Water Activity, Color Characteristics and Sensory Properties of Egyptian Gouda Cheese during Ripening

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Abstract: The objective of this study was to monitor the changes in water activity (a_w), color characteristics (color values and parameters) and sensory evaluation of Egyptian Gouda cheese during 60 days of ripening, and to determine the correlations between the changes in water activity or sensory evaluation and color parameters during the ripening time of cheese. Intravarietal comparison of water activity and color values in Egyptian Gouda cheese was performed by evaluation of instrumental values (a_w) and color parameters in terms of CIELAB color space (L*, a*, and b*). In addition to water activity and color parameters, color parameters and sensory tests were performed. The results were evaluated with statistical methods (single valued and multivariate analysis). During the first 15 days of ripening, a decrease in water activity values occurred. Simultaneously, L* and H* values decreased. After 60 days of ripening a*, b*, C* and visual color increased. The ripening time of Egyptian Gouda cheeses can be estimated with 6 variables: L*, a*, b*, H*, C* and a visual color. Evaluation of water activity, color characteristics and related sensory characteristics of Egyptian Gouda cheese (with 60 days of ripening) revealed correlations between these parameters. [Journal of American Science 2010;6(10):447-453]. (ISSN: 1545-1003).

Key Words: Egyptian Gouda cheese • Water activity • color • sensory • ripening

1. Introduction:

Cheese is one of the most popular food products consumed in the world. It is high in protein, calcium, essential fatty acids as well as nutritive values. The history of cheese dates back thousands of years - with the techniques and cultures often taken from one society to another by conquering forces. The individual characteristics of each cheese variety are due to the type of milk, the microbial starter culture and the make procedure used. Many consumers do not realize the difference between natural vs. processed cheese varieties. Natural cheese is produced by the culture of milk to form a cheese curd; through a series of steps to remove moisture, this curd becomes the finished cheese. Natural cheese is most often classified according to moisture content with the higher moisture content of the cheese correlated with a shorter shelf-life. Very high moisture cheeses, such as cream and cottage, are not aged and, thus, are often called “fresh cheeses.” Gouda is also a semi hard Dutch cheese which first made in the town of its name in Holland. Gouda is a wheel-shaped cheese typically ranging in size from 8 to 45 pounds. Gouda cheese is a sweet curd cheese with a limited number of eyes (wong, 1974, Zall, 1992 and Kosikowski and Mistry 1997).

Color is an essential ingredient in cheese product. Gouda cheese slice individually wrapped singles and cheese sauces all rely on color to provide an appetizing appearance. Cheese colors may range from pale yellow to deep red-orange, depending upon the application and consumer preference.

Color of food is mostly due to the presence of natural coloring stuffs material present. Moreover color can also be changed by enzymatic and non-enzymatic reactions. The optical characteristics of foodstuffs are complex and depend on chemical composition and surface texture. Any color can be matched by mixing together suitable proportions of three primary lights, that is red, blue and green. Expressing each color proportion in a mixture as a fraction, a color space is transformed to the two dimensional chromaticity diagram. Hence, coordinates x and y define position of a color on the chromaticity diagram. An alternative method of determining the color of food is measuring surface reflectance instrumentally. Included in these are the tristimulus colorimetric method, which locate a color as a point in three-dimensional space using, in the case of the Hunter Color Meter, the L (white-black), A (green-red) and B (blue-yellow) axes (Francis, 1980).

Texture and color are important criteria used to evaluate cheese quality; these 2 parameters are often a primary consideration of consumers when making purchasing decisions. This is especially true for "Protected Denomination of Origin" (PDO) cheeses, which often represent a large variety of textures and tastes. Ensuring consistently high-quality cheeses continues to be a challenge for people involved in the chain of production. Thus, there is an

increasing need for characterization of PDO cheeses, including study of changes that occur during ripening and intravarietal comparison (Lebecque et al., 2001). For this reason, some research groups have carried out studies on chemical, physical, and sensory characteristics of different cheese varieties (Bertola et al., 2000; Bugaud et al., 2001; Lebecque et al., 2001; Romani et al., 2002; Gómez-Ruiz et al., 2002; Pillonel et al., 2002; Pinho et al., 2004), helping to assess maturity and preventing such cheeses from adulterations and imitations.

The consumption of cheese is dependent upon the good consumer perception (IDF, 2001). The chemical aspects of cheese ripening include many significant changes in the constituents and properties of cheese, contribute very much to the development of it physico – chemical, color and organoleptic properties (Vasterdis, 1989). During cheese ripening characteristic flavor and texture of the individual cheese verities develop as a result of chemical, color and physical changes, which are more complex and their monitoring is difficult (Farkye and Fox, 1990). The sensory value is a determinate of food quality, it is greatly influenced by the sensory properties much as taste, behavior body and texture (Molnar, 1991). Determination of quality level of cheese is based on applying standard sensory tests. These sensory tests usually screen the deficiencies originating from the technology as from microbiological contamination, but partially grade the degree of maturity. Based on the abovementioned background it was thought while to study the consolation between chemical, physical and color properties of cheese and its sensory properties during ripening. The aim of this study is to establishment the degree of response of cheese and to traces the changes in color characteristics and organoleptic properties.

Therefore, the main objective of this work was to determine of cheese color characteristics, water activity released low molecular weight components, organoleptic properties and ripening indices.

2. Materials and Methods:

Gouda cheese was manufactured under the Egyptian marketing conditions in DEINA dairy factory according to the method described by Scott, (1981). Gouda cheese samples were ripened at 15^{o} C for 0, 15, 30 and 60 days

Methods of analysis:

Water activity (a_w) determination:

Water activity (a_w) determination was carried out using ROTRONIC HYGROSKOP DT (USA). This method was based on placing of Gouda cheese sample in an air tight chamber. As long as the quantity of water in the sample is much larger than the quantity of water in the air of the chamber, the measurement is accurate. The water activity was calculated as ERH i.e. equilibrium relative humidity.

Color assessment of Gouda Cheese:

Gouda cheese color was determined according to Hunter (1975). Color of Egyptian Gouda cheese was measured using spectro-colorimeter (Tristimulus Color Machine) with the CIE lab color scale (International Commission on Illumination). This color assessment system is based on the Hunter L*-, a*- and b*- coordinates. Whereas, L*- represents lightness and darkness, + a*- redness, -a*- greenness, + b*- yellowness and - b*- blueness (Hunter, LabScan XE, USA). The instrument was standardized against a White Tile of Hunter Lab Color Standard (LX No.16379): X= 77.26, Y= 81.94 and Z= 88.14.) (Sapers and Douglas, 1987). Color difference, Delta E, was calculated from a*, b* and L* parameters, using Hunter-Scotfield's equation (Hunter., 1975) as follows.

Delta E = (delta a^2+ delta b^2 + delta L^2) $^{1/2}$ .....(1)

where: a-a_o, b-b_o and L-L_o; subscript "$_o$" indicates color of control or untreated sample.

The Hue angle (H*) and Chroma (C*) were calculated according to the method of Palou et al., (1999) as follows:

H* = $\tan^{-1}$ [b*/a*]…….(2)

C* = square root of [a^2* + b^2*]....…….(3)

Sensory evaluation:

Panel for judging Gouda cheese manufactured at the dairy factory of DINA, agricultural investments during ripening period (fresh, 15, 30, 60 days) included 20 experienced panelists. The attributes such as: flavour intensity, body, texture and color were organolptically assessed at stated by Nelson and Trout (1956) using a 10 points scale.

Statistical analysis:

The ability of the descriptive vocabulary to discriminate between cheese was tested using one-way analysis of variance (ANOVA) and least Significant Difference (LSD) multiple comparison test of the panel mean scores for each cheese. These analyses were carried out using SPSS V6.1 (SPSS Inc, Chicago IL 60611, USA) Duplicate scores were subsequently averaged, standardized (1/standard deviation of the mean score for each attribute) and analysed using Principle Components Analysis (PCA). (PCA was carried out using Unscrambler V6.1 (CAMO AS, N-7041 Trondheim Noway). How each Principle Component (PC) discriminated

between the sensory characters of the cheese was then investigated using ANOVA (SPSS V6.1, SPSS Inc) according to Piggott and Sharman (1986).

3. Results and Discussion:

Effect of ripening on water activity (a_w) of Egyptian Gouda cheese:

The water activity of fresh and ripened Gouda cheese was determined and presented in Figure (1). It is obvious that (aw) markedly lowered during ripening, it was 0.93 for fresh Gouda cheese at zero time and decreased to 0.75, 0.54, 0.51 for 15, 30 and 60 days ripening of old Gouda cheese, respectively. These results are quite similar to those reported for Trappist and Hajdu cheese (Bara-Herezegh et al., 2000). These results are close the results of Walter and Seeger, (1990) who found no relationship between total moisture content of selected ethnic foods and a_w.

The results are partially confirmed by those results of Todorova and Kozev, (1995) who concluded that water activity (aw) was > 0.965 and combined with water contents of samples. Water activity (aw) was proposed as an appropriate index for Kachkaval cheese quality determination. Also, the results of Sendra et al, (1999) showed that composition, moisture loss, water activity, lipolysis. There were no differences in moisture loss in chesses made from frozen curd that had 'ripened for 60 days. Proteolysis increased in all curds and cheeses. Water activity decreased in all cheeses with increasing of ripening for 60 days.

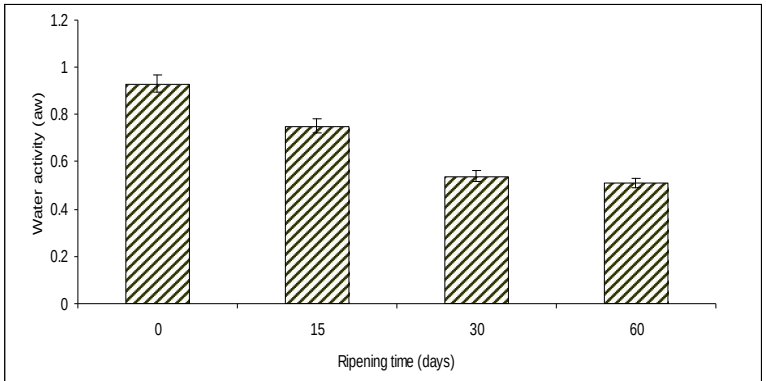

Figure (1): Effect of ripening on water activity (aw) of Egyptian Gouda cheese

Effect of ripening time on Color characteristics of Egyptian Gouda Cheese:

Tristimulus Reflectance Colorimetry (TRC) measuring the reflectance L*, a* and b* values was used to follow the extent of browning in cheese and change of color in foods (Sapers and Douglas., 1987). The results illustrated in figure (2) showed the effect of ripening time on Gouda cheese color.

These results illustrated the changes in color of Gouda cheese in terms of redness a*, yellowness b* and lightness L* during 60 days of ripening. It can be observed that the a*-value of the fresh Gouda cheese was 25.2 compared to 20.4 after 15 days, 15.1 after 30 days and increased 20.0 after 60 days, as seen in Fig 2 .

Regarding the lightness L* and the yellowness b*. It is clear that the lightness L* as well as the yellowness b* were decreased as a result of increasing the time of ripening up to 60 days. The effect of ripening time on increasing the a*-value from 15.0 at 30 Says to 20.0 after 60 days was noticed. The change in color may be referred to chemical changes occurred during ripening. Kumar et al. (2006) confirmed that cheese is a biologically and biochemically dynamic product in which series of sequential changes take place through its manufactured and subsequent ripening.

The analysis of variance identified the significant ($p<0:05$) effect of ripening time on Hunter values of Egyptian Gouda cheeses. Although the a-value showed a definite increased trend throughout ripening, the L-value decreased and the b-value increased as the cheese aged, as seen in Figure (1). Previous research on cheese colour as a function of ripening time by Rohm and Jaros (1996a) reported a decrease of L-value and an increase of a- and b-values during ripening of Gouda cheese. Martin et al., (2001) showed that the a-value did not show a definite trend throughout ripening, the L-value decreased and the b-value increasedas the cheese aged. Ginzinger et al. (1999) reported that yellowness index, a one dimensional measure of cheese colour highly correlated with b; increased as cheese aged.

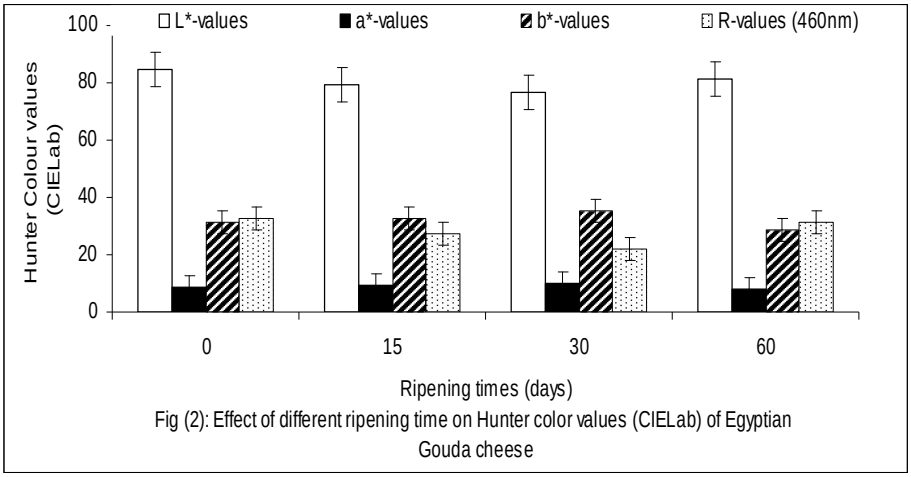

Fig (2): Effect of different ripening time on Hunter color values (CIELab) of Egyptian Gouda cheese

Color parameters during ripening time of Gouda cheese:

In addition to determination of the lightness L*, redness a* and yellowness b*, for experimented Egyptian Gouda cheese. Hue angle (H*) as well as the chromaticity (C*) were determined. Hue is the aspect of color that we describe by words such as green, blue, yellow or red. The chroma refers to reflection at given wavelength and indicates how much a color differs from gray (Eissa and Moharam, 2001). The equations No. 1, 2 and 3 are showed the DE, H* and C*.

The results in Table (1) show that the H* values were closely stable in all samples with increasing of ripening time up to 60 days at 15°C.

The chromaticity (C*) increased by the increasing of ripening time in Gouda cheese up to 30 days. Thereafter, no relation was noticed. It can be concluded that the ripening of Gouda cheese slightly inhibited the changes in color of cheese.

The total color differences (DE) increased by the increasing of ripening time in Gouda cheese up to 30 days As presented in Table 1, total colour differences of Egyptian Gouda cheeses were small, which almost correspond to the sensory difference threshold (Rohm & Jaros, 1996b). However, greatly different values of DE were found for cheeses at 15, 30 and60 days of ripening. The almost identical colour values found in cheeses could be attributed to their similar structure.

Table (1): Correlation between the different color parameters instrumentally measured L*, a*, b*, C* and H* and the visual color score during 30 days ripening at 15^0C.

Ripening time (days)	L*	a*	b*	H*	C*	DE	a_w	visual color
Fresh	84.51	8.46	31.10	0.064	32.230	0.00	0.93	6.55
15 days	79.05	9.54	32.86	0.060	34.217	5.84	0.75	8.70
30 days	76.57	9.99	35.05	0.061	36.446	9.00	0.54	8.85
60 days	NR	NR	NR	NR	NR	NR	NR	NR
R^2-values	0.94	0.95	0.75	0.91	0.77	0.92	0.76	

NR = no relation

Sensory evaluation of Egyptian Gouda cheese:

Sensory evaluation of the Egyptian Gouda cheese samples was carried out during 60 days of ripening at 15°C by 20 experienced panels using 10 points scales at 0, 15, 30 and 60 days. Difference in sensory properties of cheese samples due to the effect of ripening Gouda cheese was determined by analysis of variance (ANOVA).

The sensory scores for the quality attributes of the Egyptian Gouda cheese samples were given in Table (2). The scores were recorded at 0, 15, 30 days of ripening at 15°C. Anaylsis of variance showed high significant differences between Gouda cheese samples due to the source of samples. F-values were significant at 5% level.

The mean value for color of Egyptian Gouda cheese scored during ripening period was 6.55, 8.70, 8.85 and 9.70 at 0, 15, 30 and 60 days of ripening, respectively as seen in Table (2). Excellent color was related to the samples after 60 days of ripening. The scores for these samples were in the range of 6.55 to 9.70. The low score value was 6.55 for fresh samples at zero time.

Table (2): Sensory evaluation during 60 days ripening at 15°C of Egyptian Gouda cheese.

Ripening time (days)	Color	Flavour	Texture	Body
Fresh (zero time)	6.55^{C}	6.95^{C}	6.50^{C}	6.85^{C}
15 days	8.70^{B}	8.10^{B}	8.35^{B}	8.20^{B}
30 days	8.85^{B}	8.15^{B}	8.30^{B}	8.20^{B}
60 days	9.70^{A}	9.70^{A}	9.75^{A}	9.35^{A}
LSD	0.51038	0.50781	0.61942	0.57574

The mean value of flavor scores for all treatments of Egyptian Gouda cheese stored was 6.95, 8.10, 8.15 and 9.70 at 0, 15, 30 and 60 days of ripening respectively. Corresponding F-value for differences in flavor between the samples was 39.126 for Gouda cheese tested at 0, 15, 30 and 60 days of ripening respectively. Excellent flavor was related to the samples after 60 days of ripening (Table. 2).

The texture of the tested samples was affected by refrigeration. The over all mean score for the texture of Gouda cheese was only 6.50, 8.35, 8.30 and 9.75 at 0, 15, 30 and 60 days of ripening respectively. Corresponding calculated F-value for differences in texture between the samples was 36.690 for Gouda cheese at 0, 15, 30 and 60 days ripening respectively. Like color and flavor ripening time showed the highest score for texture, being 6.55, 8.35, 8.30 and 9.75 at 0, 15, 30 and 60 days ripening respectively (Table 2).

The overall mean score for the body of the tested samples of Gouda cheese was 6.85, 8.20, 8.20 and 9.35. at 0, 15, 30 and 60 days of ripening period at 15°C, respectively. Corresponding calculated F-value for differences in body between the samples was 25.014 for Gouda cheese at 0, 15, 30 and 60 days of ripening respectively. These levels of score indicate the importance of the ripening period in keeping a body for the tested Gouda cheese. However, there were significant differences between the individual ripening. Samples ripened for 60 days showed the highest score (9.8) in body stored at 15°C.

All these results are in agreement with the results of Davide et. al., (1988) who found that the buffalo milk Gouda cheese requires a longer ripening period in order to develop the characteristic Gouda flavor as compared with % the cow Gouda, which develops its characteristics flavour, aroma, body and texture after 2 months. The buffalo Gouda acquires these sensory properties, although to a slightly lower degree, after a longer ripening period of 4 months.

Also, Kampf and Nussinovitch, (2000) found that the coating contributed to a better color and gloss. The roughness of the coated cheese decreased after coating, since the film filled in surface ruggedness. Advantages in the textural properties of the coated cheese were observed, since the coated cheese lose less water by evaporation, a desirable softer and a less brittle texture was detected.

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The relation between the color values of Gouda cheese slices according to the visual judgment and those of color parameters obtained by instrumental determination as well as with water activity (aw):

Table (1) lists the values of the different color parameters L*, a*, b*, C* and H* as well as the mean visual color and water activity (aw) of the Gouda cheese ripened for 60 days at 15°C. A technique of regression analysis was used to predict the coefficient of the correlation between the visual color score and each of the five color parameters. The estimated values of r was found to range between 0.77 (in case of C*) to 0.95 (in case of a*) after 30 days of ripening at 15°C for Gouda cheese slices. Also, it was 0.76 (in case of aw) after 30 days ripening at 15°C Gouda cheese slices. However, the results showed that the characteristic color was different in all color parameters or no relationship after 60 days of ripening at 15°C but increased to 9.70 as a visual color. The relation between the water activity (aw) of the Egyptian Gouda cheese slices and those of color parameters obtained by instrumental determination:

Table (3) lists the values of the different color parameters L*, a*, b*, C* and H* as well as the water activity (aw) of the Gouda cheese slices for 60 days ripening at 15°C. a technique of regression analysis was used to predict the coefficient of the correlation between the water activity (aw) and each of the five color parameters.

Table (3): Correlation between tKe different color parameters instrumentally measured L*, a*, b*, C* and H* and water activity (a_w) during 60 days ripening at 15°C.

Ripening time (days)	L*	a*	b*	H*	C*	DE	a_W
Fresh	84.51	8.46	31.10	0.064	32.230	0.00	0.93
15 days	79.05	9.54	32.86	0.060	34.217	5.84	0.75

30 days	76.57	9.99	35.05	0.061	36.446	9.00	0.54
60 days	NR	NR	NR	NR	NR	NR	NR
R^2-values	0.93	0.92	0.99	0.47	0.99	0.95	-

NR = no relation

The estimated values of R2 was found to range between 0.99 (in case of b* and C*) and 0.95 (in case of DE) to 0.92 (in case of a*) after 30 days of ripening at 15°C of Gouda cheese slices. Also, it was 0.93 (in case of L*) after 30 days of ripening at 15°C. The results are partially confirmed by those of Todorova and Kozev, (1995) who proved that a relationship was found between water activity and water contents during cheese storage, and consequently organoliptic characteristics (taste, color and flavor). Also, they concluded that the water activity (aw) indexes could be used for predicting the keeping quality of both Vitosha and Balkan Kachkaval cheeses. The high relationship between DE or b* -value and water activity (R2-value=0.99) was confirmed by those of Frau et al., (2000). However, the results showed that the characteristic color was different in all color parameters and water activity (aw). No relationship between color and water activity (aw) after 60 days of ripening at 15°C.

4. Conclusions:

Color evaluation showed significant differences between Egyptian Gouda cheese related to ripening time, although due to the similar structure the cheeses, the more identical values were found for Water activity and sensory evaluation in Egyptian Gouda cheese.

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