residue remains after hydrolysis by digestive enzymes. [22]
5) Ash
They are the inorganic component found in food around 7%. [23]The ash are basically material that are remain even after the food is burnt to very high temperature. It contain sodium, potassium, calcium and magnesium in major quantity and iodine, fluorine, arsenic, zinc, aluminum, iron, copper in minor quantity. [24]

B. COLOUR VARIATION

Fruits and vegetables after getting picked from farm undergoes many chemical changes due to detachment from plant and expose to different surrounding condition. This changes include colour change, flavor change and also texture change. [25] The variation of colour of fruits and vegetables are measure by instruments like spectrophotometer. The colour space used is basically L*a*b colour space defined by Hunter Labs (1996). [26] Consumer prefer food items which are fresh in colour as it signify that the food itself is fresh. [27] The process which improve the shelf life of food many times lower the saturation of real colour of food items. Therefore nowadays many artificial colour agents are used to enhance the appearance of fruits and vegetables. [28]

STUDIES OF PHYSICOCHEMICAL PROPERTIES

Margarita et al. [29] dried aloe vera using convective tray dryer at 50 °C, 60 °C, 70 °C, 80 °C and 90 °C with air velocity of 2 m/s. They found the moisture content in fresh aloe vera was 56.08 ± 1.11 g/100g d.m. which was higher than the dried aloe vera moisture contain ranging from 16.19 ± 0.54 g/100g d.m. to 18.81 ± 0.37 g/100g d.m. The moisture contain decrease significantly with increase in drying time. This is due to cell wall damage by lengthy drying time. [30][31] The moisture contain remain higher at 70 °C as compare to other drying temperature. Same was notice by Elsa et al. [32] where they dried olive-waste cake using convective dryer at 40 °C, 50 °C, 60 °C, 70 °C, 80 °C and 90 °C. Form Fig. 1, the moisture contain of fresh olive-waste cake decreases from 208.53 ± 4.17 g/100g d.m. to 1.39 ± 0.08 g/100g d.m. as drying temperature increases. Luciano et al. [33] used forced convective dryer to dry onion at 30 °C, 40 °C, 50 °C, 60 °C and 70 °C and the moisture contain decrease from 91.24 ± 0.54 g/100g d.m. to 13.32 ± 0.88 g/100g d.m. at drying temperature 40 °C. Eun et al. [34] dried the sweet potato flour at 55 °C, 60 °C and 65 °C using convection drying oven. The moisture contain of sweet potato flour decreases from 8.67 g/100g d.m.

to 6.18 g/100g d.m. with increase in drying temperature as similar reported by Van Hal. [35] This shows that higher the drying temperature, higher will be moisture removed with respect to drying period.

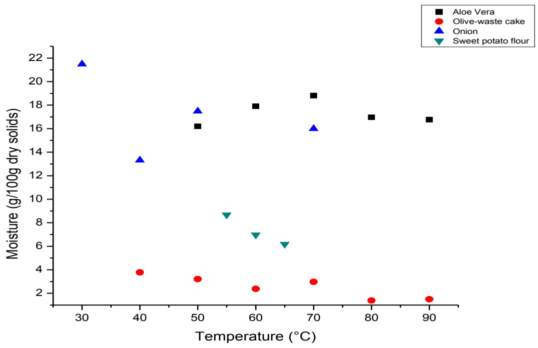

Figure 1 Proximate analysis of moisture (g/100g dry solids)during drying process

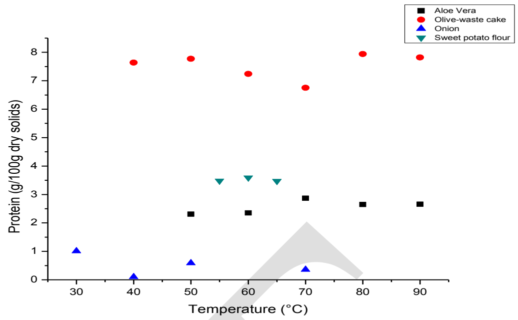

Figure 2 Proximate analysis of protein (g/100g dry solids) during drying process

The drying of aloe vera leads to decrease in protein contain as reported by Margarita et al. [29]. The protein contain for aloe vera sample dried at 50 °C had lowest protein contain 2.31 ± 0.19 g/100g d.m. as compare to sample dried at 70 °C which had 2.87 ± 0.18 g/100g d.m. Similar case was reported by Luciano et al. [33] where protein contain of onion decreases with increase in drying temperature as shown in fig. 2. The minimum protein contain was observed at 40 °C about 0.10 ± 0.01g/100g d.m. The decrease in contain of protein could be due to denaturation of protein. [36] Contradict result was obtain by Elsa et al. [32] where the protein contain of olive-waste cake increase with temperature but significant difference was not found. It range between 7.64 ± 0.48 g/100g d.m. to 7.24 ± 0.09 g/100g d.m. Where else the protein contain remain nearly same from 3.47 g/100g d.m. to 3.48 g/100g d.m. in sweet potato flour drying done by Eun et al. [34].
Margarita et al. [29] observed that thefat contain of aloe vera decreases with increase in drying temperature as shown in fig. 3. The decrease of fat was only observed till at 70 °C around 0.34 ± 0.04 g/100g d.m. After that the fat contain remain higher for higher drying temperature. Same was observed by Elsa et al. [32] for olive-waste cake where fat contain reach to minimum amount 9.28 ± 0.08 g/100g d.m. at 70 °C and thereafter remain higher for higher drying temperature. The decrease of fat contain could be due to enzymatic hydrolysis during first drying period. [37]. Similar fat contain pattern was observed for onion and sweet potato flour studied by Luciano et al.[33] and Eun et al.[34] where the minimum fat contain value 0.24 ± 0.08 g/100g d.m. and 0.59 g/100g d.m was obtain at drying temperature 30 °C and 65 °C respectively and after that it increases.
The studies done by Margarita et al. [29] and Luciano et al. [33] on aloe vera and onion respectively shows that the maximum crude fiber contain 14.31 ± 1.79 g/100g d.m. and 6.10 ± 0.89 g/100g d.m. respectively was obtained at low drying temperature 50 °C and 40 °C respectively. Whereas Elsa et al.[32] and Eun et al.[34] obtain maximum crude fiber contain 5.95 g/100g d.m. and 24.31 ± 1.21 g/100g d.m. at 60 °C for sweet potato flour and olive-waste cake respectively as shown in fig. 4.

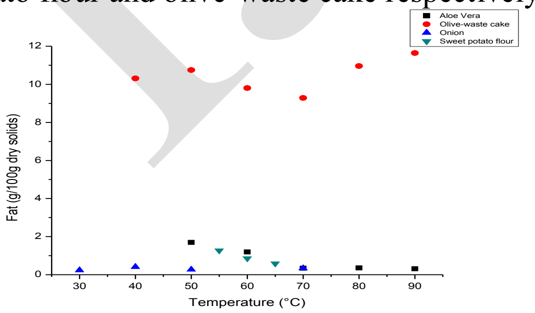

Figure 3 Proximate analysis of fat (g/100g dry solids) during drying process

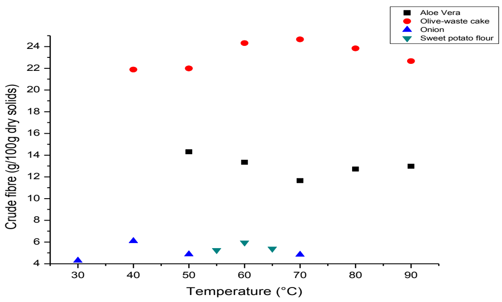

Figure 4 Proximate analysis of crude fiber (g/100g dry solids) during drying process

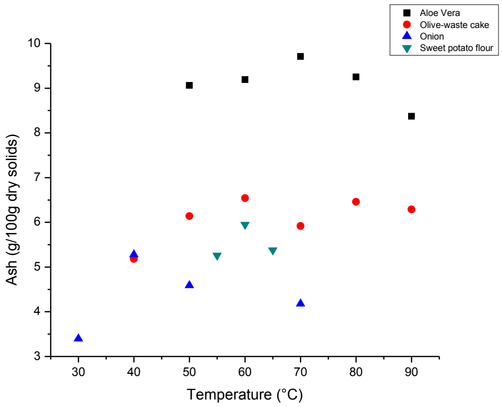

Figure 5 Proximate analysis of ash (g/100g dry solids) during drying process

Ash contain varies for different drying temperature but similar to result achieved for crude fiber. Margarita et al. [29] result shows that maximum ash contain 9.06 ± 1.17 g/100g d.m. was obtain as shown in fig. 5 at same temperature 50 °C where maximum crude fiber was obtain. The result from Luciano et al.[33] for onion shows maximum ash contain 5.28 ± 0.35 g/100g d.m. at same temperature 40 °C where maximum crude fiber was obtain. Elsa et al.[32] and Eun et al.[34] result for maximum ash contain for olive-waste cake and sweet potato flour respectively about 6.54 ± 0.05 g/100g d.m. and 3.64 g/100g d.m. respectively attended at same temperature 60 °C where maximum crude fiber was obtained. Hence, the concentration of crude fiber and ash obtain maximum at same temperature. This could be due to the fact that insoluble type fiber of dietary fiber and ash are insoluble in water and as the amount of moisture get reduce due to drying process from eatables, the density of crude fiber and ash increases per unit volume.

STUDIES OF COLOUR VARIATION

The appearance and colour of fruits and vegetables are one of the main parameter which consumer check before buying it. It helps consumer to evaluate the freshness of eatables and predict the taste of it. [38] Various colour space are there to evaluate the colour of eatables but mostly used colour space is L*a*b* colour space as it helps to easily identify the freshness of processed food items. [10] This L*a*b value also known as Hunter colour value.

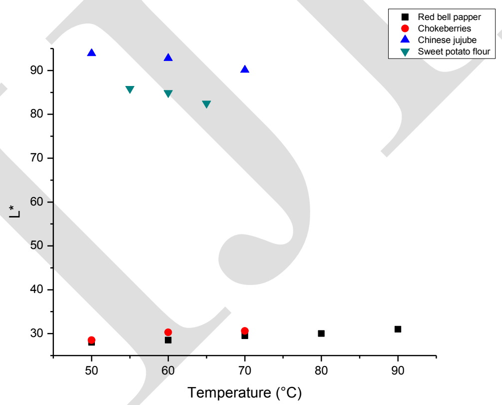

Figure 6 Effect of drying temperatures on Hunter colour values (L*)

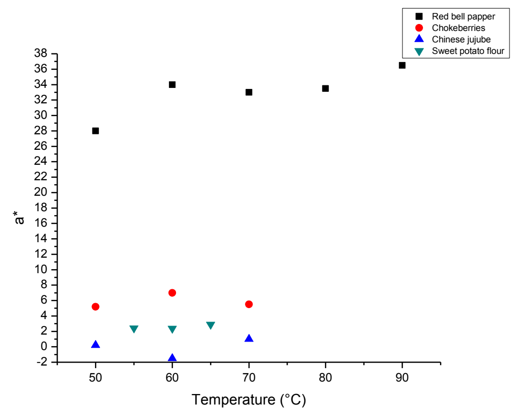

Figure 7 Effect of drying temperatures on Hunter colour values (a*)

Vega et al. [39] studied the colour change of rehydrated red bell pepper dried in convective oven at 50 °C, 60 °C, 70 °C, 80 °C and 90 °C. The value of L parameter increases from 28 to 31 with increase in drying temperature. This might be due to increase in moisture contain after rehydration. Lech et al. [40] studied the colour variation for chokeberries at 50 °C, 60 °C and 70 °C when dried using convective type dryer. Fig. 6 shows the variation in L* parameter at different drying temperature. The value of L* parameter for chokeberries increase from 28.5 to 30.6 with increase in drying temperature. Wang et al. [41] studied Chinese jujube dried at 50 °C, 60 °C and 70 °C in electric heat blast dryer. The result shows that the value of L* parameter decreases from 93.1 to 90.1 with increase of drying temperature. Similar result was observed by Eun et al. [34] where sweet potato flour was dried using convective drying oven at 55 °C, 60 °C and 65 °C. The L* parameter value decreases from 85.84 to 82.51 with increase in drying temperature. The decrease in the value of L* parameter signifies the darker colour of dried items. That means the colour of fresh fruits and vegetables have higher L* value as compared to dried ones.

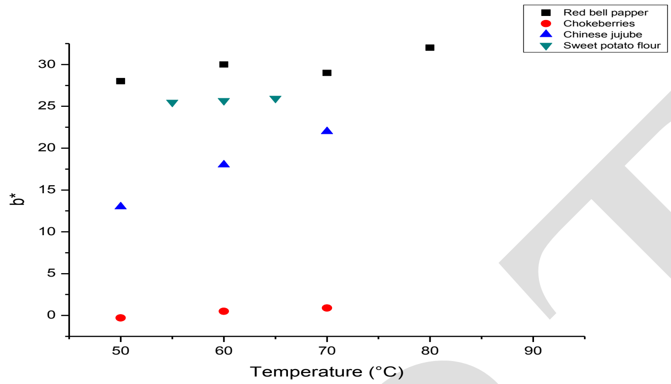

Figure 8 Effect of drying temperatures on Hunter colour values (b*)

Fig. 7 shows the variation of a* parameter with different drying temperature for different fruits and vegetables. The value of a* parameter for red bell pepper observed by Vega et al.[32] increase from 28 to 36.5 with increase in drying temperature. Also for chokeberries by Lech et al.[40] , the value of a* parameter increases from 5.2 to 5.5 with increase in drying temperature. For Chinese jujube and sweet potato flour by Wang et al.[41] and Eun et al.[34] , the value of a* parameter increases from 0.2 to 1 and 2.24 to 2.88 respectively with increase in drying temperature. The value of parameter a* indicated the redness in fruits and vegetables. From above observation it is clear that the redness of fruits and vegetable during drying process increases with increase in drying temperature.

Fig. 8 shows the variation of parameter b* value with drying temperature. The result obtains from Vega et al.[39] and Lech et al.[40] for red bell pepper and chokeberries respectively show increases in b* value from 28 to 32 and0.3 to 0.9 respectively with increase in temperature. Similar result seem for Chinese jujube and sweet potato flour by Wang et al. [41] and Eun et al. [34], where b* value increases from 13 to 22 and 25.49 to 25.95 respectively with increase in drying temperature. The b* value implies the yellowness in fruits and vegetables. The increase of b* value could be due to formation of browning component related to non-enzymatic reaction started and prolonged during drying process through Maillard reaction. [42][27][43] The browning effect of fruits and vegetables can be decrease by blanching, roasting and use of edible coating. [44]

CONCLUSION

The proximate analysis of physicochemical properties of various fruits and vegetables under drying process suggested that the drying should be done at lower drying temperature to retain its natural physicochemical composition. Fruits and vegetables dried at high temperature leads to loss of more moisture contain that those are dried at low drying temperature. Protein contain does not find any direct relation with drying temperature but decrease slightly due to denaturation of protein. Whereas fat contain decrease during first drying period due to enzymatic hydrolysis. Crude fiber and ash contain value obtain maximum at same temperature during drying process. This could be due to the fact that insoluble type fiber of dietary fiber and ash are insoluble in water and as the amount of moisture get reduce due to drying process from eatables, the density of crude fiber and ash increases per unit volume. The L*a*b* colour studies shows that the value of L* decrease with increase in drying temperature which means that processed fruits and vegetables have darker colour as compare to fresh ones. Moreover, the value of a* and b* increases with increase in drying temperature due to increase in number of brown pigment form by non-enzymatic reaction based on Maillard reaction. Higher drying temperature result in less satiability of colour pigments.

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