Effects of additives and ingredient sizing on the shelf-life of "Amaretti" cookies

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Abstract. *Cookies are characterised by moisture and water activity (a_w) higher than 7% and 0.5, respectively. Cookies have the capacity of bending after baking, when they are fresh, unlike biscuits that break when bent. Hardening is the main cause of quality deterioration of cookies, which change from soft and pliable to firm and crumbly within a few days or even hours after baking. Little research has been done on cookies.*

"Amaretti" are typical Italian cookies, found in several regions of Italy. Freshly baked "Amaretti" are soft and delicious but undergo severe hardening after seven to ten days, thus limiting the shelf-life, so Amaretti can be marketed only locally.

In the present work several attempts have been made in order to extend the shelf-life of Sardinian "Amaretti". In particular, changes to the formulation and to the almond particle size were made. The traditional formulation was, in fact, modified by adding rice starch (thickening agent) or mono-diglyceride of fatty acids (emulsifier). Almonds were grinded to a particle size lower or higher than 1mm. Amaretti baked with the traditional recipe were used as control. After baking and cooling cookies were wrapped with an aluminium foil and stored at controlled temperature and humidity. Evolution of texture (as hardness) and a_w during storage were followed instrumentally by a texture analyser and a hygrometer, respectively.

Results shows that moisture content decreased in all samples, while texture analysis revealed that the emulsifier slowed down the hardening rate, with respect to the traditional recipe, while the almond size or the tickening agent have no effects.

Keywords. Cookies, hardening, structure, sugar crystallisation, texture analysis.

Introduction

Cookies have moisture and water activity (a_w) higher than 7% and 0.5, respectively (Labuza, Panda, Roos, Sury, Roe, Sherwin, Puhek, Patist & Zoerb, 2002). The short is usually a mixture of several ingredients, made according to a fairly complex recipe and in a short time (Manley, 1998). Cookies have the capacity of bending after baking, when they are fresh, unlike biscuits that break when bent. On the other hand, biscuits usually have below 5% moisture content, with water activity of around 0.2. This may lead to absorption of water from the atmosphere following prolonged exposure to ambient conditions, making the biscuit soft and soggy (Manley, 1998), thus packaging with a moisture impermeable film is a common practice. In contrast, hardening is the main cause of quality deterioration of cookies, which change from soft and pliable to firm and crumbly within a few days or even hours after baking. While biscuit shelf-life has been extensively studied, little research has been done on cookies. Recently, a very extensive work was published on the web on the textural evolution of cookies during storage (Labuza *et al*., 2002). In this paper the extent of sugar crystallisation in lab-made cookies was determined by replacing part of the sucrose with high fructose corn syrup (HFCS) or trehalose. The authors concluded that, although a strong correlation between cookie hardening and sucrose crystallisation does exist, the two sugar substitutes reduced the firming process while not inhibiting or only slightly retarding the crystallisation rate. Thus, contrary to what has been previously reported (Roos and Karel, 1991), sucrose crystallisation is probably not the only cause of texture deterioration of cookies. Hardening, in any case, is probably a direct consequence of water redistribution among components and loss of plasticizer volume, as reported in another study (Kulp, Olewnik & Lorenz, 1993). The authors concluded that both HCFS and trehalose may act as plasticizers. More simply, it cannot be excluded that hardening is a consequence of water loss from the cookie surface.

"Amaretti" are typical Italian cookies, found in several regions of Italy. In general, amaretti cookies are made of sweet and bitter almonds, sucrose and egg white. Amaretti means bitter cookies, because of the taste given by the bitter almonds. Freshly baked amaretti are soft and delicious but undergo severe hardening after seven to ten days, as observed in our lab. This problem strictly limits the shelf-life, so amaretti can be marketed only locally. Recently, Piga, Catzeddu, Farris, Roggio, Sanguinetti & Scano (2004) made a study on texture evolution of freshly baked amaretti cookies packed with a barrier (aluminium foil) (ALL) or no barrier to water film (polyvinylchloride) (PVC). The textural tests showed significantly higher hardening of PVC cookies, compared to the ALL cookies. The latter retained good sensorial properties at the end of the storage period, although their internal structure changed from soft and moist to mealy, while the PVC cookies were no longer edible only 10 days after baking. Aw values decreased and increased in PVC and ALL lots, respectively. The author suggest that hardening may be explained by water loss in PVC and moisture redistribution in ALL.

To our knowledge, anyway, there are no studies dealing with the evolution of texture of amaretti cookies when process parameters or formulation are changed. With this in mind, we decided to conduct a preliminary investigation on the evolution of texture of freshly baked amaretti cookies, changing both the formulation and the particle size of one of the ingredients (almonds).

Materials and Methods

Amaretti preparation

1st experiment

Amaretti cookies (amaretti from now on) were manufactured in the Pilot plan of Porto Conte Ricerche (ALghero, Loc. Tramariglio, North-West Sardinia).
Ingredients for the control batch were in the following amounts:

- Sweet almonds (0.6 kg)
- Bitter almonds flavoring essence (0,3 ml)
- Sucrose (0.6 kg)
- Egg white (0.3 kg)

Almonds were added at a particle size higher (CTR) or lower than 1 mm (SIZ). Thus we had two batches with the traditional recipe, the only difference was the size of the almond particles.

2nd experiment

Other two batches were prepared by adding respectively 15 gr of rice starch as a thickening agent (RS) and 15 gr of mono-diglyceride of fatty acids (E 471) as a emulsifier agent (MDFA). A CTR batch was also made.

For both experiments ingredients were mixed together for 12 minutes at low speed with a planetary mixer, the short rested for 20 minutes, then formed into small discs of about 5 cm in diameter. Discs were cooked for 20 minutes at 180°C, cooled at ambient temperature and packaged.

The amaretti were packaged manually (in groups of three) in ALL foil. The packaged amaretti were stored at 20°C and 55% ERH.

Textural determinations

Hardness and its evolution were determined in freshly baked amaretti and at 7, 14, 21, 30, 35, 40, 50 and 60 days, by using a texture analyser (mod. TA.XT2, Stable Microsystems, Surrey, UK) with a 50 kg load cell. For SIZ samples we had to stop determinations at 50 days due to technical problems. The Texture Expert program version 1.21 was used for data analysis. Textural determinations were made in six amaretti per each lot by using a 4mm diameter cylinder probe (mod. P/4), for a puncturing test. The samples were punctured right through, in order to check whether any different structural characteristics were present inside or on the surface. To do this the contact plates were substituted with: a confectionery holder, which allows complete penetration and withdrawal of the sample, equipped with a 6 mm diameter top and bottom hole for puncturing (we therefore performed a punch test and not a punch and die test). Parameters of the test are reported in Table 1. Samples were placed centrally on the contact plate and secured on the heavy duty platform before the test commenced. Hardness measurement of samples involved plotting force (in g) versus distance (in mm) and area under the curve (as N · mm) up to 15 mm of puncturing (Papantoniou, Hammond, Tsiami, Scriven, Gordon, & Schofield, 2003) was chosen as index of hardness. The total area of the diagram was considered for cookies of experiment 1, while, in order to better investigate differences between the crust and the inner part of the amaretti, in the second experiment we decided to take the area under the curve corresponding to the exact point in which the crust is punctured, the area corresponding to the puncturing of the interior part of the cookie and the total area (crust + inner part).

Water activity and dry matter determinations

Water activity (a_w) was determined in six amaretti previously used for texture analysis, by an Aqualab instrument mod. Series 3 (Decagon, USA), calibrated in the range 0.1-0.95 with solutions of LiCl, NaCl And KCl of known activity (Labuza, Acott, Tatini, Lee, Flink & McCall, 1976). All parts of the amaretti were tested. Water content was determined in a vacuum oven for 12 h at 70°C [AOAC, 1990]. As for hardness, we take the measurements of the whole cookie in the 1st experiment, while we decided to take separate readings of the crust and of the inner part of the amaretti in the 2nd experiment.

Table 1 - TA-XT2 settings for hardness measurement by puncturing of amaretti.

Puncturing test	
Test-Mode	Return to start
Pre-test speed	3 mm sec^{-1}
Test speed	1 mm sec^{-1}
Post-test speed	10 mm sec^{-1}
Distance	30 mm
Trigger	Auto
Force	20 g
Distance	mm
Force	grams
Probe	4 mm diameter cilinder

Results and Discussion

SIZ samples

Size reduction resulted in keeping textural values up to 6 or 5 weeks for higher or lower size, respectively. After that, values did not significantly increase (data not shown). We noticed a particular evolution of texture of both the samples. In fact, starting from the 14th day, the curves experienced a double hump, corresponding more or less to the top and bottom part of the cookies, probably as the samples became harder on the surface. This may be due to water migration from the outer to the inner part. Thus, size reduction did not result in beneficial effects.

Freshly baked cookies have an a_w of 0.508 and 0.527 for higher or lower size almond particle, respectively. The cookies showed an increase of a_w values up to the 21th day, then an equilibrium was attained until the 35 days, followed by a slight decrease at the 50th day (Figure 1). This behavior may be due to sucrose crystallization. In fact, water redistribution inside the cookies could promote sucrose crystallization, which, in turn, releases water, thus increasing the a_w values (Labuza & Hyman, 1998). What could have happened in cookies during storage (we prefer to stay on a hypothetical level before making more accurate investigations)? Water could have migrated within the cookie, with consequent probable sucrose crystallization, which changed the internal structure of the cookie from soft to mealy. The starting a_w and moisture values of amaretti seem reasonably to confirm the hypothesis of crystallization. In fact, we are surely above monolayer status, while the a_w value allows crystallization to occur in less than 3 days (Labuza *et al*., 2002)]. The evolution of a_w was confirmed by the change in dry matter content (Figure 2).

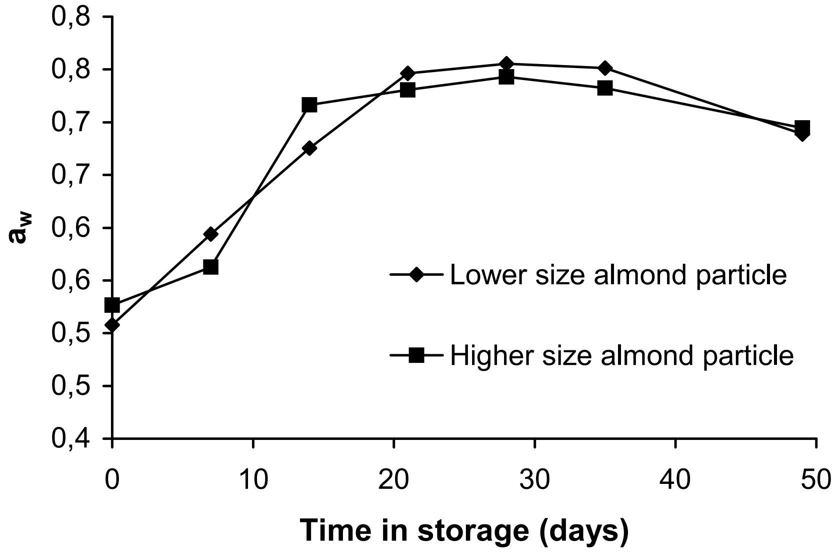

Figure 1 - Change of a_w in amaretti during 50 days in storage. Data are the means of six determinations.

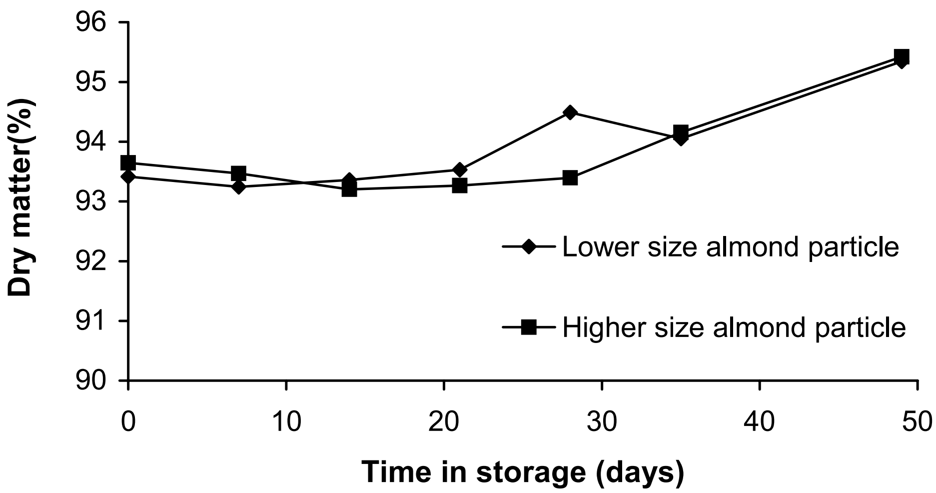

Figure 2 - Change of dry matter (%) in amaretti during 50 days in storage. Data are the means of six determinations.

RS samples

Significant differences were found in both the samples for a_w values in freshly baked amaretti between the CTR and RS samples, either for the inner part (0,82 CTR; 0,71 RS) and the crust (0,56 CTR; 0,51 RS) (Table 2). During storage the a_w values increased in the inner part of RS samples, while CTR cookies showed a significant decrease after seven days, than the values increased again and were very similar to that of freshly baked amaretti until 50 days in storage (Table 2). The inner part of RS samples showed significant lower values at 30 and 50 days in storage, with respect to CTR. The crust, on the other hand, showed a sudden increase for both samples after seven days of storage and values at the 60 days were 0,74 and 0,77 for RS and CTR samples, respectively. The RS samples had always lower values, if compared to CTR, except the 40 days sample.

Table 2 – Evolution of a_w and moisture content in amaretti cookies formulated with the traditional recipe (CTR) or with the addition of rice starch (RS).

Sample	Sampling period (days)	Moisture		Water activity	
		Inner	Crust	Inner	Crust
CTR	0	14.10a*AB**	6.25Aa	0.818aA	0.564aF
RS		13.49aB	5.67A	0.710bE	0.510bE
CTR	7	13.12aC	6.16aA	0.753aE	0.719aE
RS		12.97aC	5.40bB	0.747aD	0.704bD
CTR	14	14.39aA	5.47aC	0.782aD	0.761aD
RS		14.18aA	5.13bC	0.780aC	0.753bB
CTR	21	14.02aB	5.44aC	0.788aC	0.763aCD
RS		13.60bB	5.15bC	0.780aC	0.753bBC
CTR	30	12.91aD	5.86aB	0.800aB	0.761aD
RS		12.74aC	4.95bD	0.791bBC	0.749bBC
CTR	40	11.02aF	5.20aD	0.805aB	0.771aBC
RS		10.40bE	5.05aC	0.804aA	0.770aA
CTR	50	11.51aD	5.17aD	0.802aB	0.777aAB
RS		11.18aD	5.15aC	0.797bAB	0.771bA
CTR	60	10.02aG	5.14aD	0.806aB	0.772aA
RS		9.72aF	5.08aCD	0.802aA	0.743bC

* Data followed by different lowercase letters show significant differences between samples (CTR vs RS) within each storage period and for each column. Data are the mean of six determinations.

** Data followed by different capital letters show significant differences between samples of the same batch during the storage period (CTR vs CTR and RS vs RS) and for each column. Data are the mean of six determinations.

Moisture content of both the inner part and the crust of RS and CTR samples showed the tendency to decrease. The concomitant a_w increase and moisture decrease of the crust could be explained again by sucrose crystallization. As expected the crust was drier than the inner part.

Results of texture analyses showed an increase in hardness in both CRT and RS samples considering the crust, the interior and the cookie as a whole. As an example, the evolution of hardness in the inner part of samples is reported in Figure 3. Adjunction of rice starch resulted in some cases (0, 30 and 50 days) in significant higher hardness values, but never in lower values, with respect to CTR cookies. It is to highlight the particular evolution of hardness values. If we consider, on the other hand, the evolution of the hardness of the whole cookie there was a more uniform evolution, anyway, the hardness showed a significant increase during storage for both samples and RS cookies had quite always significant higher hardness values, with respect to CTR (data not shown). Thus, it seems that the amount of rice starch used not only resulted in prevention of hardness increase, on the contrary it could have enhanced the hardening.

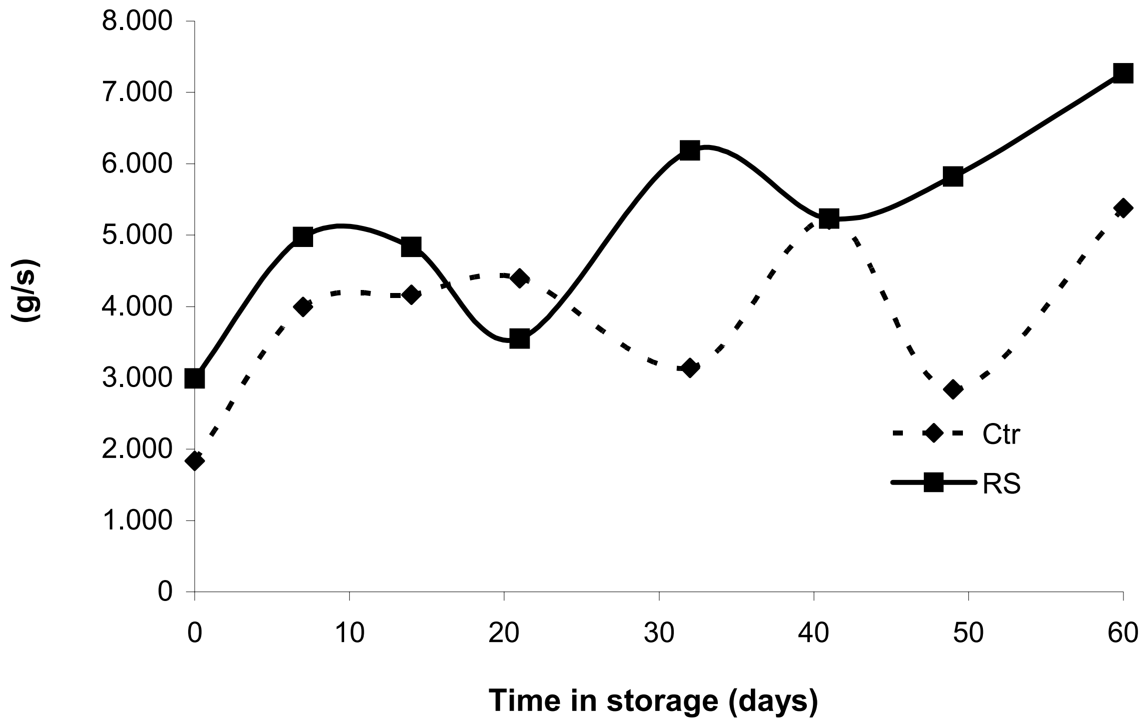

Figure 3 - Textural evolution of the inner part of amaretti prepared using rice starch during 60 days in storage.

MDFA samples

Data on aw values confirm what previously reported for RS samples both for the crust and for the inner part of the CTR and MDFA cookies, if we except that we had significantly higher values for the inner part up to the 21th day for CTR, while the MDFA inner part experienced a dramatic loss at 7 days, than values returned similar to 0 days and then increased significantly (data not shown). The MDFA sample showed always values significantly higher than CTR, both for the inner part and for the crust, with the exception of 21 and 30 days for the crust. Moisture values are also quite always significantly higher in MDFA samples and in both thesis the inner part showed the tendency to decrease.

Data regarding the hardness evolution evidenced an increase in hardness for both samples, considering the crust, the interior and the cookie as a whole. The Figure 4 show the hardness evolution of the crust, in which we found significantly lower values for the MDFA samples up to 30 days. We have also to highlight the sharp increase in hardness at 7 days and the subsequent diminution. This behaviour can be surely linked to the a_w evolution. The trend found in the crust was also evidenced for the interior part and for the whole cookie (data not shown). It is to highlight, moreover, that MDFA samples had always lower hardness values in all the cookie parts, with respect to CTR samples and that the increase at 7 days was less pronounced. Thus, we can state that the emulsifier slowed down the hardening mainly of the interior, but did not have always beneficial effects regarding the moisture loss. We also noticed on freshly baked amaretti, that the crust of MDFA samples had less cracks on the crust, we respect to CRT cookies.

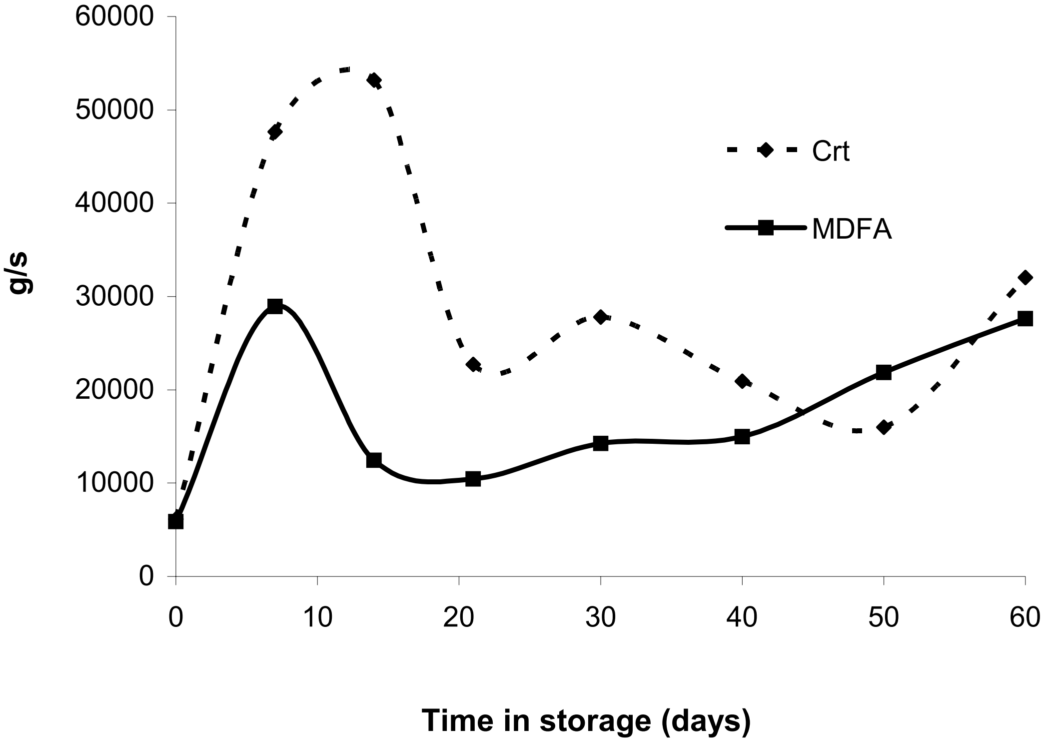

Figure 4 - Textural evolution of the crust of amaretti prepared using mono-diglyceride of fatty acids during 60 days in storage.

CONCLUSIONS

Results of our investigation clearly point out that it is possible to slow down the natural hardening behavior of amaretti by using an emulsifier (E 471), anyway is more difficult to block the moisture loss, which, in turn, could be resulted from an imperfect tight seal of the packages.

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Nomenclature

ALL	Alluminium
a_w	activity of water in the product
°C	degree Celsius
CTR	Control batch
ERH	Equilibrium relative humidity
g	gram
h	hour
kg	kilogram
mm	millimetre
MDFA	Mono-diglyceride of fatty acids added batch
%	percent
PVC	Polyvinilchloride
RS	Rice starch added batch
sec	second
SIZ	Batch with reduction of almond particle size

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