

THE COLOR OF DRIED FRUIT THROUGH THE COLOR ANALYSIS SENSOR

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Abstract – The consumption of dried fruit in the world, primarily almonds from hazelnuts followed by walnuts and pistachios, has increased exponentially in recent decades and has increased especially in the past year.

The consumer directs his choice of consumption on dried fruit, not only from his taste preferences but also from the color of the packaged product.

To determine the color with a fast method is fundamental for a commercial success of the product.

I. INTRODUCTION

One of the methods of analysis for the observation of color is given by a system represented by the use of the colorimeter.

The aim of this research was therefore to evaluate the color of packaged dried fruit pre-washed by large-scale distribution (GDO), the sample chosen was the pistachio which sees a significant increase in consumption worldwide (2). Pistachio has an extremely varied use in the food scenario. Once harvested, the pistachio must be dried and the husk that covers the wooden shell must be removed, it is then dried to allow the preservation and its sale on the market. The pistachios are used both shelled and peeled, often roasted and salted, but for a greater exaltation of the product it is preferable not to toast or salting. They are used in pastries, especially for the preparation of ice cream, creams, drinks and for the production of sausages such as salami or mortadella, or as seasonings in the Mediterranean diet.

The pistachio samples listed the requirements that must be chromatic and in parallel for a confirmation of the color of the chlorophyll content. Pistachios are fruits of the *Pistacia Vera* L. plant.

The pistachio tree belongs to the *Anacardiaceae* family, its fruits are marketed both as fresh but more often toasted or salted. We can then divide the pistachios into two families and their distinction is given by the coloring, the pistachios are covered with a film and enclosed by a rigid shell, the Sicilian pistachios have a higher chlorophyll content than the Middle Eastern ones where the color is less intense (3). The production areas are Turkey, Iran and Italy, particularly in Sicily.

In Sicily it was originally imported by the Arabs in the provinces of Agrigento and Caltanissetta, and then made its appearance on Etna.

At least ten different pistachio varieties shall be counted.

In Italy grow the *Pistacia Vera*, the only species that produces edible fruits, the *P. Terebinto* (utilized as grafting plant of the *Pistacia Vera*) and the *P. Lentiscus*, evergreen plant utilized for ornamental and landscape purposes. *Pistacia Vera* grows in Sicily on the lava soils of the southwestern slope of Etna, and the main variety is the so-called Bianca. The Middle Eastern varieties are mainly represented by Iranian

products and are about ten, in general the commercial division consists of two categories: round and elongated.

The main varieties: Fandoghi (round variety), Kalleh Ghouchi (round variety), Akbari (long variety) and Ahamad Aghaei (long variety). The Turkish Varieties are mainly two of remarkable success, which have characteristics very similar to those of Sicily.

The Perfect green turkish variety, that has a negative aspect given by a small fruit but a very bright green color.

The other Turkish variety is the Mawardi with variable pistachio colour, internally from yellow-green to green-brown, it is covered by a thick brown skin tending to violet.

Pistachios, like all dried fruit, are high calorie fruits, but they are equally rich in nutritional properties (7).

Pistachios are made up of about 20% protein, 40% fat, 10% fiber and 8% sugar. The minerals present in greater quantities are calcium, iron, phosphorus, magnesium, potassium. Among the most abundant vitamins are those of group B and vitamins A, C, K (11).

Pistachios are also rich in antioxidants, which counteract free radicals with a positive effect for the health of the consumer. Pistachios also contain phytosterols, which reduce the levels of bad cholesterol. Undoubtedly among the dried fruit, pistachios represent an important food with regenerative properties, here is the importance in observing some quality parameters.

Color is certainly one of the most important parameters for the determination of quality in food and the point of ripeness in fruits, there are an infinite number of colors, the use of a sensor that analyzes the color makes the result of unbiased analysis (2).

In fact, the visual evaluation by man can be influenced by external factors but also the nuances would not be analyzed correctly.

An example can be given by the yellow color, in fact if we add adjectives like, lively, dull, dark, we do not give a homogeneous definition to the product that could be mistaken with the ochre color that has a tonality ranging from golden yellow to brown, but also red, resulting in confusion between the crimson, the vermilion, the rose and the strawberry, thus creating confusion in the determination of the analysis.

The Munsell color system is a color space used as an international standard to define colors according to three dimensional coordinates: hue (Hue) (H), brightness (Value or Lightness) (V) and saturation (Chroma) (C).

The operation of the system consists of three independent dimensions represented by a system of cylindrical coordinates: the tonality, measured in degrees on a horizontal circle; the saturation, measured radially from the neutral axis of the greys outwards; brightness, measured vertically on the grey axis from 0 (black) to 10 (white). Munsell determined the positioning of colors in the system by measuring the human perceptive response to colors.

The Hue (Hue) Munsell divided each horizontal circle into five main colors: red, yellow, green, blue and violet, indicated with their initials in English: R (red), Y (yellow), G (green), B (blue) and P (purple), and in five other intermediate colors adjacent to them.

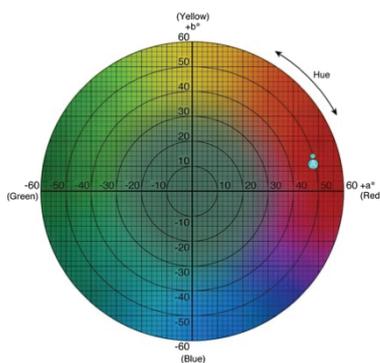
Each of these ten subdivisions is further subdivided into 10 sub-subdivisions so as to give the key one of one hundred values.

Two colors, of equal brightness and saturation, which are opposite on the circumference of the shades are called complementary colors and their additive mixture generates gray of the same brightness.

Brightness (Value or Lightness) varies vertically along the vertical axis of the cylindrical coordinates from a minimum value of 0 (corresponding to black) to the maximum value of 10 (corresponding to white). between these two extremes are all shades of gray. Saturation (Chroma) is measured radially from the center of each circular sector of the cylindrical coordinate system and represents the degree of "purity" of color, where lower values correspond to lighter colors and tending to gray.

Note that there is no inherent limit to the saturation value in the Munsell system, different areas of the color space have different maximum saturation coordinates. for example, light yellow colors have higher saturation potential values such as light violets, because of the nature of the human eye and the physics of optical stimuli.

Other methods for the determination of colour have been developed by an international organisation (Commission International de l'Eclairage - CIE), the two best known models are the colorimetric space Yxy defined by the CIE, and the coloring space L*, a*, b*, designed in the late 1970s called the CIELAB system, tab.1.



Tab. 1 Color solid horizontal section for space L*a*b*

On the tables of the Italians fly the consumption of nuts, from walnuts to almonds to hazelnuts, with an increase of 10% of purchases in the last year for a market that has exceeded the historic threshold of the billion of euro in 2019 (4).

The consumptions of the Italians have practically doubled in the last ten years, and have reached the 3 kilograms per person per year. Walnuts and hazelnuts and pistachios are rich in antioxidants, fatty acids that are good for cholesterol, mineral salts and vitamin E, almonds are useful for maintaining strong and healthy skin, hair and nails and to strengthen the immune system, pistachios contain many fibers, iron minerals and vitamins (group A and group B), while pine nuts are a source of zinc, potassium and vitamin B12.

Real superfoods for psychophysical well-being" to buy in shell, already shelled or in the form of processed as bars.

In Italy about 500 thousand tons of nuts are collected per year. Walnuts and hazelnuts are present throughout the Peninsula, although the production is concentrated between Piedmont, Campania, Lazio, Sicily, Emilia Romagna and Veneto (14).

Almonds and pistachios are typical of the South with Puglia, Calabria and Sicily in the lead. The growth in consumption is also leading to a strong import.

The arrivals of nuts from abroad exceeded 900 million euros in 2019, in particular from the United States (usually walnuts and almonds from California), Iran (for pistachios), Turkey (for walnuts and hazelnuts) and China (pine nuts) but there are also products from Chile, Argentina, and

Australia (12).

The consumer can defend himself by verifying the origin of the nuts on the label which must be placed on the packages or on the shelves.

II. MATERIALS AND METHODS

Pistachios have an extremely important nutritional value, are composed of about 45% of fat and are mainly fat "Good" as monounsaturated (including oleic acid, the same as olive oil) and polyunsaturated (mainly linoleic acid, Omega-6 series) (8).

In addition to fats, pistachios are represented by 20% protein and 27% carbohydrates, they are also an excellent source of fiber (10.6 g/100 g).

The calories of pistachios are about 560 per 100 grams of edible part. Among the minerals, (9) the most represented are potassium, phosphorus, magnesium and calcium, while the most present vitamins are; vitamin E in particular γ -tocopherol powerful lipid antioxidant essential for maintaining the integrity of the mucosa and skin, which also acts as a scavenger of the harmful free radicals of oxygen, vitamin C and vitamin B6.

They are rich in magnesium that helps prevent osteoporosis, diseases of the nervous system and immune system (13).

This mineral is involved in more than 300 essential metabolic reactions and plays a key role in a wide range of important biological reactions.

The pistachios are very rich in fiber and thanks to the high content of dietary fiber the pistachios promote the health of the digestive system, satiety and the reduction of the risk of incurring in various diseases (cardiovascular, diabetes type 2 and obesity) (6).

Important concentrations of phosphorus necessary for hormonal production and health and helps the body to use the vitamins of group B.

Its deficiency can cause abnormal levels of serum phosphate (hypophosphatemia) resulting in loss of appetite, anemia, muscle weakness, bone pain, rickets (in children), osteomalacia (in adults), increased sensitivity to infections and numbness.

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Another mineral element present is the basic calcium of our organism as a structural element, is involved in cell signalling, in the mediation of constriction and relaxation of blood vessels, in the transmission of nerve impulses, muscle contraction and secretion of several hormones such as insulin (15).

The iron present in pistachios is non-eme (not easily absorbed) and is an essential mineral for development and health as a key component of hemoglobin, the protein that pierces oxygen, essential for cell growth and differentiation (5).

Pistachios are very rich in antioxidant substances such as carotenes and chlorophyll, which help to remove toxic free radicals from the human body by protecting it from various diseases such as infections and certain types of cancer (16).

Pistachios play a role for health with anti-inflammatory action Pistachios are an excellent source of antioxidant molecules (in particular proanthocyanidins) that act by reducing inflammation and oxidative stress (11).

If taken in moderation, pistachios can help to control body weight thanks to their high satiating effect.

The importance of the qualitative determination of a very rapid analysis system is now of fundamental importance, especially in the dry fruit sector, given the significant increase in consumption.

The samples were all treated in the same way, immediately after purchase and kept at a controlled temperature of 15 °C, . The six samples were stored under the same environmental conditions and subsequently analysed, . the samples analysed were not treated during the transformation either chemically, salt added, or physically, with exposure to heat sources for roasting.

All the pistachio samples come from elongated and not round varieties. This analysis, in order to be quick and precise, should not have a long preparation as in traditional methods of analysis, the present work wants to compare two methods, one innovative and one traditional, the former uses colour analysis sensors that do not modify the structure of the product, while the traditional method has a long preparation that in addition to changing the structure and will only eventually use a spectrophotometric sensor, also having higher costs, due to the disposal of the chemicals used for the extraction of colour.

The samples pre-washed from the large-scale retail trade are all pistachios of the same brand and fresh varieties.

The samples were stored at a controlled temperature of 15 ° C, in special airtight and dark containers to avoid the interaction of the chlorophyll present in the samples with sunlight.

The samples of the standard weight of 50 g were divided, shelled and without tegument, were ground in Waring Blendor with a water-cooled jar. The material thus obtained was sieved and the pistachio fraction was used for analysis, which passed through a 35 mesh sieve, but was collected in a 50 mesh sieve.

This product was placed in a 8 cm diameter petri dish and compacted homogeneously. The color has been evaluated, according to the CIE-Lab system. through the reflection colorimeter with a measuring area equal to a disc of 50 mm in diameter. The material thus obtained was prepared for analysis and was used by the pistachio fraction passing through a 25 mesh sieve.

The color was evaluated according to the CIE-Lab system. using a colorimeter measuring area equal to a 50 mm diameter disco.

The readings of the same sample were repeated 10 times in different points of the capsule after mixing the contents of the same, previously the color sensor has been calibrated through a reading on a colorimetric tile known reading.

For the determination of chlorophyll the method AOAC 942.04 (2) was used.

50 g of pistachios, shelled and without tegument, were ground and homogenised; 5 g of ground pistachios were added 0,1 g of CaCo₃ and extracted with 25 ml of acetone mixture: water (85:15) stirring in Waring Blendor, with a water-cooled jar, for 1'.

The extract was filtered on Büchner using a Whatman 40 filter and the residue was washed with a few ml of acetone: water (85:15).

The residue and filter were extracted, filtered and washed a second time as described above.

The filtrates were collected in a 100 ml flask and made up to the mark with acetone: water (85:15). 50 ml of filtrate were transferred to a separating funnel containing 50 ml of ethyl ether and added to 100 ml of distilled water.

The phases were allowed to separate (the fat-soluble pigments pass into the ethereal phase) and the water was removed. Washing with water was repeated 5 times until all the acetone was removed from the ethereal layer.

The ethereal phase was collected in a 25 ml volumetric flask and homogenised, transferred to an Erlenmeyer flask, with Na₂SO₄ added as an anhydrous flask and stirred for about 10' until the solution became clear.

For each sample the extraction was done in triple.

A spectrophotometer was used to determine the absorbance of the solution at wavelengths of 660 and 642,5 nm.

The value had to be between 0,2 and 0,8 (optimal value around 0,6 at 660 nm).

The chlorophyll concentration value has been calculated using the formulae below. Calculation of chlorophyll concentration;

$$\begin{aligned} \text{Total chlorophyll (mg/L)} &= 7,12 A_{660} + 16,80 A_{642,5} \\ \text{Chlorophyll a (mg/L)} &= 9,93 A_{660} - 0,777 A_{642,5} \\ \text{Chlorophyll b (mg/L)} &= 17,60 A_{642,5} - 2,81 A_{660} \end{aligned}$$

III. RESULTS

The subdivision of the samples according to the variety in two groups marked by the letter A and B, has given of the remarkable qualitative cues, first all the samples analyzed, are of first quality, with aroma not modified by the vacuum packaging system and therefore with an optimal start. There were no problems regarding the rancidity of the product,

The packaging that the industry used also preserved the color, not only the plastic film used but the package has preserved the interaction with the sun rays.

The samples named with the letter A, are composed by Italian varieties and in particular by Sicilian varieties. Unlike the samples named with the letter B, they are composed of Middle Eastern varieties.

This first distinction, highlights how the Sicilian varieties are very rich in chlorophyll which is the main green pigment.

Unlike the Middle Eastern varieties where the concentration of chlorophyll is less marked, giving space to a colour tending to yellow, due to the presence of carotenes that have a colouration tending to yellow

Tables 2 and 3 show the average results obtained from the objective determination of the color of the samples. The values of flexibility and * and b * which describe the chromaticity coordinates in a three-dimensional space (the coordinates L, a, b) consider that time changes, there is a gradual modification of the sequence and at the same time an increase in the values of a * and b * which corresponds to a substantial color replacement.

The analyzes for chlorophyll (3) are conducted by the state with the aim of evaluating the possibilities of variations of the total chlorophyll and of the two forms and of the pistachios stored in the air.

The data are listed in tables 2.

| Samples | L* | a * | b * |
|---------|--------------|---------------|--------------|
| A1 | 60,62 ± 0,31 | -14,81 ± 0,22 | 44,76 ± 0,28 |
| A2 | 60,58 ± 0,39 | -14,68 ± 0,33 | 44,67 ± 0,35 |
| A3 | 61,01 ± 0,34 | -14,90 ± 0,27 | 46,30 ± 0,32 |
| B1 | 53,54 ± 0,30 | -12,52 ± 0,29 | 23,96 ± 0,27 |
| B2 | 53,60 ± 0,33 | -12,57 ± 0,29 | 24,72 ± 0,25 |
| B3 | 57,36 ± 0,41 | -13,24 ± 0,24 | 34,65 ± 0,22 |

Table 2. Values of CIELab parameters measured on pistachios stored.

In the CIELAB analysis, it can be noticed how the Sicilian varieties have a marked tendency to the greenish colouration with values ranging from L* 61,01 ± 0,34 to 60,58 ± 0,39, samples A3 and A2, same thing for values a* and b*.

Less marked presence of chlorophyll for Middle Eastern pistachio samples, as can be seen above all in sample B2.

| Samples | Total chlorophyll (mg/kg) | Chl. a (mg/kg) | Chl. b (mg/kg) |
|---------|---------------------------|----------------|----------------|
| A1 | 3,88± 0,44 | 1,85± 0,33 | 0,74± 0,33 |
| A2 | 3,80± 0,53 | 1,80± 0,33 | 0,62± 0,33 |
| A3 | 3,78± 0,21 | 1,83± 0,33 | 0,71± 0,33 |
| B1 | 3,45± 0,41 | 1,68± 0,33 | 0,56± 0,33 |

| | | | |
|-----------|-----------|-----------|-----------|
| B2 | 3,57±0,33 | 1,64±0,33 | 0,68±0,33 |
| B3 | 3,61±0,33 | 1,84±0,33 | 0,76±0,33 |

Table 3. Chlorophyll content of pistachios stored.

The results of the analyses carried out with the traditional AOAC 942.04 method highlight with the human factor but above all a long and laborious process, consisting of a series of steps, has developed very similar values but always with a clear tendency to the fact that the Sicilian samples have a greater green pigmentation, due to chlorophyll compared to Middle Eastern samples, where the shade of green is less marked. With this method the most "green coloured" samples are A1 and A2 with not much difference to the A3 sample.

Different discourse for the Middle Eastern samples, which do not have a "green colouration" equal to the Sicilian ones, but denotes a confirmation for the B3 sample of greater green colouration than the other two samples B.

This differentiation is due not so much to the food processing process and its marketing but rather to genetic factors in addition to the pedoclimatic conditions of cultivation. Sicilian cultivation areas, unlike those in the Middle East, have the potential due to the climate but especially the soil, extremely mineral, typical of volcanic areas, this fact causes the plant and therefore the fruit to develop biochemical processes aimed at the concentration of essential elements for survival that affect, especially the development of the fruit.

IV. CONCLUSION

The consumption of dried fruit and especially pistachio in this last decade has greatly increased, this increase was exponential during the first six months of 2020, due to the fact that the consumer was forced home.

The development therefore of systems that imply an implementation of the use of instrumentation, that not only speed up the chemical analysis but that safeguard the correctness of the result.

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At the same time, the use of systems which can also be automatic in the food processing chain has a dual effect, due primarily to the fact that the food does not undergo lengthy preparation processes to carry out the analysis but above all, the protection of the environment and thus the reduction of disposal costs.

In fact, not using chemicals in the preparation of the analysis, but carrying out the analysis on the product as it is.

A comparison of the two analytical methods for the determination of colour, using a colorimeter based on a sensor system and comparing the results obtained by determination using AOAC method 942.04, of the most important pigment present in pistachios, that is chlorifilla, showed how; a more marked variation of the results, therefore, a greater precision in the use of the sensor system for the determination of colour than the AOAC 942.04 method, in which the complexity of the passages during the analysis and especially the human factor, can make this system less precise but not less effective, in fact, the results may overlap in different samples, with minimal differentiation.

The use of color is undoubtedly an extremely important resource and above all very fast and that safeguards the environment by reducing not only the time of obtaining the results but also a halving of costs, the results obtained that are very easy to interpret, especially in the qualitative aspects. Research needs to be more committed through funding for the improvement of processing processes, which require a greater use of sensor technology to safeguard food quality and health.

In fact, one aspect not to be underestimated is the interaction between agriculture, food and health through a thin thread that is sensory technology. This winning synergy is certainly the key to sustainable development in the food sector, passing from the collection of the

product, to its processing and storage to allow the consumer even far physically to enjoy the food.

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