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Effect of Agricultural Processing on Ripening Enzymes in Date Palm: A Review

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Abstract

Since enzymes are essential for the ripening of fruit and have a physiological role in that process, in this study, the most significant factors that contribute to the roles of invertase and cellulase in the ripening process were determined. The enzyme invertase is well-known for promoting the breakdown of sucrose into reduced sugars to enhance the quality of fruits. Fruit moisture content isn't always the main factor in determining freshness (ripeness) as well as the efficiency of various hydrolysis enzymes presenting during the last stages of ripening such as invertase and it's thought to play an important part in controlling sugar levels to support all aspects of plant growth. Numerous enzymes are known to have an impact on the fruit's softness. It is known that the cellulase enzyme is active when the cell wall of cells is soft, it aids in the softening and ripening of fruits, which is one of the essential factors that affect the level of quality of dates and the quantity of their consumption. Researchers came to different conclusions about the primary causes of fruit ripening, according to the variety, stage, and chemical structure, so the true causes of enzymes' role in the ripening stage remained unknown. In this study, invertase and cellulase from several species of date palm fruits and an understanding of the ripeness of the fruit were used to identify the physiological mechanisms behind the variations in the pattern of enzyme alterations, The importance of enzymes, and their function in the ripening of the several date palm species were highlighted, the procedure about which, there is still a lot that is unknown.

Introduction

The date palm (*Phoenix dactylifera* L.) has historically been one of the most valuable fruit crops in the dry areas of the Arabian Peninsula, the Middle East, and North Africa. Dates have had a major impact on the economies, societies, and environments of many of the countries where they are grown. Dates are a major source of income and basic food for the local population [1-3].

3.43 million tons of dates were produced in total in 1990, and 625,000 ha of land was used for harvesting. The demand for goods on international

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markets has grown during the previous three decades and now occupies 1.092,000 ha, or 8.52 million tons. Date palm production has always been concentrated in Egypt, Iran, Iraq, and Saudi Arabia, and a big part of their exports to these countries comes from date palms [4].

Additionally, date fruit offers its users several health advantages and necessary nutrients; for example, dietary fibers, protein, carbohydrates, enzymes, lipids, minerals, vitamins, phenolic acids, and carotenoids are among the main active compounds of dates **[5-7].**

Growth stages of date palm:

The date palm's natural fruit passes through five stages of growth and development, and Arabic phrases have been used in scientific references to clarify these stages. The date palm fruit grows and develops through a variety of internal and external changes. These changes are frequently described based on how the fruit's color and chemical structure change, Hababuk, Kimri, Khalal, Rutab, and Tamar are five different fruit growth stages (Fig. 1; [8]). Depending on the date's growth and development at different stages of maturity and ripeness, Different variations in color, sweetness, texture, and chemical characteristics are seen both externally and internally [8, 9].

Hababuk stage, dates typically take 7 months to fully ripen from the moment they first emerge from the spath or casing. They require extremely hot, drought with lots of water at the roots. Dates are hand pollinated at the hababuk stage, and we are experimenting with a few different techniques for this (pollinating is labor intensive) - Removing the spathe is the primary technique *(hard covering, envelope)* from the region of the flower cluster, A brown paper bag contains the flower cluster - the bag's bottom is tied to keep pollen near to the flower - male pollen is applied to the flower cluster using a dusting bottle to cover the top, finally, we staple the bag's top, and give the flower or bag a good shake - hopefully, then the male pollen is evenly distributed across the cluster of female flowers. When temperatures are hopefully suitable for pollinating the date, pollination often occurs between September to October, we also have an advantage - Autumn is when some date types flower (*Barhee cultivar at this stage, reviews of double flowers in other types*), however, the male palms have been bred to flower up to four times a year while the harvest is in full swing - enabling us to keep pollen for use as required [10].

Stage Kimri (green stage) it is not good for eating at this stage because the fruit is quite hard and green in color. This period lasted from a tiny green berry to date as being nearly full-size. Depending on the variety, it can last anywhere between nine and fourteen weeks, making it the longest period of date growth and maturation. We tie the bunches to a frond in the early Kimri stage while they are still in the paper bag to position them and, hopefully, limit any fruit loss. The fruit bunches are packaged in the late Kimri or early Khalal seasons to keep the ripening dates safe from sunburn and rainbirds. A nylon mesh bag or a paper bag is used for this [10].

Stage Khalal (color stage), according to the variety, the fruit's color fully changes from green to greenish-yellow, yellow, pink, red, or scarlet when it is mature and hard. Depending on the variety, it lasts for three to five weeks, during which the date fruit reaches its peak weight and size, and sugar content increases quickly while moisture content decreases (around 50:85 % M.C.). During the Khalal stage, the date fruit stores the majority of its sugar as sucrose, which includes both sucrose and reducing sugar. A few cultivars can be harvested and consumed when still in the khalal stage, but the majority are astringent, like immature persimmon [10].

Stage Rutab (wet, soft, sweet ripe stage), most people are familiar with dates at this stage of ripeness - the plump, sweet, and juicy Medjools, you see in your local supermarket [10]. The most important thing that distinguishes the rutab stage is the enzymatic reactions and changes that transfer the fruit from a solid living tissue to a soft, lifeless

tissue consisting mainly of sugars, with excellent good taste and soft texture, free of tannins. The fruit starts to develop a less appealing tint and loses its characteristic khalal stage color in the rutab stage, which may be between dark to black due to the variety, and at this stage, the fruit loses a lot of moisture and shrinkage occurs in the flesh of the fruit.

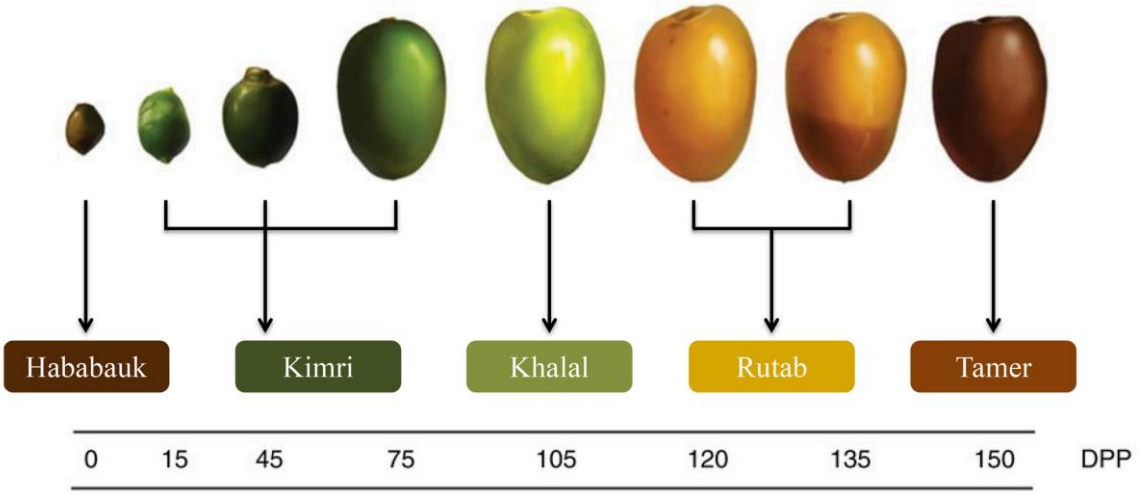

Fig. 1. *Five stages of date fruit growth, listed in DPP (days post pollination)* **[8].**

Enzymes of date palm:

Enzymes are highly specialized, large-molecular-weight protein molecules that are created in tiny quantities by cells. Each type of enzyme aids in accelerating a particular sort of specialized chemical reaction [11].

In date palms, several enzymes are involved in ripening changes, and these include Invertase, Polyphenoloxidase, Pectinase, Pectinesterase, Polygalacturonase, and Cellulose. Invertase is one of the most crucial enzymes found in date palm fruits, and it has a big influence on the quality and texture characteristics. As is well known, this enzyme turns sucrose into monosaccharides (glucose, and fructose) [11].

Much research was done on the changes in invertase enzyme activity throughout the ripening of date palm fruits from various date palm varieties. The appearance of the invertase enzyme activity begins with the fruits entering the stage of complete physiological ripening (Khalal), and its intensity increases until the Khalaal stage ends [11, 12].

The major stages (Kamari, Khalal, and Rutab) of maturity of the date palm cultivar Al-fruits' Hilali's invertase and cellulase enzyme activity reaches the highest level at the end of the Khalal stage, 7956.42 and 1289.35 units/kg.min [11, 13].

Influence of pollen type on ripening enzyme activity:

The pollen source is essential in influencing the characteristics of seeds, and fruits with two known effects: the xenia effect (It is a direct result of the pollen on the endosperm and embryonic characteristics), and the other effect is the metaxenia effect (It is the effect of the pollen grain on the natural characteristics of the fruits, i.e. the parts far from the embryo and endosperm, which include differences in fruit weight, size, length, diameter, color, chemical content, contract percentage, and maturity date) [11].

Many studies have been concerned with studying the effect of the pollen variety on fruits, in a study of the effectiveness of ripening enzymes (Invertase, Cellulase, Polygalactoeoronase,

Pectinestrase, Polyphenoloxidase). During the growth of the fruits of the date palm cultivar Halawi and affected by the pollen cultivar, In the early stages of growth, it was discovered that invertase and cellulase enzyme activity was low, then rose to reach its highest value in the fifteenth week after pollination (the khalal stage).In the date stage, it fell to its lowest value, as the study showed that there is a superiority in the effectiveness of the enzymes produced from the regular khkri pollen compared to the green ghanami pollen [11, 14, 15].

The activity of the ripening enzymes (invertase and cellulose) was affected by the pollen variety and stage. There was an activity of the enzyme invertase and cellulose leases in the hababok stage of pollinated fruits with red ghanami, while the pollinated fruits with sesame recorded the highest enzymatic activity in the wet stage, while the highest enzymatic activity was recorded for pollinated fruits with green and gramophone. The normal after the Al-Kamri stage shows variations in enzyme rates depending on the stage and kind [11, 16].

Effect of some agricultural treatments on the effectiveness of ripening enzymes:

The effectiveness of ripening enzymes is affected by spraying and other agricultural operations. The activity of the invertase enzyme was affected by the paper bag treatments of the taste, and the fruits bagged with brown paper showed an increase in the enzyme's activity compared to those exposed fruits. Increasing the activity of invertase and cellulase enzymes for fruits treated with sachet and spraying with licorice at a concentration of 5 g/L. The high concentration of the enzyme-sensitive Al-Sayer variant of sucrose is what is causing this increase [11, 16].

When using different treatments of tuber solution at rates of 2 and 4 ml/l and ascorbic acid at a concentration of 500 and 1000 mg/l, spraying on the date palm trees of the Halawi cultivar at a rate of one and three sprays when the pollen appeared and the fruits entered the curry stage. Compared with the control treatment, which was superior in increasing the enzymatic activity with a significant difference [11, 17].

When using salicylic acid as a spray on fruits with concentrations of 25 and 50 mg/L, the results showed that there was no effect of spraying with salicylic acid at the two mentioned concentrations in increasing the enzyme activity in the interstitial stage, and the comparison treatment was superior in this trait, but The cellulase enzyme and polyphenol oxidase activity both increased in the interstitial stage at a rate of 50 mg/L [11, 18].

The highest enzymatic activity was recorded in the wet stage. This can be explained by the fact that at the khalal stage's end, Sucrose is transformed and enzymatically converted into reducing sugars (glucose and fructose) at this stage, and the fruits begin to produce ethylene gas (the ripening hormone), which controls the expression of a large number of genes and the production of necessary proteins [11].

Conclusion

Since enzymes are essential for the ripening of fruit and have a physiological role in that process, In this study, the most significant factors that contribute to the roles of invertase and cellulase in the ripening process were determined. The enzyme invertase is well-known for promoting the breakdown of sucrose into reduced sugars to enhance the quality of fruits. Fruit moisture content isn't always the main factor in determining freshness (ripeness), as well as the efficiency of various hydrolysis enzymes present during the last stages of ripening, such as invertase, and it's thought to play an important part in controlling sugar levels to support all aspects of plant growth. Numerous enzymes are known to have an impact on the fruit's softness, Regarding, it is known that the cellulase enzyme is active when the cell wall of cells is soft, It aids in the softening and ripening of fruits, which is

one of the essential factors that affect the level of quality of dates and the quantity of their consumption. Researchers came to different conclusions about the primary causes of fruit ripening, according to the variety, stage, and chemical structure, so the true causes of enzymes' role in the ripening stage remained unknown. In this study, invertase and cellulase from several species of date palm fruits and an understanding of the ripeness of the fruit were used to identify the physiological mechanisms behind the variations in the pattern of enzyme alterations, The importance of enzymes and their function in the ripening of the several date palm species were highlighted about which, there is still a lot that is unknown.

Conflicts of Interest

The authors hereby declare no conflicts of interest.

Authors` Contribution

All authors contributed in the experiments, analysis, and preparation of this manuscript.

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