Aliments et nutriments

Influence of the salt addition on the couscous quality

Etude de l'influence de l'addition du sel sur la qualité du couscous

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Reçu le 14 octobre 2021, Révisé le 27 décembre 2021, Accepté le 31décembre 2021

Abstract ***Introduction***. Couscous is a product made from durum wheat semolina and water. No other ingredient is added except salt. The effect of salt on the couscous quality is poorly understood, and has never been studied. ***Objective***. The effect of adding salt was studied on the quality of couscous. ***Material and methods.*** Two commercial semolina were used. During the couscous manufacture, the rolling yields were determined. After pre-cooking and drying couscous, the particle size analysis enabled us to determine the mean equivalent diameter (D50), and the geometric standard deviation(Sg). In order to assess color and culinary quality of couscous, brown index, yellow index, swelling capacity of couscous, caking index, and water solubility index were determined on dry couscous. ***Results.*** The salt addition had an effect on the rolling operation yields. The percentages of couscous and lumps decreased with the salt addition, whereas the percentages of non-agglomerated semolina increased. The particle size showed that the D50 lowered with the salt addition. On the other hand, the Sg remained unchanged. Salt addition decreased brown and yellow indexes, caking index, water solubility index, and swelling capacity of couscous. ***Conclusion.*** The salt influences the couscous agglomeration by promoting the formation of fine fractions and ameliorates the coloring, and the culinary quality of couscous by improving the stickiness.

Key words: *Durum wheat semolina, Couscous, Quality, Salt (sodium chloride)*

Résumé *Introduction*. Le couscous est un produit composé de semoule de blé dur et d'eau potable. Aucun autre ingrédient n'est ajouté excepté le sel. L'effet du sel sur la qualité du couscous est mal connu et n'a jamais été étudié. ***Objectif*.** L'effet de l'addition de sel sur la qualité du couscous est étudié. ***Matériel et méthodes.*** Deux semoules commerciales ont été utilisées. Durant la fabrication du couscous, les rendements du roulage ont été déterminés. Après la pré-cuisson et le séchage du couscous, les analyses granulométrique ont permis de déterminer la granulométrie médiane (D50) et la dispersion géométrique (Sg). Pour évaluer la couleur et la qualité culinaire du couscous, l'indice de brun, l'indice de jaune, la capacité de gonflement du couscous, l'indice de prise en masse et l'indice de solubilité ont été évalués sur les couscous secs. ***Résultats*.** L'addition du sel a eu un effet sur les rendements de l'opération de roulage. Les pourcentages du couscous humide et des grumeaux ont diminué avec l'ajout de sel, alors que les pourcentages en semoules non agglomérées ont augmenté. La granulométrie a montré que la D50 a diminué avec l'ajout de sel. En revanche, la Sg reste inchangée. Concernant, la couleur et la qualité culinaire des couscous, l'addition de sel a réduit l'indice de brun, l'indice de jaune, la capacité de gonflement du couscous, l'indice de prise en masse et l'indice de solubilité. ***Conclusion*.** Le sel influence l'agglomération du couscous en favorisant la formation des fractions fines et améliore la couleur ainsi que la qualité culinaire des couscous en améliorant le collant.

Mots clés : *Semoule de blé dur, Couscous, Qualité, Sel (Chlorure de sodium)*

Introduction

Couscous is a product made from durum wheat semolina which is added, for agglomeration, drinking water, and is subject to physical treatments (kneading and rolling), and heat treatments (pre-cooking and drying). No other ingredients are added except salt; which may be present in the hydrating water used for the semolina agglomeration [1].
Couscous is well known as a staple meal in Algeria. In most Algerian localities, there could be no event, party or occasion without the preparation of a couscous-based dinner. Couscous often occurs in different occasions as the favourite dish of Algerian families, such as weekends (especially Fridays), different holidays (marriage and circumcision), public holidays, religious festivals (Eid al-Fitr, Eid al-Adha, etc.), family reunions, invitations and funerals [2].
Couscous is considered to be good quality when the particle size is uniform and there is no unusual odor. After cooking, its hould be firm and unsticky, with a high water absorption capacity [3].
In a study carried out on the traditional couscous manufacture in northeastern Algeria, Chemache *et al*., [2] reported that the use of salted water for a wet agglomeration can influence the couscous quality. The survey of manufacturers revealed that 87% of housewives hydrated the semolina with a salted water solution. Their choice was justified, on the one hand, to improvethe flavor of the final product and, on the other hand, to protect against microbial deterioration during storage. However, the influence of the salt addition on the couscous quality has never been studied.
Salt plays a multifunctional role in processed foods. It is mostly added for flavoring, and thus, it plays a vital and important role in cereals processing by improving the physical functionality and process ability, such as strength and dough handling [4]. Salt, which is a crucial additive for many cereal food products, is generally added to ameliorate dough characteristics, and pasta quality [5]. According to the same authors, and due to the critical technological functions of salt, its removal can have adverse effects on dough properties, and the end-use quality, such as reduced dough strength, less desirable texture, and a shorter shelf life. Salt, when mixing the dough, results in a different molecular conformation, and a network structure changes, not as gluten proteins, and contributes to the rheological properties differences [6].
In the absence of any study on the salt influence on the couscous quality, we were interested to those made on other types of pasta. Indeed, several studies

have been done on the effects of salt on the noodles quality. Salt strengthened gluten in the dough, improved flavor, coloring and textural properties of cooked noodles, and inhibited enzyme activities and microorganisms growth [7]. It improved the elasticity of fresh noodles [8,9], contributed to a better appearance of the noodle surface; smoother and softer [8,10], and increased the firmness of noodles [10,11].

Adding salt to couscous is not just for flavor. The effect of salt on the gluten and the hydration of the constituents of the semolina, as well as, on the enzymes must have an effect on the couscous quality. The objective of this study was to determine the effect of the salt addition on the couscous quality.

Material and methods

Couscous preparation

Samples of couscous were made according to the traditional method from two commercial semolina: extra semolina (ES) (protein content (% md) 16.21; lipid content (% md) 0.746; D50 (µm) 318.33; yellow index 32.77; brown index 26.97), and common semolina (CS) (protein content (% md) 15.37; lipid content (% md) 1.075; D50 (µm) 341.67; yellow index 28.49; brown index 26.51) from Labelle Unit (Ouled Moussa Boumerdes). A part from the addition of salt, the same manufacturing conditions were applied to the different products. The couscous was rolled by hand in a wooden bowl.

The hydration of semolina was carried out either with distilled water, without salt or with distilled water salted at 2%. The hydration rate was set at 38%, according to the work of Lefkir *et al.*, [12]. The mixture obtained from the first step (hydration/ mixing) was sieved by a sieve (2900 µm). The refusal of this sieve constituted lumps. Then, the resulting passage was sieved twice through a second sieve (1600 µm) so as to form the couscous grains properly. Then, the product was sieved by a third sieve (1000 µm). The refusal of this last sieve constituted the wet couscous, and the passage formed the non-agglomerated semolina. The products of the different stages (lumps, wet couscous and non-agglomerated semolina) were weighed to establish the rolling yields. The wet obtained couscous was steamed, and then dried on a clean cloth at room temperature. To assess the quality of couscous, analysis were carried out on dry couscous.

Granulometric analysis of couscous

The granulometric analysis was determined by sieving a 100g sample using the RHOTEX laboratory Plansichter. This analysis maked it possible to determine the mean equivalent diameter (D50), and the dispersion parameter or the geometric standard deviations (Sg=D84/D50=D50/D16), representative of the homogeneity samples.

Couscous color determination

The brown and yellow indexes were determined using a chromameter (Minolta CR-410 illuminant D65). These conditions were ethose adopted by the Commission Internationale de l'Eclairage (C.I.E). The results were expressed according to the C.I.E measurement unit system (L, a, b). The couscous or semolina sample (thickness=2.5mm) was placed under a light source. The yellow index corresponded to the value (b) and it was higher as the couscous or semolina was more yellow. The brown index was the value (100-L) and it increased with browning.

Assessing methods of couscous culinary quality

Couscous hydration capacity was determined by the cold-swelling and the hot-swelling, according to the method of Guezlane & Abecassis [13]. Caking index was estimated by sieving, after preparation of couscous, using the rapid method [14]. Evaluation of water solubility indexes were determined according to the method of Anderson *et al*., [15].

Statistical analysis

The data processing used statistical methods. Statistical variables were calculated using STATISTICA version 10 software. The variance analysis made it possible, depending on the level of significance, to determine the influence of the factor studied. Means were compared using ANOVA analysis. When significant effects (p<0.05) of treatments were detected in ANOVA, multiple comparisons of means were conducted using Tukey's approach.

Results

Ease of rolling and efficiency

The process and formation of couscous grains were achieved after several steps. In order to assess the effect of salt on the ease of couscous rolling, observations were noted. During hydration and mixing, it was noticed that the agglomeration behavior of the studied semolina was different depending on the salt addition. In fact, semolina hydrated with salted water clumps less than those hydrated with unsalted water. It was also noted that when sieving the products through the second sieve (1600µm), to finalize the formation of couscous grains, the products rolled with salted water were harder and more difficult to sift.

The yields results of the rolling operation in function of the salt addition are shown in **Fig. 1**. It was clear that the percentages of wet couscous and lumps decreased with the salt addition. On the other hand, the percentages of non-agglomerated semolina increased. Analysis of these results showed that the salt caused insufficient hydration of the semolina particles which madethe effect of reducing the rolling rate, in favor of the fine fractions.

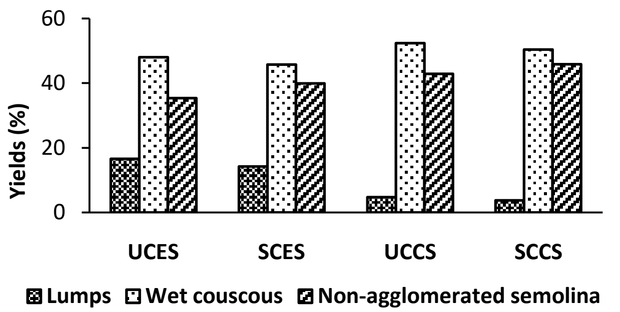

Fig. 1. Salt effect on couscous rolling yields

UCES : Unsalted couscous extra semolina ; SCES : Salted couscous extra semolina ; UCCS : Unsalted couscous common semolina ; SCCS : Salted couscous common semolina

Granulometric analysis of couscous

The results relating to the granulometric distribution of couscous are presented in **Table 1**.

Table I. Granulometricanalysis of couscous

	Meanequivalentdiameter(D50) (µm)	Geometric standard deviation(Sg)
UCES	863.33±5.77[a]	1.15±0.006[a]
SCES	852.33±2.52[ab]	1.14±0.006[a]
UCCS	838.33±10.41[bc]	1.17±0.01[b]
SCCS	825±5[c]	1.17±0.006[b]

UCES : Unsalted couscous extra semolina ; SCES : Salted couscous extra semolina ; UCCS : Unsalted couscous common semolina ; SCCS : Salted couscous common semolina. Each value is expressed as mean ± standard deviation of three experiments. Values followed by different letter are significantly different at p<0.05.

By comparing the results of products made with salted water to those rolled with unsalted water, the mean equivalent diameter (D50) decreased with the salt addition. Moreover, the geometric standard deviation (Sg) remained unchanged.

Couscous color

The results of salt on the couscous color are shown in **Fig. 2**. A decrease in the yellow (Fig. 2A), and the brown (Fig. 2B) indexes was noted with the salt addition.

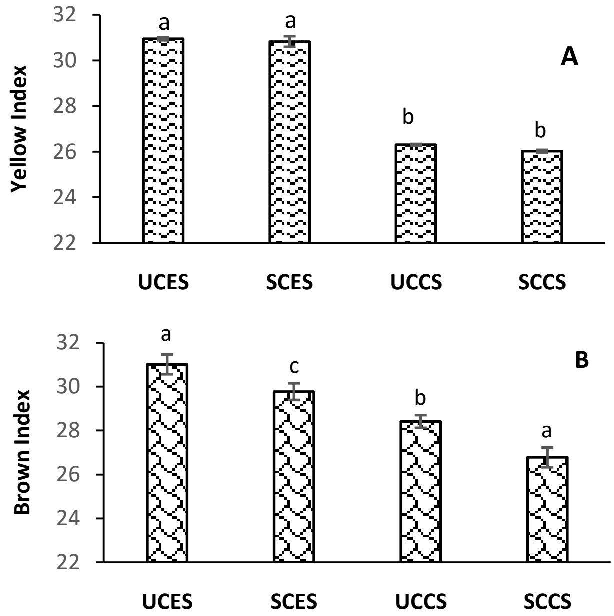

Fig. 2. Effect of salt on couscous color

UCES : Unsalted couscous extra semolina ; SCES : Salted couscous extra semolina ; UCCS : Unsalted couscous common semolina ; SCCS : Salted couscous common semolina. Each value is expressed as mean and standard deviation of three experiments. Distinct letters in each bar indicate significant differences at p<0.05.

Characteristics of culinary quality

Swelling capacity of couscous

The results of the cold swelling capacity and the hot swelling capacity of couscous are shown in **Fig. 3.**

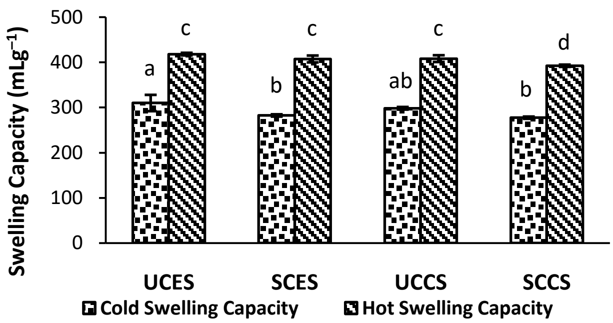

Fig. 3. Effect of salt on swelling capacity of couscous

UCES : Unsalted couscous extra semolina ; SCES : Salted couscous extra semolina ; UCCS : Unsalted couscous common semolina ; SCCS : Salted couscous common semolina. Each value is expressed as mean and standard deviation of three experiments. Distinct letters in each bar indicate significant differences at p<0.05.

The analysis of this figure in function of the effect of salt showed that the values of cold and hot swellings of couscous made with salted water were lower than those of couscous rolled with water without salt.

Caking cooked couscous

The results obtained for the caking index of the samples studied are shown in **Fig. 4**. It was noted that the values of the caking index recorded for the couscous rolled with salted water were lower than those of the couscous rolled with water without salt. From these results, it appeared that the salt addition to the hydration water decreased the stickiness and thus improved the culinary couscous quality.

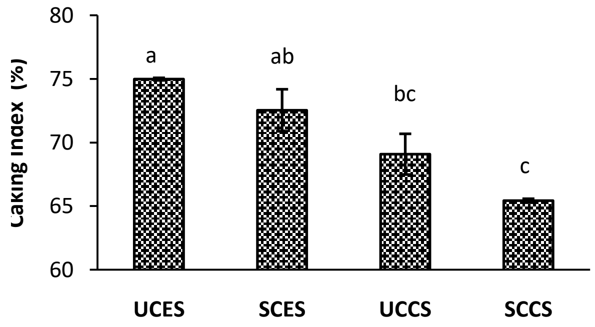

Fig. 4. Salt effect on caking index

UCES : Unsalted couscous extra semolina ; SCES : Salted couscous extra semolina ; UCCS : Unsalted couscous common semolina ; SCCS : Salted couscous common semolina. Each value is expressed as mean and standard deviation of three experiments. Distinct letters in each bar indicate significant differences at p<0.05.

Water solubility index

The results of couscous water solubility index are presented in **Fig. 5**. The comparison of the water solubility indexes of the products rolled with salted water to those of the products hydrated with water without salt showed that the salt addition decreased the water solubility index.

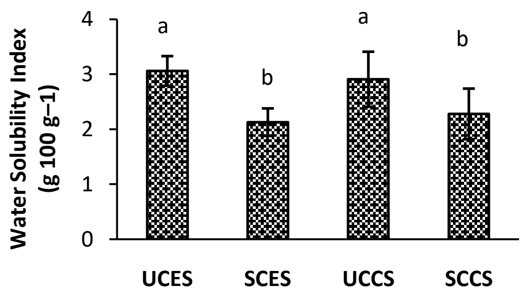

Fig. 5. Salt effect on water solubility index

UCES : Unsalted couscous extra semolina ; SCES : Salted couscous extra semolina ; UCCS : Unsalted couscous common semolina ; SCCS : Salted couscous common semolina. Each value is expressed as mean and standard deviation of three experiments. Distinct letters in each bar indicate significant differences at p<0.05.

Discussion

The objective of this study was to evaluate the influence of salt on the couscous quality. The presented results demonstrated the significant effect of salt on the parameters studied to assess the quality of couscous.

Rolling was the first step in the couscous making process. During this step, the semolina particles were hydrated and agglomerated to form couscous grains. This operation yield was very important, and determined the final couscous yield of the manufacturing process. Indeed, non-agglomerated semolina and lumps were necessarily recycled [12]. This step can, in fact, generate large quantities of products to be recycled (too big or too small) which represent flows up to 2.5 times greater than the flows of native semolina [16]. It is therefore clear that in the rolling control lies one of the key elements of couscous productivity in the couscous manufacturing process [12].

Salt addition to the hydration water caused changes in the agglomeration of the semolina, which led to a reduction in the rolling rate, in favor of the fine fractions, and the grain size of the couscous. This decrease can be explained by an insufficient availability of water. Moreover, with the salt addition, the formed agglomerates were harder and firmer. Indeed, many studies have noted that sodium chloride changes the hydration characteristics of the gluten protein. The salt addition decreased the water absorption of wheat flour [8,9]. Due to its affinity for water, salt increased competition for available water, resulting in delayed hydration of gluten proteins [17,18]. The slowing of the gluten hydration was due to the fact that the salt neutralized the charges on the surface of the gluten, and thus weakens the repulsive forces between proteins, and their accessibility by water molecules [19].

Furthermore, the salt addition causes changes in the secondary structure of proteins, leading to a more rigid protein network [6,10]. The presence of salt protects the charges of the gluten molecules, reducing the electrostatic repulsion between proteins, which in turn induces stronger hydrophobic and hydrophilic inter-protein interactions between proteins, producing consequently an increased aggregation and a strong gluten network [19].

To ensure a good treatment of dough, it is necessary to maximize the quantity of water added during mixing. On the other hand, the strengthening and tightening effect of dough with salt allows the addition of more water without causing problems during the processing of the dough. Salt can also facilitate hydration of flour particles during mixing [7]. In the case of couscous, the limit for the hydration rate is 38%, beyond which, rolling couscous is difficult [12]. The obtained results in this study and the observations noted on the agglomeration and couscous rolling suggested the possibility of increasing the hydration rate (38%) to improve couscous yields.

Color was related, on the one hand, to the final content of carotenoid pigments and, on the other hand, to the enzymatic and non-enzymatic browning reactions [20]. According to Debbouz *et al.*, [21], the color did not only depend on the pigment content of the semolina but also on the presence of oxidizing enzymes, and the manufacturing conditions. Salt slowed down the oxidative discoloration process [7], and consequently, improved the couscous color.

The culinary quality results showed that the salt addition decreased the swelling capacity of couscous, the cooked couscous caking, and the solubility index in water.

The swelling values of couscous can be related to the hydration capacity of the semolina. High couscous swelling values may be an indicative of a high quality product [3]. The swelling capacity of agglomerates depends on the crystalline state of the starch granules [22,23]. During the couscous hydration and rolling, the starch granules hydrate and during the pre-cooking, these hydrated starch granules gelatinize. During these stages of the couscous manufacture, starch undergoes significant transformations which modify its swelling capacity. The increase in water content during couscous rolling increases the swelling capacity [12,24]. Higher water contents of wet agglomerates improve the gelatinization mechanisms of starch granules during pre-cooking [24].

The caking index values are related to the degree of the cooked couscous agglomeration [3]. The water solubility index is measured as the amount of solubilised solids during the immersion of a couscous sample in excess water [3,21]. The low values of caking index and the water solubility index are indicatives of the high quality products [3]. Cooking losses could have a decisive effect on the couscous tackiness. In fact, under the heat effect, starch grains will swell, and release a part of their content, especially amylose in the mass of the couscous grain to the surface which leads to an increase in stickiness [25]. The gelatinization mechanisms promote partial leaching of starch granules from amylose chains, which are capable of dissolving in water [22]. The significant salt effect on swelling, stickiness and the water solubility index comes down to its influence on the starch gelatinization. Several studies have reported that sodium chloride slows the starch gelatinization [26-28]. Gelatinization is thought to be delayed due to a limited water content [9]. The salt-induced change in gelatinization is driven by changes in starch hydration, caused by the effect of ions on water structure [29,30].

Conclusion

The salt addition to the hydration water has an effect on the yields of the rolling operation. The percentages of couscous and lumps decrease with the salt addition. On the other hand, the percentages of non-agglomerated semolina increase. The mean equivalent diameter decreases with the salt addition, whereas, the Sg remains unchanged. This influence of the salt addition on the yields and grain size of couscous is related to a decrease in the availability of water during the semolina hydration. So, to be able to improve the yield and increase the grain size of the couscous, the hydration rate must be increased. The color of couscous is improved by the salt addition. Regarding the culinary quality, the salt addition to the hydration water decreases the caking index and water solubility index, which ameliorates the couscous culinary quality by improving the stickiness. On the other hand, the swelling capacity of couscous decreases. The effect of salt on the couscous quality appears to be a very complex study. For a better understanding of this influence, it is necessary to study the effect of salt on the biochemical modifications of the semolina constituents (proteins, starch and lipids).

Conflict of interests

The authors declare no conflict of interests.

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