HOW COULD DIFFERENT FLAVORS AND OTHER INGREDIENTS HELP IN THE SODIUM REDUCTION IN SAVORY PRODUCTS?

INTRODUCTION

Sodium chloride (NaCl), usually known as *table salt* or just *salt*, is the main source of sodium in the diet and, besides the words salt and sodium are many times used as synonyms, NaCl is composed by around 40% sodium and 60% chloride in a mass basis[1]. The amount of salt or sodium in foods is normally expressed as grams (g), milligrams (mg) or millimols (mmol), 1 g of NaCl corresponding to 0.4 g or 17 mmol of sodium[2]. Salt is a unique food ingredient that is used extensively in the culinary, at households, in food service and in food manufacturing[3]. Despite the important physiological functions that sodium plays in human body, like regulation of extracellular volume, maintenance of acid-basis equilibrium, neural transmission, renal function, cardiac flow rate and myocyte contraction[4,5,6], the intake of high amounts of this nutrient has been shown as an important risk factor for hypertension and, as a consequence, for the development of cardiovascular diseases[4,7,8,9,10,11,12]. Sodium has been therefore one of the key elements for which maximum intake levels have been established, as its average worldwide consumption is currently far above the recommendations, despite the different cultural habits[6,8,12,13]. The same scenario includes Brazil, where this study was carried out[14].

In general, the sodium naturally present in foods contributes only with about 10% of the total daily intake for this nutrient and the main percentage is originated by the salt consumption, through processed foods or salt added to home preparations or restaurant foods, depending on the population habits[9]. The reduction in the sodium daily intake has been strongly recommended by the World Health Organization to a limit of 87 mmol (equivalent to 2000 mg sodium or 5 grams salt), for adults[6]. There are some evidences, however, that suggest an even lower intake, around 1200-1500 mg/day, considering its potential impacts in public health[4]. Specific studies have been performed in many countries to diagnosing the sodium consumption and setting strategies for its consistent reduction, like the *Canadian Community Health Survey* (CCHS)[15], the INTERSALT[16,17] and INTERMAP[18,19,20,21].

However, as in the case of sugar and fat, reducing salt is a big challenge, both from the sensorial and technological perspectives, as it has a relevant impact in terms of salty taste and overall flavor, and thus in consumer acceptance, besides playing important functions in the texture, processing and preservation of many products. Additionally, salt is one of the cheapest ingredients used in food formulations[4,9,22,23,24,25,26,27,28]. Given its relevance in the formulation of foods in general, particularly in savory products, when salt is significantly reduced in a certain product, its consumer acceptance also normally decreases[29]. There are some factors other than the amount of salt itself that can influence saltiness perception, like the product´s serving temperature[30], individual´s salt taste threshold[31] and also repeated exposure to a low salt product or low salt diet[32,33]. The sodium reduction reached only through salt decrease in a certain product is limited and depends on the food matrix and the initial sodium content[23]; as a general basis, sodium reduction around 15-20% can be reached by simply reducing salt, without considerable impacts to the product´s quality and acceptance, as shown in frankfurters[34], bread[35], ready-meals[36] and soups[33,37,38].

Many different ingredients, compounds and technologies have been studied to compensate the negative impacts of salt reduction in foods, all of them having both advantages and trade-offs, and until the present not a single one has been appointed as an ideal solution. Among the most explored ingredients are acids, herbs, spices, vegetables, flavors, proteins, flavor enhancers and salt replacers, which help in the reformulation of reduced sodium products, with the aim of improving its sensory profile and consumer acceptance4,23,27,39,40. Most of those studies, however, have been focused on each single cluster of ingredients and only a few evaluated the interaction of different ones. The interaction between flavor components and taste, particularly salty taste, has been studied and the addition of some flavors to reduced-sodium products has shown to be a potential route for the improvement of overall flavour in such products[41,42].

The sensory evaluation of reduced sodium products has been done through the well-known acceptance and discriminative tests, including descriptive quantitative analysis[34,35,36,38,43,44]. Some innovative methodologies have been also developed and studied, involving emotions associated to the intake of certain foods, that could allow a broader understanding of the parameters involved in their acceptance[45,46,47,48]. It has been demonstrated, for example, that the labelling of sodium reduced processed food and the information provided before consumption can affect the consumer perception, positively or negatively, as well as their perceptions and expectations[49,50].

The first aim of this study was to determine the main attributes of an instant chicken soup impacted by its simple salt reduction at different levels; the second aim was to explore if the addition of distinct ingredients to the formulation with less salt could positively impact its sensory profile, first isolated and then in different combinations, in an attempt of recovering the attributes potentially decreased with the salt reduction. The general proposal of this research was to generate technical knowledge to support sodium reduction in other savory products, specially with the use of flavors and salt enhancers.

METHODS

Prototypes development

An instant chicken soup formulation containing 400 mg sodium/100 g ready-to-eat product (table 1), available from *Symrise Flavors and Fragrances* (São Paulo, BR), was used as the starting point for the present study. The soup preparation consisted in adding 200 mL boiling water to 20 g of powder formulation and mixing it until complete dissolution. Based on the original formulation (table 1), progressive sodium reductions were made as a first step; in a second one, different flavors, citric acid, herbs & spices and salt enhancers were added to the prototype with less sodium from the first step. In a final stage, combinations of such ingredients were added to this same formulation with less sodium, based on the learnings from the second step.

TABLE 1 - INSTANT CHICKEN SOUP FORMULATION

Ingredient	Supplier	Amount (%)
Instant corn starch Ultratex M®	Ingredion	40,00
Maltodextrin	Ingredion	27,82
Cheese flavor	Symrise	7,00
Salt	Norsal	6,55
Monosodium glutamate	Ajinomoto	5,00
Liofilized chicken breast	Liotécnica	4,00
Sugar	Guarani	3,00
Powder vegetable fat	Kievit	2,00
Chicken flavor	Symrise	1,50
Onion flavor	Symrise	1,00
Garlic flavor	Symrise	0,50
Parsley flakes	Temperart	0,50
Sylicon Dioxide	Rhodia	0,50
Turmeric poder	Temperart	0,30
Disodium inosinate	Ajinomoto	0,15
Caramel poder	Ingredion	0,15
Nutmeg poder	Temperart	0,03

Salt Reduction

From the original chicken soup formulation (called Base 1), the sodium content was reduced in 3 levels, resulting in the prototypes *Base 2*, *Base 3* and *Base 4*, with 15, 25 and 35% sodium reduction, respectively, as shown in table 2. The aim of this step was to determine the main attributes of the instant chicken soup impacted by the simple salt reduction and identify the prototype with most different sensory profile compared to the original soup, which will be the basis for the second step of the study (addition of ingredients).

TABLE 2 - PROTOTYPES WITH SODIUM REDUCTION

Prototype	Sodium content (mg/100 g RTE soup)	Sodium reduction (%)**
Base 1*	400	-
Base 2	340	15
Base 3	300	25
Base 4	260	35

**Original formulation (table 1)*
***Compared to the original formulation (table 1)*

Addition of garlic and onion flavors

On top of the formulation *Base 4*, additional amounts of the onion and garlic flavors already present in the original formulation were added, resulting in 3 prototypes:

- OG001: 50% more flavors
- OG002: 100% more flavors
- OG003: 200% more flavors

Garlic and onion are widely used in dry savory products like soups and studies have shown that they can contribute to the overall flavor in reduced sodium products[1,4,23,27,40,42,51,52,53]. In this study, garlic and onion were added as flavors, to explore if this route can show positive results as the ones obtained with powder onion and garlic. The use of flavors instead of powders can be interesting to avoid variations due to seasonality, origin, climate and shelf-life and also issues related to sourcing and quality standards.

Addition of citric acid

On top of the formulation *Base 4*, citric acid was added in 3 different levels, in order to evaluate its effect at different levels on the salty perception and overall flavor of the soup. Three prototypes were developed in this route:

- AC001: 0.02 g citric acid/20 g powder soup
- AC002: 0.03 g citric acid/20 g powder soup
- AC003: 0.04 g citric acid/20 g powder soup

Citric acid was the acidulant of choice in this study, as it is one of the most commonly used in savory products; also, it has been referred at the literature as a promising aid to compensate sodium reduction in some food products[27,54,55].

Addition of chicken flavor

From the prototype *Base 4*, two new prototypes were generated, by increasing the chicken flavor already present in the original formulation:

- ARO1: 100% extra chicken flavor;
- ARO2: 200% extra chicken flavor;

The addition of flavors is also mentioned in many studies as an important tool to improve the sensory profile of sodium reduced products[1,4,23,27,40,41,42,51,52,53]. In this study, extra amounts of chicken flavor were added, as chicken is a key cluster of attributes for this product, that presented a decrease in intensity when the sodium was reduced.

Addition of herbs and spices flavors

Different herbs & spices, in the format of natural flavors from *Symrise Flavors and Fragrances* (parsley, thyme, coriander and black pepper) were added on top of *Base 4*, resulting in 4 prototypes:

- *Parsley 01*: 0.3% parsley flavor
- *Thyme 01*: 0.18% thyme flavor
- *Coriander 01*: 0.15% coriander flavor
- *Pepper 01*: 0.4% black pepper flavor

(percentages are based on the powder soup)

The use of herbs and spices have been mentioned at the literature as promising ingredients to improve the sensory profile of reduced sodium savory products[1,4,23,27,40,42,51,52,53]. As in the case of onion and garlic, in this study, the herbs and spices notes were added in the format of flavors, to explore the potential contributions of such a route, with the benefit of avoiding variations due to seasonality, climate conditions, origin and shelf-life and also issues related to sourcing and quality standards.

Addition of salt enhancers

To the formulation *Base 4*, two different salt enhancers from *Symrise Flavors and Fragrances* were added, each one at the level recommended by the supplier for this application. Both compounds act as enhancers for salty taste and overall flavor. Two prototypes were then generated in this phase:

- *Enhancer 1* (Symlife® salt 402858): 2.31 g/ 20 g powder soup
- *Enhancer 2* (Symlife® salt 402859): 2.82 g/20 g powder soup

Many different compounds are currently available in the market worldwide, designed for reducing sodium in a variety of food goods. The main barriers for their use are, in general, high costs and potential off notes (metallic, in the case of KCl, for example)[1,4,23]. The salt enhancers used in this study were recommended by *Symrise Flavors and Fragrances*, as promising ingredients, both in terms of cost in use and sensory performance.

Addition of combined ingredients

With the results obtained in the quantitative descriptive analysis performed with the prototypes previously developed (added with the single ingredients previously described), combinations of those ingredients were then proposed and evaluated the same way. Such combinations were based on the most relevant results obtained in terms of sensory profile in the previous step, when adding the ingredients isolated. The intention was to explore the potential improvements of the adding more than one ingredient at a time. The prototypes generated in this last step were:

- *P3A* - Symlife® 402858 (2.83 g/20 g powder soup) + chicken flavor present in the original formulation (twofold the original amount)

- *P4B* - Symlife® 402859 (1.86 g/ 20 g powder soup) + onion and garlic flavors present in the original formulation (twofold the original amount of each one)

- *P5B* - Symlife® 402859 (1.86 g/20 g powder soup) + onion and garlic flavors present in the original formulation (twofold the original amount of each one) + chicken flavor present in the original formulation (twofold the original amount)

- *P6* - chicken flavor present in the original formulation (twofold the original amount) + citric acid (0.03 g de citric acid/20 g powder product);

- *P7* - chicken flavor present in the original formulation (twofold the original amount) + onion and garlic flavors present in the original formulation (double the original amount of each one)

QUANTITATIVE DESCRIPTIVE ANALYSIS

The prototypes developed in the study were all evaluated through quantitative descriptive analysis[56]. The first step was to select the assessors with the best sensory performance, based on their discriminative power, repeatability and consensus and eliminate outliers[57]; all the individuals had previous experience with quantitative descriptive analysis, as they participated in several studies at Symrise´s laboratory. A trained panel of 10 assessors from Symrise internal panel, from 25 to 40 years old, all non-smokers and with sufficient availability to take part in the sensory analysis, was selected based on classic analysis for the selection of judges[57] and in statistical multivariated analysis[58]. This final group developed a consensus vocabulary of 20 attributes, over 4 tasting sessions, using the Repertory Grid method[59] and the Symrise Global Language (Symscript®). The panelists were then submitted to a 4 training sessions, such that each panel member had the same sensory memory in relation to the anchors (minimum and maximum) of the intensity scale for each attribute. After this training phase, the prototypes developed in the study were presented to the panelists for evaluation. Samples were presented at 65ºC, in plastic cups (30 mL each sample), all coded with three- ramdom digit numbers and in balanced order, together with mineral water to clean the palate between samples.. The evaluation of the prototypes was performed in triplicate, using a 10 points line scale for each descriptor term[56,60]. All tasting sessions were carried out in the sensory laboratory, in a room with appropriate ventilation, illumination and isolation. The data from quantitative descriptive analysis was analysed through ANOVA (Variance analysis - Fischer). The significance of the average scores was tested with Tukey tests at 5% level. All the calculations were carried out using the software XLSTAT for Windows (Addinsoft, France, Version 10).

RESULTS AND DISCUSSION

During the sensory panel check, the values of P for F_{sample} and $F_{repetition}$ were within the expected values (<0.50 and >0.05, respectively), meaning both successful discriminatory power between the samples and repeatability. The results of the quantitative descriptive analysis of the prototypes developed in the different phases of the study are presented in the sequence.

Salt reduction

The sensory profile of the prototypes evaluated in this first step is shown in figure 1. As a result of the salt reduction, not only salty taste was decreased but also other attributes mainly related to chicken profile. When salt was reduced from 15% on, significant differences were noticed in comparison to the original formulation, in many of the evaluated attributes, making evident the need of reformulation to compensate these missing attributes. The prototype that presented the most different sensory profile compared to the full sodium was the one with 35% sodium reduction, so then this was the one selected as the basis for the next steps of the study. The three sequential reductions on salt level were compared to the original product. Salt reduction resulted in significant decrease in the attributes: **flavor impact, odor impact, salty taste, salty aftertaste, white meat, dark meat (Base 4), fat/skin, HVP, umami, body, condiment - garlic/ onion (Base 3 and 4), cooked, acidity (Base 4), and condiment - spice.**

As extensively reported in the literature, salt reduction in small steps is the preferred route adopted by food industry for sodium reduction[1,4,23,27,35,44,61,62], as drastic reductions represent a potential risk to consumer acceptance. Progressive salt reduction is generally efficient to reach up to 15% sodium reduction, without a big impact in quality and acceptance. More extensive reductions can be reached, providing the industry moves at the same time, allowing the consumers to get adapted to less salty foods and so changing their preference, and also using specific ingredients to help reducing sodium without compromising the product´s identity.

In the next steps, the original prototype will be called "full sodium" and the 35% sodium reduced will be referred as "reduced sodium".

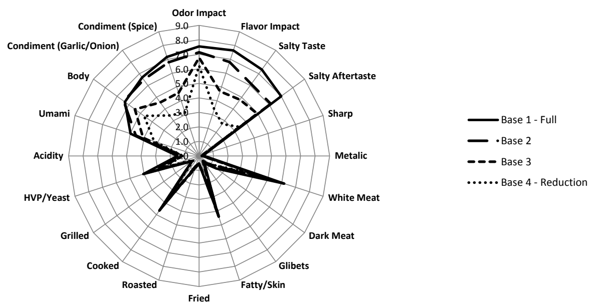

Fig.1. Sensory profile of original prototype (Base 1) and prototypes developed with salt reduction (Base 2 - 15% sodium reduction, Base 3 - 25% sodium reduction and Base 4 - 35% sodium reduction)

Addition of garlic and onion flavors

The three additional levels of onion and garlic flavors tested improved the perception of the attributes **flavor impact, salty taste** and **salty aftertaste**, compared to reduced sodium sample. In these prototypes, the effect of decreasing chicken attributes (meat profile) was also observed, as shown in figure 2. Chi & Chen[51] also evaluated the addition of garlic and onion to a reduced sodium soup, with positive results in terms of the overall profile of the product. Cook, Linforth & Taylor (2003)[63] suggested an interaction between garlic flavor and salty taste, in a way that the first one seems to enhance the second. In the present study, the use of garlic and onion flavors showed to be a good alternative to garlic and onion powders, at the light of the positive results obtained in terms of sensory profile of the reduced sodium prototype and also with the benefit of the standardized characteristics of such ingredients.

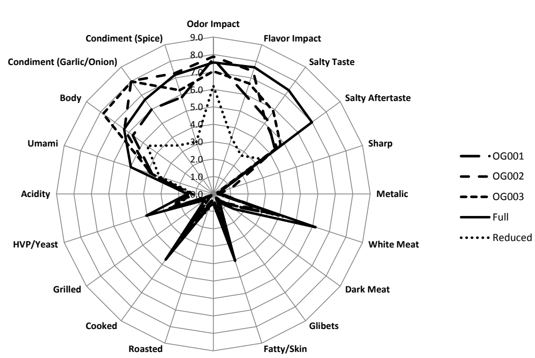

Fig.2. Sensory profile of prototypes developed with addition of onion and garlic flavors to the prototype 35% reduced in sodium

Addition of citric acid

Adding citric acid in three different levels resulted in significant differences in **flavor impact, salty taste and salty aftertaste**. The average scores obtained for these attributes were significant superior to the prototype reduced in sodium but still lower than the full sample, as presented in figure 3. Also, the addition of citric acid allowed a recovering effect of the attributes **body** and **condiment - garlic and onion** (average scores without significant difference compared to the full sodium sample and significantly higher that the ones for the reduced sodium sample).

It is suggested at the literature that the acids, despite not imparting salty taste, have the property of intensifying it and also enhancing the overall taste of a certain product, thus acting like an interesting tool to recovering some attributes lost with salt reduction[4,52,55]. Besides citric acid, other acids are also recommended at the literature, like malic, tartaric and adipic[27,54,55], what was confirmed in the present study.

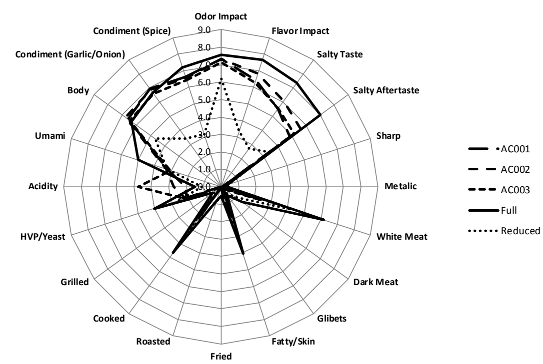

Fig.3. Sensory profile of prototypes developed with addition of citric acid to the prototype 35% reduced in sodium

Addition of chicken flavor

The same chicken flavor used in the original formulation was added in two additional dosages in order to verify whether it could improve the sensory perception, mainly in that attributes related to the chicken taste. Compared to the reduced sodium sample, both prototypes developed showed an improvement in **flavor impact, salty taste** and **salty aftertaste** but still did not achieve similar statistical performance as the full sodium sample, as presented in figure 4.

For the attributes **body** and **condiments - Garlic and onion/spices**, the prototype AR01 did not present significant difference compared to full sodium sample and, at the same time, showed significant higher scores than the reduced sodium one. However, even with the extra amounts of chicken flavor, the attributes related to meat profile could not be totally recovered.

The addition of extra amounts of chicken flavor showed to be an efficient strategy to bring back the overall flavor perception for the sodium reduced soup. Adding chicken flavor resulted in improvement not only in the overall chicken flavor, but also in the **salty taste** and other attributes such as **body** and **mouthfeel**, that had been missed when salt was reduced. However, according to this study, a more complete solution might be developed through a combination of ingredients.

The addition of flavors probably contributes to an improvement in the overall flavor of the product and also intensify the mouthfeel, thus helping to recover some of the attributes lost when reducing salt from the formulation. According to Noble (1996)[42] and Doyle & Glass (2010)[9], some tastes can intensify flavors and also the opposite, mainly when there is a logic association between than, as in the case of salty taste and savoury flavors, in the case of soups.

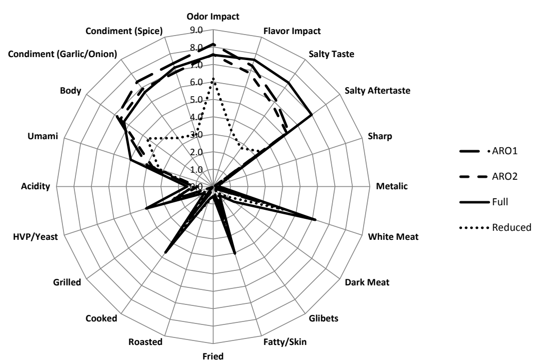

Fig.4. Sensory profile of prototypes developed with addition of extra amounts of chicken flavor to the prototype 35% reduced in sodium

Addition of herbs and spices flavors

The addition of herbs and spices natural flavors resulted in significant differences in profile, compared to the reduced sodium prototype, in the attributes **odor impact, flavor impact, salty taste, salty aftertaste and spices** (onion and garlic included) for all ingredients tested. For **odor impact,** the sample added with parsley and pepper flavors did not present significant difference when compared to the full sodium sample; for **flavor impact,** the same statistical performance of the full sodium prototype was obtained with thyme; for the attribute **sharp**, the same statistical performance was achieved by samples with parsley, thyme and coriander. For the attribute **body**, the samples that showed no significant difference from full were the ones added with parsley, coriander and pepper flavors. Figure 5 shows the performance of all ingredients tested in this study compared to the full sodium and to the reduced sodium samples. According to Doyle & Glass (2010)[9], many herbs and spices add flavor to foods and can thus contribute to the development of sodium reduced products. Such ingredients have in its composition volatile and non-volatile compounds that contribute in the intensification of the overall flavor of a certain product and also impart freshness, which can further contribute in the reformulation of reduced sodium products. Ghawi, Rowland & Methven (2014)[37] explored the use of herbs and spices (basil, cumin plus coriander and oregano) in tomato soups reduced in salt and observed an enhancement of the perception of salty taste. In the present study, it was confirmed that the addition of herbs & spices notes in the form of flavors is also a valuable tool for sodium reduction in savory products, based on the positive results obtained in the sensory profile of the reduced sodium prototype and with the benefit of the standardized characteristics of such ingredients.

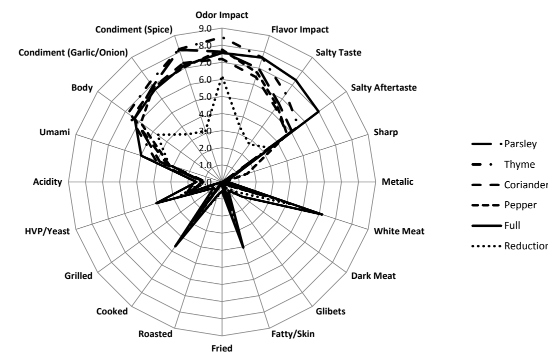

Fig.5. Sensory profile of prototypes developed with addition of herbs and spices to the prototype 35% reduced in sodium

Addition of salt enhancers

The sensory profiles of the samples produced with the two salt enhancers (Symlife® salt - Symrise) are shown in figure 6. Symlife® 1 showed an improvement in the attributes **body** and **condiment - spices**, while Symlife® 2 presented better performance in the attributes: **odor impact**, **flavor impact**, **salty taste** , **acidic** and **condiment - onion and garlic**. The scores achieved for these attributes were significantly higher than the ones for the reduced sodium sample and at the same time did not present significant difference from the full sodium sample. Regarding meat attributes, both Symlife® (1 and 2) versions tested did not achieve the same profile as the full sodium sample in the levels tested, driving the study to a design combining them with other ingredients, in order to redesign the whole formulation.

In general, the compounds used in salt reduced formulations contains potassium chloride (KCl) that can impart metallic aftertaste, according to the use level. The ingredients evaluated in this study (Symlife® salts 402858 and 402859) were specially developed in order to minimize the metallic perception and also to improve the salty taste perception, what was confirmed with the positive results achieved in this study.

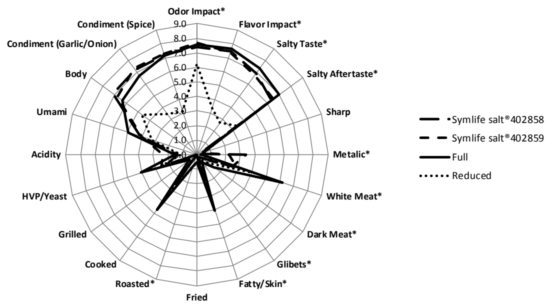

Fig.6. Sensory profile of prototypes developed with addition of two different salt enhancers to the prototype 35% reduced in sodium

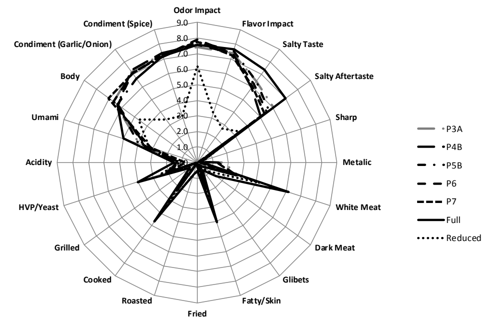

Fig.7. Sensory profile of prototypes developed with addition of different combinations of ingredients (tested at the previous steps) to the prototype 35% reduced in sodium)

Addition of combined ingredients

Regarding the attributes **odor impact** and **flavor impact**, all prototypes developed presented the same performance as the full sodium sample. On the other hand, significant superior performance was obtained compared to reduced sodium sample. Results are presented in figure 7.

The best sensory performance in **salty taste, salty aftertaste** and **salty aftertaste** was achieved with the prototypes P3A e P5B. For the attribute **metallic**, the average scores for prototypes P6 and P7 did not present significant differences compared to both the full sodium and reduced sodium prototypes. For the attributes **condiment - garlic and onion** and **condiment - spices**, none of the prototypes showed significant difference from the full sodium, but all of them presented significant higher scores compared to the reduced sodium one.

Comparing the results obtained with the different initiatives tested, both with isolated and combined ingredients, better results were achieved when prototypes contained salt enhancers (Symlife®) combined to other ingredients. The average score for the attribute **metallic** decreased when the salt enhancers were not added alone to the prototypes formulations (P3A, P4B and P5B). These results show that this can be a very good solution for salt reduced products, once metallic aftertaste is one of worst off-note related to the use of salt enhancers in general.

Symlife® combined with onion and garlic flavors (prototypes P4B e P5B) showed good **performance** in terms of **salty taste** and **salty aftertaste**, as well as prototype P5B in **flavor impact** and **odor impact.** Chicken flavor plus onion and garlic flavors (P5B) showed improved scores for the same 4 attributes previously mentioned, when compared to the effect of chicken flavor added isolated (prototype ARO1) .

CONCLUSION

Sodium reduction in foods is not a simple task, as it normally requires a considerable reduction in the amount of salt and thus affecting the product´s overall flavor, with potential impacts consumer acceptance. In the case of the instant soup evaluated in this study, it was observed that by reducing 15% of its sodium content, the resulting product was still very similar to the original one. At 25% sodium reduction, a relevant impact in sensory profile was observed and, at 35% sodium reduction, the changes were even more evident in most of the evaluated attributes, making evident the need of a reformulation to compensate such impact. All initiatives explored, with both isolated and combined ingredients, resulted in positive results in sensory profile, compared to 35% sodium reduced formulation, even though not achieving statistical similarity to the full sodium sample for all attributes measured. The flavors and salt enhancers explored particularly showed to be very useful tools in the development of sodium reduced savory products and, in the case of onion, garlic, herbs and spices, flavors can replace the original ingredients when these are not available by any reason. The use of other flavors, like chicken, onion and garlic, combined with salt enhancers allowed for a considerable reduction in metallic perception normally associated with the use of the enhancers. The current findings show that different combinations of ingredients are possible in a way to achieve the sodium levels recommended by the food regulatory and international organisms without compromising the product´s identity.

In a general perspective, the findings from this research can be useful as a basis for sodium reduction, not only for soups, but also for other savory products, like bouillons, seasonings, sauces and culinary bases and encourage the developers of such products in using combinations of ingredients as the ones explored in the present study, making broader the variety of reduced sodium products available to help consumers to reduce their total intake of this nutrient.

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