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Overall nutritional and texture analysis of ham sausages with the effects of starch

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Abstract: Ham sausage is usually considered as unhygienic and mal-nutritious food because its complicated ingredients containing high amount of starch rather than actual meat. This research mainly focuses on evaluating the effects of starch addition on taste, texture, and nutritional values of different brands of ham sausage available on market by taste testing and nutritional analysis. The analysis of nutritional content involves three indicators which are glycemic index and glycemic load, caloric contributions of starch, and the index of nutritional quantity of the overall product. The inquiry of taste testing will involve an experiment done by involving 30 volunteers to taste test each sample of ham sausage and rate the texture from four aspects: elasticity, hardness, powdery and chewiness from a scale of zero to ten. The results obtained is that sample b has received the highest scoring among all but it is not the one with the least amount of starch content, which leads to the conclusion of starch additions varied within a small amount won't possess huge impact on the texture of ham sausages.

Keywords: Sensory analysis; Texture; Nutrition.

1. Introduction

1.1. The history of ham sausages

The processed meat industry of China has been categorized into mainly two sections – western meat products and Chinese traditional meat products. Since the reform and opening, Chinese meat industry has thrived, creating significant contributions to both the economy and technology. Ham sausage, belonging to the category of western meat products, was introduced to China in 1986 by a Japanese production line. Being cheap, nutritious, and palatable all at once, ham sausage quickly became a stable consumer good of Chinese citizens. With more technological progress made, brands such as Shuanghui, Chundu, and Zhengrong emerged and quickly dominated the processed meat market. After 1996, a shuffle of brands occurred, turning Yurun, Jinluo, and Shuanghui to be the monopolies of this industry.

1.2. The classification of ham sausages

Ham sausage, specifically, can be categorized into five types according to its primary ingredient: fish flesh, pork, chicken, beef, and lamb. This research mainly focuses on sausage containing pork, which is also referred as ham sausage.

Ham sausages are further classified into granulated and emulsified ham sausages for the amount of meat pieces visible to naked eye. Granulated ham sausages have visible pieces of meat inside the casing of the ham sausages. On the other hand, emulsified ham sausages don't. Thus, they are smoother in texture within the casing of the ham sausages.

However, as ham sausage is in prevalence, unsubstantiated theories about its harms also emerge, such as the concerns on the primary source of meat being leftovers and unhygienic sources. Another concerning problem is the addition of starch. Starches are used in ham sausage to not only preserve the appearance but also ensure a consistent texture such as chewiness, elasticity, density, and hardness. However, the addition of starch in ham sausages also brought negative voices in the public and doubts. People starts to consider "starch-less" ham sausages as a better alternative.

1.3. Summary of project research

This research will focus on a scientific analysis of the taste and nutritional values of ham sausages with the effects of starch addition. To analyze the taste and texture of ham sausages, the method obtained is using inquiries and questionnaires on sensory information about the ham sausages, rating each individual sausage with different indexes and measurements. To analyze the nutrimental values, three main indicators, the Glycemic index, Glycemic load, and Index of nutritional quantity, and caloric measurements will be applied. The data of these indexes are obtained from the labels and ingredient list on the packaging of the purchased ham sausages.

2. Theoretical bases

In market, ham sausage can be labelled as premium, fine, or ordinary according to the level of starch content. The premium ham sausage includes less than 6% of starch and more than 12% of protein in its total mass. The fine ham sausage contains less than 8% of starch and more than 11% of protein. The ordinary one contains less than 10% of starch and more than 10% of protein. As starch addition gradually increases, the classification of ham sausage decreases.

Besides the starch level, flavor is one major concern. The sensory evaluations from three aspects – color, texture, and flavor – tested the texture and flavors of ham sausages, indicating which one is the most suitable of tasting. Texture is further described in hardness, chewiness, and elasticity. By first sampling three commercial sausages and taste testing the sensory details, each sample was ranked a score out of 10 on the criteria. After ranking and evaluating each type, the scores turned out that sample A received the highest rating in color (8.85 out of 10), sample B got the highest ratings in flavor and texture (8.62 and 8.82, respectively). Sample C was the highest in score of tenderness by measuring the shear value to be the lowest. However, sample C has suffered from a poorer rating of all three aspects among the samples, leading to the conclusion of less recommended to purchase. This

experiment offers a method of researching and analyzing the texture of the ham sausages with more scientific aspects of measurement.

Moreover, a previous experiment has indicated that the nutritional values of ham sausages could be represented by the index of nutrition quality (INQ). The INQ is a ratio of the nutrient-to-calorie content of foods which can be used to measure out whether a certain food or diet is nutritious or not.

3. Research methods and experiments

3.1. Nutritional analysis

The nutritional analysis of ham sausages focused on the following three values of measurement.

3.1.1. Glycemic index and the glycemic load

The glycemic index (GI) is a useful tool to measure how fast the intake raises the blood sugar level. It is defined as the change in the area under the two-hour blood glucose response curve of a person when a certain amount of carbohydrate (usually 50 grams) is consumed within 12 hours of fasting using the formula of GI = (iAUCtest food/iAUCglucose) x 100. GI is ranked on a scale of 0 to 100, from the lowest to the highest. Food with a high GI value tends to be digested faster and is effective in raising blood sugar level. For instance, the GI value of pretzels is 83, while that of peanuts is 7 . By comparing the GI value, we can generate a rough picture of the amount of carbohydrates in different intakes. The measurement of GI value comes from experiments of selecting experimenters to consume a certain type of food with known quantity, and then measure the change in blood sugar level of the contestants to determine the GI value of foods [10].

The GI value of ham sausages usually ranges between 46 to 49, whose average value is 47.5 [11]. Although this is considered as a relatively low GI value on a scale of 0 to 100, the GI value of ham sausages is significantly higher than that of pork and that of chicken. Both pork and chicken have very low GI value (nearly 0), meaning eating pork or chicken will not have a significant impact on blood sugar levels [12].

However, the GI measurement system is not perfect. Even though GI values can be an indicator of the amount of blood sugar levels, the portion size is not in consideration. An alternative to the glycemic index is the glycemic load (GL value). This value is calculated by multiplying the amount of carbohydrate in the actual serving size with the food's GI, then dived the number with 100. With regard of this calculation method, we can achieve the result of the GL value of ham sausages by following formula:

GL of ham sausages=$\frac{47.5\times 1.2g}{100} = 0.57$.

GL values of food higher than 20 is considered food with high GL, ranging from 10-20 are foods with intermediate GL, and GL value less than 10 is low GL food. Ham sausages are foods with low values of GL, which is less likely to cause type 2 diabetes (reference regarding the relationship between GL and diabetes).

3.1.2. Caloric contributions of starch

The aim of calculating the caloric contributions of starch in ham sausages is to see the main source of energy in ham sausages and obtain the conclusion of whether or not starch is the main contributor of calories among all sources of energy. The packaging of the ham sausages are not directly indicating the percentage of starch addition into the ham sausage but a rough estimation of a range (seen from the three levels: premium, fine, and ordinary). The ham sausage regarded in this part of discussion is categorized as the "premium" level, which contains less than 6% of starch. Specific calculations involve analysis of the ingredients and the nutrition of the ham sausage seen from the table 1 which includes all of the nutrients ham sausages contain.

Table 1. The nutritional contents of the ham sausages.

Nutritional elements	Amount/100g
Energy	183.9 kcal
Protein	18.0g
Fat	12.0g
Carbohydrates	1.2g
Fibers	0.0g
Sodium	900mg

The specific amount of starch is calculated by this formula:

Starch content = $Carbohydrate - fibers - sugar$ (All in grams) [13].

The actual calculation is $1.2g - 0.0g - 1.0g = 0.2g$. 1.0 gram of sugar is added to 100 grams of ham sausages. Thus, there is 0.2 grams of starch in every 100 grams of ham sausage. Each gram of starch offers the same number of calories as sugars, which are 4 calories. 0.2 grams of starch will offer 0.8 kcal to the total caloric amount, which is approximately 0.11% of the total calories in 100 grams of ham sausages. To draw conclusion, the caloric effects of starch addition to ham sausages is considered as minor, thus it is not a great contributor of whether ham sausages are high in calories or not.

3.1.3. The index of nutritional quantities

As shown above, the GI value of ham sausages and the effect of starch wasn't obvious to place it into the notorious side of the public opinion tendency. The GI and GL values often demonstrate a one-sided perspective of the food we actually consume, thus more indexes and measurements are needed. The index of nutritional quantity (INQ) can be calculated by the formula of nutritional density/energy density.

INQ is calculated in the following ways [14]:

a). Nutritional density

The nutritional density is the amount of nutrients the food serves over the amount of nutrients that humans have to eat according to the nutritional reference values.

The nutritional density of ham sausages is calculated in the following way:

All of the nutrients in 100 grams of ham sausage is shown in table 1. The nutritional density involves this chart and the nutritional reference value of the nutrients from table 2.

Table 2. The reference amount of nutrient intake of protein, fat, carbohydrates, fibers, and sodium.

Nutritional elements	**Amount/day**
Protein	60.0g
Fat	60.0g (maximum)
Carbohydrates	300g
Fibers	25g
Sodium	2000mg

The nutritional density of each nutrient is calculated in table 3.

Table 3. The nutritional density of protein, fat, carbohydrates, fibers, and sodium in ham sausages

Nutritional elements	Amount/100g	Nutritional density
Protein	18.0g	0.3
Fat	12.0g	0.2
Carbohydrates	1.2g	0.004
Fibers	0.0g	0.0
Sodium	900mg	0.45

b). The energy density

The energy density of a certain food is the calories it can provide over the standard number of calories humans consume every day.

Calculations:

$\frac{183.9}{2000} = 0.09195$

c). The index of nutritional quantity

INQ=Nutritional density/energy density.

This can be expressed in this form in table 4.

Table 4. The index of nutritional quantity of the macro nutrients in ham sausages.

Nutritional elements	Amount/100g	INQ
Protein	18.0g	3.26
Fat	12.0g	2.18
Carbohydrates	1.2g	0.04
Fibers	0.0g	0.00
Sodium	900mg	4.89

If the INQ of a certain nutrient exceeds 1.0, it is counted as abundant in this food or the diet. If the INQ is less than 1.0, it is counted as poor in this nutrient [14]. Seen from the chart above, the INQ of protein, fat, and sodium is abundant in a large quantity. However, carbohydrates are poor in ham sausages as well as vitamins and fibers. Ham sausages only contain protein, fat, carbohydrates, and sodium as its nutrients, which the complete lack of vitamins, minerals, and other nutrients such as anthocyanin and carotene is obvious. Moreover, abundance of sodium present in ham sausages is considerably high. With the consumption of no more than 300 grams of ham sausages (approximately 7-8 sticks of ham sausages), humans would exceed the standard level of sodium consumption.

3.2. Inquiry of texture with regard do starch content

This is the second part of the experiment which correlates texture of ham sausages with the amount of starch addition.

The measurements of texture have several indicators. The ones that are most closely related to the effects of starch addition are chewiness, elasticity, hardness, and powdery. Many are concerned with the addition of starch affecting the texture of the product. This concern is substantiated by an experiment of inquiry on selected population in the society. The design and procedures:

Table 5. The food labeling of all four samples of ham sausages and their respective starch to mass ratio,

Nutrients/Amount	Sample A	Sample B	Sample C	Sample D
Energy	183.9 kcal	181.9 kcal	170.0 kcal	167.1 kcal
Protein	18.0g	14.0g	11.9g	17.5g
Fat	12.0g	11.5g	8.9g	9.5g
Carbohydrate	1.2g	5.9g	10.7g	3.1g
Sodium	900mg	990mg	720mg	960mg
Starch percentage	0.2%	4.9%	9.7%	2.1%

First of all, the inquiry of starch addition is set up as a form with evaluations of the four indicators of texture and samples of ham sausages representing the four brands of selection. Sample A is from Shuanghui with the type of “Wang zhong Wang”; Sample B is from Jinluo with the type of “Run li duo”; Sample C is from Yurun with the type of also named “Wang zhong Wang”; finally, Sample D is from Jinluo’s sub type called “Wang zhong Wang”. Then, 30 participants are chosen randomly from the age group of 12-60, with the majority as working class. The participants are intended to taste the ham sausages without knowing the brand and the mass percentage of starch. Each piece of sausage is cut into 8 even cylinders with one piece approximately 1.5 centimeters in length and 2 centimeters in width. The pieces of ham sausages are placed in different plastic bags with labels of sample A, B, C, and D with each starch content of 0.2%, 4.9%, 7.9%, and 8.5%. The participants are tasting each sample differently with a rinse in mouth to prevent overlapping tasting textures. After they have tasted the ham sausages, a scoring of each ham sausage is needed. They have rated each sample from the aspects of the four indications of texture, each out of 10. In the middle of filling out the questionnaire of the texture, participants are not allowed to communicate between each other.

4. Results

4.1. Results obtained from the nutritional analysis

With the analysis of nutritional quantity from three aspects, we obtain the conclusion that starch is not a main contributor of the amount of nutrients nor the number of calories present in 100 grams of ham sausages. The caloric contribution of starch is minimal comparing to other macronutrients such as protein and fat. Also, the INQ values indicates that ham sausages are rich in protein, fat, and sodium, but poor in vitamins, minerals, and several other important nutrients such as carotene and anthocyanin. The INQ of protein, fat, and sodium highly exceeds 1.0 which is considered rich in theses nutrients, but with accordance to the ingredient list of the ingredients, no source of minerals and vitamins are provided and no carotene and anthocyanin is present. Furthermore, the amount of sodium, which mainly comes from salt added for storage, is considerably high. Consuming 100 grams of ham sausages almost meet up approximately half of the standard suggested amount of intake of sodium each day.

4.2. Results obtained from the inquiry

Sample B has received all of the highest scores among all for samples in all aspects of measurements. Sample A is the runner up among all four samples. Sample C has performed the worst in powdery, the rest of the worst being Sample D. The starch content of sample A has the lowest percentage but it hasn’t exhibited any best performances among all four. On the other hand, Sample B has the second highest starch content, but has exhibited the best performance among all three. Looking at sample C, which has the highest amount of starch, only showed the worst performance in powdery shown in figure 1.

The x-axis is the sample type, the y-axis is the scores rated from 0 to 10.

Overall, the amount of starch mass percent is not having a significant affect on the texture of ham sausages. Only powdery is affected by the mount of starch in the ham sausage. Sample C contains greatest quantity of starch in its formula,

and it has shown the worst performance in powdery. However, Sample B has the second largest quantity of starch in its formula, and still performed the best among all. Even though from this experiment, starch amount doesn't seem to be a significant factor affecting the texture, it still has some effects. The amount of starch with in each Sample doesn't have a great variation, thus minimal starch amount in ham sausages won't possess huge threats to affecting the texture of the overall product.

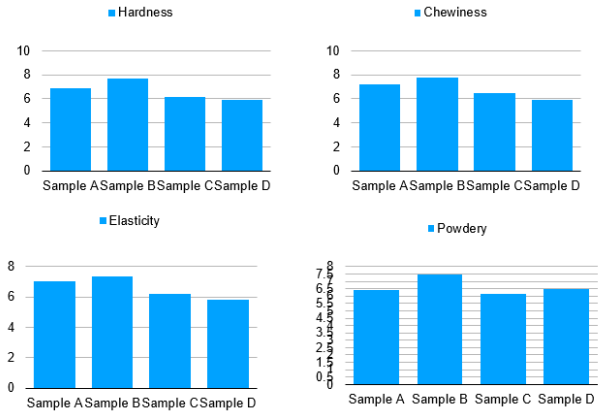

Figure 1. The scoring of the four aspects of texture of ham sausages from participants.

5. Discussions

The INQ values indicates that ham sausages are rich in protein, fat, and sodium, but poor in vitamins, minerals, and several other important nutrients such as carotene and anthocyanin. Overconsumption of ham sausages would not be recommended because of the overtake quantity of sodium, consuming less than 200 grams (approximately 5 sticks) a day would be recommended. The over consumption of sodium would lead to potential cardiovascular diseases, chronic kidney diseases, osteoporosis, and more severely cancer [15]. Furthermore, the substitution of ham sausages for major protein sources in meals is also not recommended because it is poor in other nutrients that pork, beef, chicken, fish, and lamb can provide. On the other hand, the evaluated results indicated that the nutritional values are not as little as expected by the majority. The richness in protein and fat can still provide nutritional benefits for humans. Also, with the supplements on minerals and vitamins, consuming ham sausages could provide enough protein and fat thus avoidance should not be implemented. The recommendation level of intake is about 100 grams per day not counted in meals due to its high sodium content which is about 2-3 sticks depending on brand and different masses of individual sticks. Furthermore, the results in the inquiry is not as significant as expected. The expected result would be that starch has huge significance in affecting the texture of ham sausages. Actually, the status quo is not the case. The starch percentage is showing a testable effect on the texture of ham sausages, which have shown in a range of similar starch contents, the pursuit of "starch free" or seeing the addition of starch as threats to maintain a good texture is not necessary at all.

6. Limitations

Even though the result of the experiment doesn't show a significant effect of starch content in texture, it only covers a limited amount of people and a limited number of brands. The samples selected are the brands of ham sausages are only that has the greatest commercial transition shown from e-commerce platforms among all types of ham sausages.

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