Uso de sal esférica para la reducción de sodio sin variación del gusto salado en la obtención de una hamburguesa de carne de cordero con aptitudes tecnológicas y sensoriales

Use of spherical salt for reducing sodium content with no change in salty perception in the development of a lamb meat burger with high-rated technological and sensory properties

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Resumen

Se utilizó sal esférica como estrategia para la reducción del contenido de sodio en una hamburguesa de carne de cordero con respecto a una hamburguesa control —elaborada con sal de mesa al 1,5%— con el objeto de conservar la misma percepción de gusto salado en el producto final. La formulación de este último fue definida mediante una serie de pruebas desarrolladas con un panel de evaluadores entrenados en percepción de gusto salado. Se determinó el contenido de sodio, la composición centesimal y el contenido graso del producto crudo y se estimaron el rendimiento y la humedad expresible. Mediante un ensayo hedónico con 112 consumidores se determinó la aceptabilidad del producto final. Se logró desarrollar una hamburguesa con 14,75% menos de sodio y sin diferencias perceptibles en el gusto salado con respecto a la muestra control, valorada positivamente por más del 85% de los consumidores. Adicionalmente, las características tecnológicas del nuevo producto se hallaron dentro de los parámetros esperados.

Palabras claves: *Quitosano, quitooligosacárido, yogur, simulación digestiva*

Abstract

A spherical salt was the strategy used to reduce the sodium content in a lamb meat burger in relation to a control sample —formulated with 1.5% sodium content— in order to maintain the same salty taste perception. The final product was defined by a series of tests developed with a sensory panel trained for salty taste detection. Sodium content, centesimal composition and fat composition were analyzed on raw burgers. Cooking yield and expressible moisture were estimated. A hedonic test was performed with the final product to assess overall acceptability. The developed burger contained 14.75% (w/w) less sodium than the control sample but no difference in its salty taste and presented adequate technological features. Furthermore, the burger obtained 87.5% of positive reviews in the acceptance test.

Keywords: *Spherical salt, sodium reduction, salty taste, lamb burger, sensory evaluation.*

Introduction

Elevated sodium intake has been associated with a number of non-communicable diseases (NCDs) including hypertension, cardiovascular disease and stroke. NCDs are the main contributor to mortality and morbidity globally. A lower intake of sodium may reduce blood pressure and the risk associated to NCDs (World Health Organization, 2012).

Even though salt enhances flavour, preserves freshness and improves appearance and texture of food, there are strategies for its reduction. It is possible to modify the size and the structure of the salt particle thereby enhancing its dissolution. The change in the structure promotes the same salty taste with reduced salt level in the product (McGuire, 2010). Salt microspheres (SODA LO®) are made by a patented technology that turns standard salt crystals into free-flowing crystalline microspheres. These low-density crystals efficiently deliver salty taste by maximizing surface area relative to volume. While spherical salt is represented by hollow crystalline microspheres of sodium chloride of 10-20 μm of diameter, crystals of table salt have an approximate size of 500 μm. However, a successful salt reduction depends on multiple aspects related to type of product, composition, processing requirements and manufacturing conditions. These factors will determine whether the product is suitable for modification as well as the technological limitations for salt reduction (Ruusunen & Puolanne, 2005). It is well known that about 75% of the dietary sodium comes from processed and restaurant foods, whereas only a small portion comes from salt added to food when cooking or eating. Commercial classic burgers contain large amount of sodium (De Landeta et al., 2012) and represent a very popular and accepted frozen product.

On the other hand, nowadays lamb meat does not represent an important part of daily diet of many countries, representing less than 2 kilograms/capita/year (OECD.org, 2015). Argentinian population barely consume this type of meat for several reasons as the lack of habit and lack of knowledge about its nutritional composition, but also because of its seasonal availability and because there are not practical cuts for an easy cook or storage available in the market (Iglesias, 2013). As stated by Moré et al. (2000), the global image of lamb meat for Argentinian consumers is good despite its low consumption (approximately 1.5 kg/person/-year). To achieve the potentiality reflected by its image, the authors propose a modification on the supply conditions considering products, presentations, designs and target population.

The aim of this work was to analyze the use of spherical salt (at 1.1%, 1.3% and 1.5%) for sodium content reduction in a lamb meat burger with no changes in the salty taste perception in relation to a control sample, assessed by sensory analysis. Also, to study the effect of that salt replacement over the technological properties, the composition and the product acceptability.

2. Materials and methods

2.1. Burgers formulation

Lamb leg meat and fat represented the raw material for the burgers elaboration. Forty male Corriedale lambs were reared to 24.5 ± 1.5 kg live weight on natural pasture of Mesopotamic region of Argentina. Lambs were conventionally slaughtered in a commercial abattoir and legs were taken after 24 h at 4°C (K = T°C + 273.15) and transferred to a frozen chamber (-18 ± 2°C). The day before each elaboration lamb legs were transferred to a refrigerator (4 ± 2°C). All subcutaneous and intermuscular fat was removed and used as the fat source. Lean meat and fat were minced through 10 mm plate of a meat grinder (Altamura S.A., Argentina). Subsequently the meat and fat were placed in the freezer (-18 ± 2°C) for 20 min. The concentration of fat selected was 15% (w/w).

The types of salt used were table salt (NaCl, Celusal ™) for the salty taste training (at different levels) and for the formulation of the control sample (at 1.5%), and spherical salt (SODA-LO® salt microspheres, Tate&Lyle) for the lamb meat burger development (at 1.1%, 1.3% and 1.5%). It is important to emphasise that the NaCl level chosen for the control sample (1.5%) arises from the lowest sodium content found between the nutritional information labels of beef burgers available in Buenos Aires capital city market. Beef burgers were considered for market research instead of lamb meat burgers, since there were not commercial lamb meat burgers available in the city market at the time. The first step of the elaboration was the addition of the salt to the fat in a partially frozen state for preventing the dissolution of the spherical salt particles —microspheres are water-soluble and the fat is expected to protect them—. The type and concentration of salt was added according to the formulation. Later, the lean meat and the fat (5.7:1) were mixed and the additives added. The additives used were: sodium tripolyphosphate 0.15% w/w ($Na_5P_3O_{10}$, Arysa Argentina SA) as texturizer, binder and preservative and butyl hydroxyl toluene 0.01% w/w (Ytrio SRL, Argentina) as antioxidant.

In each elaboration three-kilogram batches of the formulation were mixed by hand until a homogenous mix was obtained (approximately 5 min) and then processed into square meat burgers (1 cm thick and 7 cm side) by using a semiautomatic plastic shaper.

Burgers were placed between plastic sheets, vacuum packed and frozen at -18 ± 2°C until the assays.

2.2. Cooking procedure and cooking yield

Burgers were cooked according to AMSA guidelines (Belk et al., 2015) from frozen state for 13 min (to achieve an internal temperature of 71°C) in a preheated electric grill (155 ± 5°C) (George Foreman®, Spectrum Brands, USA). Internal temperature was verified using a probe-type thermocouple connected to a data acquisition system (Hewlett Packard 39470A). The thermocouple was inserted as close to the geometric centre of the burger as possible. The cooking yield of lamb meat burgers in function of salt type (table salt and SODA-LO™) and salt concentration (1, 1.5 and 2%) was studied. Cooking measurements were done over nine replicates. Per cent cooking yield was determined (Equation 1).

Cooking Yield (%)=(Cooked burger weight/Frozen uncooked burger weight) x 100

2.3. Sensory tests

2.3.1. Sensory panel selection and training sessions

Recruitment and selection of panellists were carried out and a basic tastes recognition test (ISO 8586-1:1993) was performed. The subjects who achieve 75% or more correct answers were selected (Meilgaard et al., 2007). Then they performed a ranking test for assessing differences among 4 codified samples of sodium chloride solutions based on the intensity of salty taste (ISO 8587:2006). Those subjects who ranked the samples in the correct order and those who inverted only adjacent ones were selected (Meilgaard et al., 2007). The Best Estimated Threshold (BET) for salty taste of each subject was determined. Sensory tests were carried out twice in morning sessions on consecutive days. The group BET was determined with the geometric means of the individual thresholds (ISO 3972:2009; ASTM E679-04).

The training with burgers was conducted once the subjects gained experience in the recognition of salty taste with solutions. Different concentrations of table salt were used for the elaboration of the burgers for the training sessions (Table 1). A thirteen-member trained sensory panel was calibrated in the salty taste descriptor. Assessors received lamb meat burger samples (1 x 1 cm wide) with 0, 1, 1.5, 2 and 2.5% of table salt coded like showed in Table 1. After a group discussion these samples were given scores of 0.5, 4, 6, 8 and 10 respectively on a 10 cm salty taste intensity scale. The sample with no added salt but all the other ingredients was not considered the zero on the scale since the additives provide a slight salty taste.

During training sessions an unstructured scale was used where, in first instance, each sample was localized according to its intensity in salty taste. In successive sessions, the training continued only with the control sample marked on the scale to allow subjects to calibrate in the intensity scale. The members received the other 4 samples coded with 3-digit numbers and had to score them according to the consensus score, with a variation in the scale no greater than ± 1.5 point. Water was provided for palate cleansing between samples over all sessions.

2.3.2. Sensory tests for product determination

The first step aimed to confirm that the salting power of the spherical salt in the lamb meat burgers was different to that of the table salt. Burgers with different concentrations of spherical salt were formulated and then evaluated by the trained panel in three sessions with the control sample (table salt 1.5%) as reference marked on the 6 of the intensity scale. Spherical salt samples were formulated at 1%, 1.5% and 2.5%. The trained panel had to score them according to saltiness in the intensity scale.

Then, two types of tests were conducted: a qualitative one —paired comparison test— and a hedonic test —acceptance test—. The paired comparison tests (ISO 5495:2005) were carried out to determine which of the formulations with spherical salt could not be differentiated from the control sample, meaning that both samples had a similar saltiness. Four different lamb meat burger formulations with SODA-LO™ were prepared to do the comparisons against the control sample: 1.5%, 1.3%, 1.1% and 0.9%. Each test was replicated twice on different days to achieve the number of responses required = 26. The parameters selected for the test were: $\alpha = 0.05$, $\beta = 0.50$ and pd= 40%.

A hedonic test (ISO 11136) was performed to assess the acceptability of the final formulation of lamb meat burger. Samples of hot burger of 2 x 2 cm were served in closed thermic recipients. A 9-point hedonic scale was used where 9 = like extremely and 1 = denoted dislike extremely. The acceptance testing was carried out with 112 consumers (Hough et al.,2006) between 18 to 65 years old.

2.4. Determination of sodium content

Sodium content was assessed according to AOAC 968.08 (1995) method. The analysis was performed by duplicate. The results were expressed on mg Na/100g of sample.

2.5. Centesimal composition

Water content and ash were determined by gravimetric method (Kolar, 1992). Fat was determined by the Soxhlet method, using Soxtec System HT 1043 (Tecator, Sweden) according to AOAC (1990) procedures. Total nitrogen was determined by the Kjeldahl procedure (Kjeltec, 2020 Analyzer, Foss Tecator, United Kindom) (Price et al., 1994). All tests were performed in triplicate and the results were expressed as percentage (%).

2.5.1. Fatty acid analysis

Lipid extraction followed Folch et al. method (1957) modified. An aliquot of 5 ± 0.5 g of sample was grounded with the addition of 5 ml chloroform and 10 ml of anhydrous methanol and homogenised for 3 minutes (Omni International, 17106, USA). Then, 5 ml of chloroform were added and the sample homogenised 1 minute. Then 2.5 ml of distilled water were added and the sample was homogenised 1 more minute. The mix was filtrated with vacuum and the filtrated was centrifuged to separate the phases. The superior phase (aqueous) was eliminated by aspiration and the lower phase (chloroform) was filtrated to eliminate solid impurities to obtain the chloroform crude extract. Methyl esters were prepared by trans methylation with a methylating reagent (methanol + 4% HCl). Fatty acid methyl esters were quantified by gas chromatography. The fatty acid composition was analysed by GC CP-3800 (Varian, USA), equipped with a flame ionisation detector, automatic injector and a fused silica capillary Varian WCOT column (100 m 0.25mm CP-Sil 88 for FAME df= 0.2μm). The carrier gas was ultra-pure nitrogen at a constant flow of 2.5 ml min -1; the injector and the detector temperature were set at 250°C. The column temperature was 70°C, held 4 min, raised to 170°C at a rate of 8°C min-1, held for 25 min, and raised to 200°C at a rate of 2.5°C min-1, held 15 min, and finally raised to 220°C at a rate of 5°C min-1. Fatty acids were identified by comparing the retention times of FAME with standard PUFA n°2 (Animal Source, Supelco, USA). The results were expressed in g per 100 g of total lipids.

2.6. Expressible moisture

Expressible moisture was determined following Szerman et al. (2012) method. Samples were run in triplicate.

2.7. Statistical analyses

A two-way ANOVA was used for evaluating the effect of the type of salt and the level of salt over burgers´ yield. The following model was used: $X_{ijk} = \mu + T_i + \beta_j + \gamma_{ij} + \quad_{ijk}$ where μ is the overall mean response, T_i is the effect due to the i-th level of factor A, β_j is the effect due to the j-th level of factor B and γ_{ij} is the effect due to any interaction between the i-th level of A and the j-th level of B. A randomized complete block design was used for the training sessions. The following model was used: $Y_{ij} = \mu + T_i + \beta_j + \quad_{ij}$, where Y_{ij} is the dependent variable, μ is the overall mean of all experimental units, β_j is the effect of block j, T_i is the effect of the treatment and $\quad_{ij}$ are the random errors. Data were evaluated with a significance level $\alpha=0.05\%$. When significant differences were found, means were compared using a Tukey test. GLM procedure of InfoStat software (2015) was used for the analysis. Data from paired comparison tests were compared with tabular data according to binomial distribution.

3. Results

3.1. Panel members' selection and training

The process began with the methods of recognition of basic tastes and ranking of solutions by salty taste intensity. Thirteen out of 30 candidates recruited for selection conformed the final group and achieved the training sessions.

The group threshold for salty taste calculated as the geometric mean of the individual thresholds was 0.27 g/l of NaCl.

3.2. Product characterisation

3.2.1. Product yield

ANOVA showed significant effect of salt level at 5% level (Table 2). Salt type effect and interaction type*level showed no significant differences ($p > 0.05$). The cooking yield averages and SD were: 89.47 ± 6.13% for 2% formulations, 79.01 ± 3.75% for 1.5% formulations and 75.64 ± 2.36 for 1% formulations. As expected, samples with a level of 2% had higher cooking yield values than samples with 1.5% ($p < 0.05$) and these, higher cooking yield values than samples with 1% because of the properties of NaCl over water retention (Ruusunen & Puolanne, 2005). The cooking yield recorded in the final product was 77.07 ± 4.31.

3.2.2. Sensory evaluation

Table 3 shows the effect that the replacement of table salt for spherical salt in lamb meat burgers had on the perception of salty taste, always offering the control sample (1.5% table salt) identified to the assessors which corresponded to a 6 on the salty perception scale according to the training sessions.

With a LSD of 0.9 no significant differences were found between control sample and that formulated with spherical salt 1% ($p > 0.05$). The samples formulated with spherical salt 1.5% and 2.5% were found to be saltier than the control sample ($p < 0.05$) which could imply a stronger salting power of the spherical salt over the table salt at the same level.

According to these results, the salt concentration interval of SODA LO™ between 1% and 1.5% was selected to analyze perceptible sensory differences in the salty taste in relation to the control sample and find out if an achievement of a sodium reduction could be possible without affecting the salty taste. Paired comparison tests were carried out between the control sample (1.5% of table salt) and four formulations of lamb meat burgers with spherical salt: 1.5, 1.3, 1.1 and 0.9% of spherical salt.

On the first paired comparison test carried out, 1.5% spherical salt burger was saltier than control burger ($p < 0.05$). On the second test, no differences were found between control sample and 1.3% spherical salt burger ($p > 0.05$) indicating these results the lack of a difference in salty taste perception between both formulations. On the third test the control sample was considered saltier than 1.1% spherical salt burger ($p < 0.05$). Due to these results, the comparison between control sample and 0.9% spherical salt formulation was not carried out.

Thus, the formulation with 1.3% of spherical salt was defined as the aim product.

3.2.3. Sodium content

Table 4 shows the results of the sodium determination of different burger formulations.

Remarkably, the sodium content of the formulation selected was 555 ± 4 mg 100g-1, representing 14.75% less sodium than the control sample. It is important to highlight that the spherical salt used contains a 6% less sodium than the table salt selected (36.30 g% vs 38.53 g% respectively). This fact allows to explain the difference between the sodium content between formulations with the same level of different salts.

3.2.4. Chemical composition

Table 5 shows the proximal composition of the final burger, formulated with 1.3% spherical salt.

Although the theoretical fat content of the burger formulation was 15% (w/w), the centesimal composition showed a lower value (12.19%). This difference could be attributed to undifferentiated connective tissue mixed with the added fat on the successive elaborations.

The fatty acids profile obtained is shown in Table 5. Main fatty acids ratios and indexes are also shown.

Regarding this topic, many studies have been focused on the improvement of fatty acid composition of meat and meat products, according to human diet requirements. On this regard, the relative amounts of polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA) seem to play a key role in a healthy and balanced diet (Pighin et al., 2016). Interestingly, results obtained in the present study show a PUFA: SFA ratio above 0.4 and a n-6 : n-3 ratio under 4. Moreover, since meat and fat of ruminants are one of the few fat sources with low levels of n-6, these products also represent an option for reducing the excessive intake of this fatty acid. It is worth noting that lamb meat from extensive production is a lean meat with a low content of saturated fat and cholesterol (García, 2004). The high content of SFA found could be associated to the addition of subcutaneous fat on the formulation. The same reason was possibly the responsible of the reduction of PUFA. SFA and MUFA contents were similar to those reported by Linares et al. (2012) in lamb leg meat burgers, but PUFA content was higher. They also reported a lower n6 : n3 ratio (0.45), and lower atherogenic index (AI) and thrombogenic indexes (0.74 and 1.00 respectively). These differences could be related to the no addition of extra subcutaneous fat in their study.

3.2.5. Consumer acceptability

Figure 1 shows the results of the hedonic test carried out with the final product (1.3% spherical salt). A high level of acceptance of the final product was obtained. The proportion of positive reviews was higher than the negative ones (85.7% vs 6.3% respectively) with 8% of neutral answers (neither like nor dislike).

5. Discussion

In relation to the 13 members panel trained, the group threshold for salty taste ¬—0.27 g/l of NaCl— was consistent with the values described by other authors. Viñas & Salvador (1998) reported a threshold of 0.21g/l achieved by the ascending method, and World Health Organization (2003) reported threshold values between 0.2 and 0.3 g/l. This result was encouraging to continue the training.

The trial in which the burgers formulated with different concentrations of spherical salt were faced against control sample hinted at the existence of a difference implying a stronger salting power of the spherical salt in relation to the table salt at least in that concentration range studied and this represented the starting point to define the working salt concentration interval —between 1% and 1.5% of spherical salt —.

Once defined the final product from the paired comparison tests developed, the sodium content determined let us confirm a reduction of 14.75% in relation to the control sample. Considering that no change in the salty perception was perceived, this point represented the most important result of our experiment. Subsequent determinations helped us characterise the product. The burger physico-chemical assessments showed similar parameters to those described for commercial burgers. Considering the cooking yield as a key feature on meat products development, it was imperative to ensure this characteristic. In lamb meat burgers Cózar et al. (2013) and Paseto Fernandes et al. (2014) reported cooking yield values between 72% and 79.9% in formulations with 1% of table salt (w/w) and between 75% and 78% in formulations with 2%. The results obtained for 2% table salt burgers in this work were even higher than those previously mentioned and the cooking yield of the final product was 77.07 ± 4.31, within the expected range. This difference could be related to the type of formulation, achieving an improvement in cooking yield when raw material of good quality is used (Cózar et al., 2013). The proximate analysis of the final burger showed a similarity to that described for Linares et al. (2012) for lamb burgers: moisture: 62.18%, protein: 17.23%, fat: 10.71% and ash: 1.91%. Both results are comparable to moisture (64%) and protein: (18%) content reported by Bender (1992) for lamb leg composition on a FAO report.

The consumer acceptability test carried out revealed an optimal position of the product to take into account at the time of a possible launch onto the market. This result is very valuable considering that the sensory appeal is the essential platform without which the product is unlikely to succeed (Lawless & Heymann, 2010).

Conclusions

A lamb meat burger with a sodium reduction of 14.75% and with no perceptible modifications in salty taste in relation to a control sample was developed by utilising a SODA LO™ salt microspheres. The trained sensory panel conformed for this purpose constituted the adequate manner for achieving our aim. Considering that reducing salt intake is an important public health target and that maintaining consumer acceptance of the products is a challenge, this development represents an example of the existence of possibilities for reducing the content and consequently the intake of sodium from this type of products.

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Table 1 Levels of table salt used in the formulation of lamb meat burgers for training sessions

Table salt (%)	Code
0	F1
1	F2
1.5	Control sample
2	F3
2.5	F4

Table 2 Two-way ANOVA results for cooking yield. n=9

Parameter	Salt type effect		Salt level effect		Type * level effect	
	F-ratio	*P*-value	*F*-ratio	*P*-value	*F*-ratio	*P*-value
Cooking Yield	1.30	0.259	48.21	<0.0001	0.51	0.601

Table 3 Salty taste perception in different formulations of lamb meat burger

Parameter	Spherical salt (%)			SEM	P-value
	1	1.5	2.5		
Salty taste perception	5.2[c]	6.9[b]	8.1[a]	0.26	<0.0001

Table 4 Means ± SD of sodium content of the lamb meat burgers according type and level of salt added (n =3)

Type of salt	Level (%)	Sodium content (mg $100g^{-1}$)
Table salt	1.5	651 ± 2
Spherical salt	1.5	612 ± 7
Spherical salt	1.3	555 ± 4

Table 5 Means ± SD of composition of the lamb meat burger with 1.3% spherical salt (n =3)

Parameters	
	mg%
Sodium	555 ± 4
	%
Moisture	67.61 ± 0.35
Protein	17.31 ± 0.88
Ash	1.55 ± 0.08
Fat	12.19 ± 0.19
Fatty acids	**g%**
SFA[a]	47.81 ± 1.03
UFA	38.79 ± 0.68
MUFA[b]	34.24 ± 0.69
PUFA[c]	4.56 ± 0.01
CLA	1.41 ± 0.19
n-3[d]	1.59 ± 0.09
n-6[e]	2.97 ± 0.08
n-6/*n*-3 ratio	1.88 ± 0.16
UFA/SFA	0.81 ± 0.12
MUFA/SFA	0.72 ± 0.01
PUFA/SFA	0.10 ± 0.01
AI[f]	0.96 ± 0.01
TI[g]	2.00 ± 0.04

a: Total saturated fatty acids, SFA (C14:0 + C16:0 + C18:0)

b: Total monounsaturated fatty acids, MUFA (C16:1 + C18:1 n-9)

c: Total polyunsaturated fatty acids

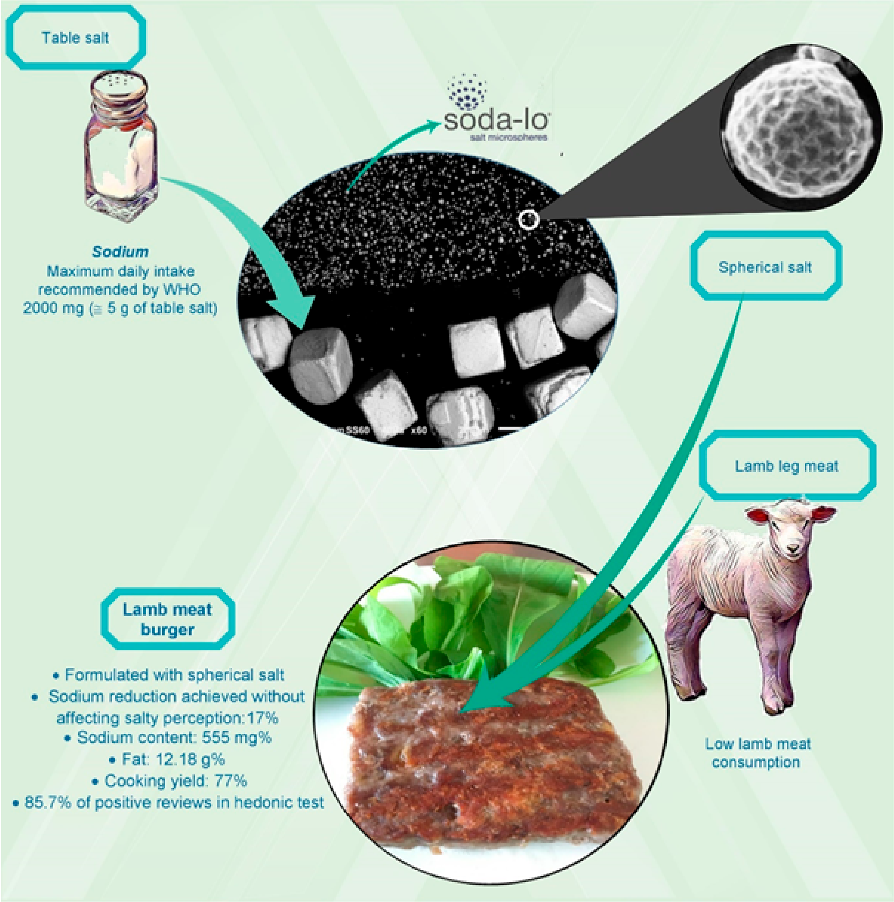
d: n-3 (C18:3 + C20:5 + C22:5 + C22:6)

e: n-6 (C18:2 + C20:3 + C20:4 + C22:4)

f: atherogenic index (4 x C14:0 + C16:0) / (MUFA + n-6 + n-3)

g: thrombogenic index (C14:0 + C16:0 + C18:0) / (0,5 . MUFA + 0,5 . n-6 + 0,5 . n-6 + 3 . n-3 + n-3/n-6)

Graphical abstract



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