

RESEARCH ON PHOSPHORYLATED STARCH AS FOOD ADDITIVES IN PORK PIES

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ABSTRACT

This paper presents a research on an application of phosphorylated starch as food additives in producing pork /beef pies. Firstly, many characteristics of pork (beef) pies such as cohesion, gumminess, springiness, compressive strain and product quality using sensory evaluation have been investigated on experimental samples 1,2,3,4 and reference samples of small manufacturer (sample-cs) as well as Vissan (vissan). Secondly, obtained results of above parameters using the "*R-numerical analysis and graphical compilation*" indicate that the prominent properties of pork pies are gumminess, springiness and compressive strain. The most favorite sample is sample-cs, with the voting rate of about 80-90%, having nearly the same characteristics as the experimental samples. The experimental samples from 1 to 4 have the voting rate of about 70%, and this number for the vissan sample is about 20-30% with characteristics completely against the above 4 samples. From these results, the experimental programming method and optimization techniques allow us to produce safely and efficiently modified starch additives for pork pies.

1. INTRODUCTION

Pork pies are traditional food in many Asian countries, and, probably, the Vietnamese pork pies have the most sophisticated receipt and the most flavorful taste [13]. From main raw materials such as pork or beef, skilful chefs convert them into the traditional specialty [14]. In order to obtain proper texture and sensory characteristics for consumers' demand and a longer conservation period, manufacturers usually add food additives into pork pies. However, many manufacturers use borax which is not a food additive. According to investigation results of the Hochiminh Healthcare Center, pork pies have the highest percentage (68%) of total pork pie production in the market containing borax, and these figures for noodles, raw pork pies and mixed pork rice cakes are 60% - 68%, 45% and 25% respectively. Borax, a kind of sodium salt of boric acid (H_3BO_3), has the formula $Na_2B_4O_7 \cdot 10H_2O$ (sodium borate) which is a toxic chemical substance that has been banned over the world and in Vietnam. Borax is colorless, dissolvable in water and antiseptic but very noxious. When an amount of borax is injected into human beings, only 80% of the amount will be eliminated and the rest will be permanently accrued inside bodies. Hence, using a little amount of borax in a long period is as hazardous as using a large amount of borax at once [15]. Although manufacturers are aware of borax's noxiousness, they still use this substance because the final product price with borax is much lower than the price of final product with other food additives authorized by the Healthcare Ministry such as Phosphate mix, Biotas, Polyphosphate, etc. due to their high import prices. Another reason for the spreading abuse of borax is its strongly antiseptic feature and, therefore,

food products are easily preserved in a long period - which is suitable for current food product distribution conditions in Vietnam.

Phosphorylated starch, also called phosphate starch, is formed by adding phosphate groups to a starch molecule and therefore, has very different characteristics such as viscosity and high gelatinization compared to natural starch. Thus, it can be used as food additives to increase resilience, consistency, emulsification and stability of final products [11]. There have been some researches on phosphate starch and its applications in food industry. In 1999, Kharidad Humamad, et.al., at Putra Malaysia University published the paper "*Application of native and phosphorylated tapioca starches in potato starch noodle*" [10]. In 2004, Eduardo San Martin-Martinez, et.al., announced the paper "Starch phosphates products by extrusion: physical properties and influence on yogurt stability" [9]. In 2007, A.A.Karim, et.al., published their research on the effects of phosphor content on gelatinization and retro-gradation of six kinds of potato starch. Their result indicated that phosphor content decreases swell and retro-gradation of potato starch under a heating exposure [8]. In Vietnam, the work "Research on various factors affecting the modification processs of starch by phosphorylation" of Truong Minh Hanh, et.al in 2006 [4] identified optimal technical conditions to produce phosphate starch within the permitted threshold of Food and Drug Aministration (FDA).

Hence, researching on phosphate starch as food additives in pork pies to meet the sensory taste and the preservation period, to replace unauthorized additives as well as to reduce imported food additives are the necessary and urgent issue nowadays.

In the following sections, we focus on the research methodology and the following main research aspects:

- Concurrent effects of two variable factors, namely phosphate starch content and sodium benzoat content, on pork pie texture properties using the experimental programming TYT2²
 - Effects of the above factors on pork pie texture properties using the sensory evaluation
 - Processing the obtained results by using R-software to determine the most preferred pork pie property and hence, to conclude that it is feasible to replace phosphate mix with phosphate starch in pork pie receipt as well as to determine the optimal value for phosphate starch and sodium benzoat content in the receipt.
- Determining the pork pie preservation period when using sodium benzoate in the receipt.

2. RAW MATERIALS AND RESEARCH METHODOLOGY

2.1. Raw material

We make use of cassava starch of Quang Nam cassava starch manufacturer.

2.2. Chemicals and equipments

- Sodium tripolyphosphate ($\text{Na}_5\text{P}_3\text{O}_{10}$): commercial name Sodium tripolyphosphate Food Grade 90% supplied by Prayvon (France).
- Sodium Benzoate: commercial name Sodium Benzoate BP98

2.3. Research methodology

2.3.1 Method to produce phosphate starch

Natural starch, being mixed with Sodium tripolyphosphat solution, is phosphorylated at 100°C – 140°C in 90 - 150 minutes. The resulting powder mixture is cooled down at room temperature and dissolved in distilled water. It is neutralized by HCl 0.5 M and cleanly washed by distilled water many times. It is then processed by the centrifugal machine and dried at 50°C. Dried starch is crushed, sieved to obtain phosphorylated starch [3]. Phosphate starch produced by this process has a degree of substitution (DS) of P group into starch is 0,0197 which is less than the allowed threshold 0.02 of FDA [4]. Chemical and physical properties of phosphate starch are determined by many methods such as measuring viscosity by capillary viscometer, measuring water absorbability and dissovability of starch by Richter, M., S.Augustat and F.Schierbaum methods, determining acid degree of starch by total acid normalization principle using solution NaOH 0.1 N with phenolftalein indicator [3]. Heavy metal content is determined on the extreme spectrum machine CPA HH3 and HACH 8008 (detecting Fe).

2.3.2 Method to investigate phosphate content on pork pie properties

The five (5) pork pie samples were produced at a manufacturer using its own production process with main material which is lean beef and usual phosphate mix of the manufacturer was replaced by proposed phosphate starch. The phosphate starch contents of the five samples were: 0.20%, 0.27%, 0.33%, 0.40%, 0.47% (g/g pork pie) and the content of sodium benzoate was fixed at 0.093% (g/g pork pie) which is below the allowed threshold 0.1% of the Healthcare Ministry.

The typical pork pie production process is as follows:

Fat -> Shredding -> Grinding ↘

Lean -> Selecting, Shredding -> Rough Grinding -> Crushing-> Mixing -> Packaging, Binding -> Boiling -> Cooling -> Final Product -> Preservation.

Pork pie quality is evaluated by two methods:

- Determining the texture properties using Food Texture Analyse System such as cohesion, gumminess, springiness and compressive strain.
- Sensory evaluation of pork pies using consumers' preferences survey.

To determine the texture properties of pork pies by Food Texture Analyse System, we use two probe's ends to determine cohesion, gumminess and springiness of pork pies at one end, and to determine compressive strain of pork pies at the other end.

Measurement principle: we put a measured sample on the basic plate, the sample will be compressed under a compression force from the probe's end attached at the opposite die and then released. The obtained result carrying information about the texture properties of measured sample is shown on the force-path curve and force-time curve. From these curves, various parameters such as cohesion, gumminess, springiness and compressive strain will be constituted and thereafter show the texture properties of the measured sample. Each measurement was performed three times and then obtained their average values.

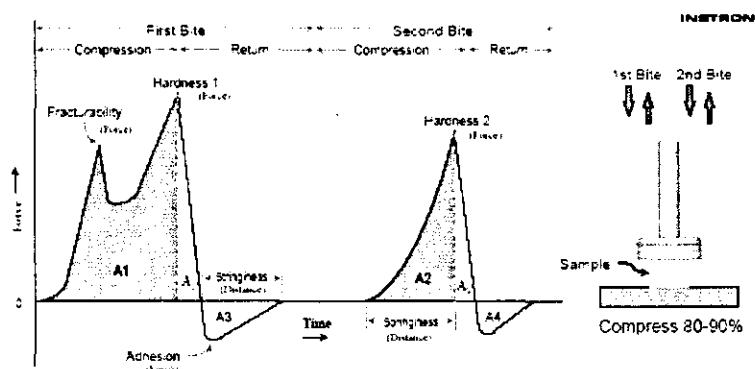


Figure 2.1. Analyzed curves describing texture properties TPA

To evaluate sensory quality, we use consumers' preferences survey [2, 7]. Experimenters, including 35 4th-year female students, 25 4th-year male students who are also regular pork pie consumers, from Industrial University were introduced a number of indexed samples and were invited to use these samples and then rated each sample through a 9-scale grade corresponding to three particular sensory tastes flavor, resilience and general taste. The grade scale is as follows: 1: Totally dislike 2: dislike a lot 3: dislike 4: relatively dislike 5: neutral 6: relatively like 7: like 8: like a lot 9: totally like. The results obtained from the experimenters were statistically examined by Fisher and Yates method.

2.3.3. Method to investigate concurrent effects of two variable factors, phosphate content and preservative Sodium Benzoate content, on pork pie texture properties and quality

We use mathematical method which is totally experimental programming TYT 2ⁿ. From this model, the seven (7) experimented samples are examined to measure the texture properties and to evaluate sensory quality. After that, we analyze the figures and graphs using R-software [6] by establishing matrix $T(m,n)$, where m denotes the 7 samples (5 samples from experimental model and 2 samples from other manufacturers), n is the measurement of the texture properties, i.e. cohesion, gumminess, springiness and compressive strain, of 7 samples as well as collecting the grades of the above 60 experimenters for 7 samples. Through R-software, matrix T is analyzed using Principal Components Analysis (PCA) combined with Preference Mapping analysis to determine the relationship between consumers' favourites and the pork pie texture properties and to classify the pork pie samples. The analyzed results will help with determining which texture properties are mostly preferred by consumers and, thereafter, the optimal content of phosphate starch and sodium benzoate in the receipt by Excel-solver.

3. RESULTS AND DISCUSSIONS

3.1. Examining on phosphate starch quality at laboratory

The obtained chemical and physical requirements, phosphor content and heavy metal contents are shown in tables 3.1 and 3.2.

Comment: Dissolvability, hydration ability, viscosity of phosphate starch is higher than cassava starch, therefore phosphate starch is able to dissolve, absorb water and create high

viscosity. Moreover, heavy metal contents are insignificant. From the P content, we could compute the degree of substitution (DS) of P group into starch is 0,0197 which is less than the allowed FDA threshold 0.02 [4]. So, we can conclude that phosphate starch completely satisfies rigorous conditions of a typical food additive.

Table 3.1. Chemical and physical characteristics of phosphate starch and raw starch

Criteria	Unit	phosphate starch	raw starch
Humidity	%	12	11,7
Acid	ml/100g starch	0,967	1
Viscosity	CSt	464,64	59,34
Water absorption	%	93, 5	25,04
Dissolvability	%	73,29	3,98
Whiteness		Less white than raw starch	White

Table 3.2. P Content and heavy metal contents of phosphate starch and raw material

Criteria	Unit	Phosphate Starch	Raw material
P(as PO_4^{3-})	mg/g	0,0372	0,0016
DS	-	0,0197	-
Zn	mg/g	0,0038	0,0032
Cd	mg/g	0,0000	0,0000
Pb	mg/g	0,0004	0,0004
Cu	mg/g	0,0006	0,0006
Fe	mg/g	0,0086	0,0086

3.2. Effects of phosphate starch content on pork pies quality

The main objective of this section is determining the optimal phosphate starch content to supplement into pork pies from the process described in 2.3.2.

The obtained results of texture properties of above five pork pies are depicted on graphs 3.1 to 3.4 showing that phosphate starch affects significantly the texture properties of pork pies. While the content is from 0.3% to 0.4%, these properties are at their good ranges; in particular, the cohesion, gumminess and springiness values are at their maxima and the compressive strain value is at its minimum.

Comment: Sample 3 and sample 4 have high grades for flavor, resilience and general taste and in particular, sample 3 has the highest grades for all three criteria. Combining with the results on figure 3.1 and 3.4, we can infer that the phosphate starch content of 0.33% yields the best pork pie quality.

The sensory evaluation results (section 2.3) are depicted in figure 3.5

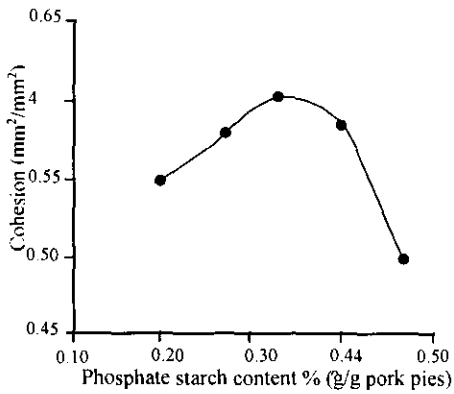


Figure 3.1. Effects of phosphate starch content on the cohesion of pork pies

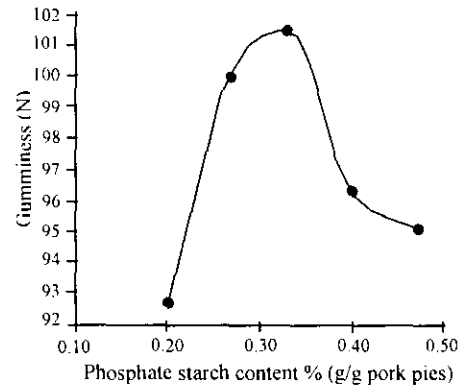


Figure 3.2. Effects of phosphate starch content on the gumminess of pork pies

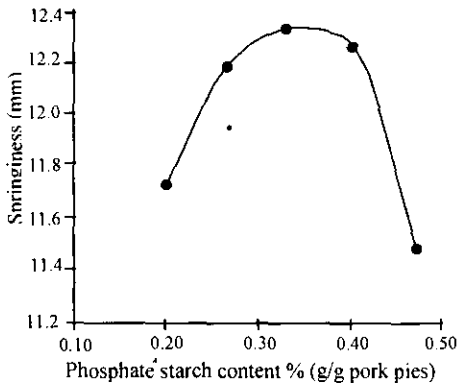


Figure 3.3. Effects of phosphate starch content on the springiness of pork pies

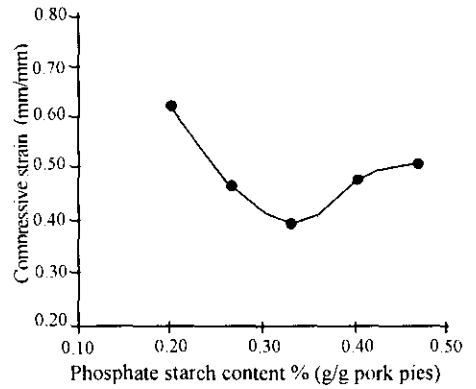


Figure 3.4. Effects of phosphate starch content on the compressive strain of pork pies

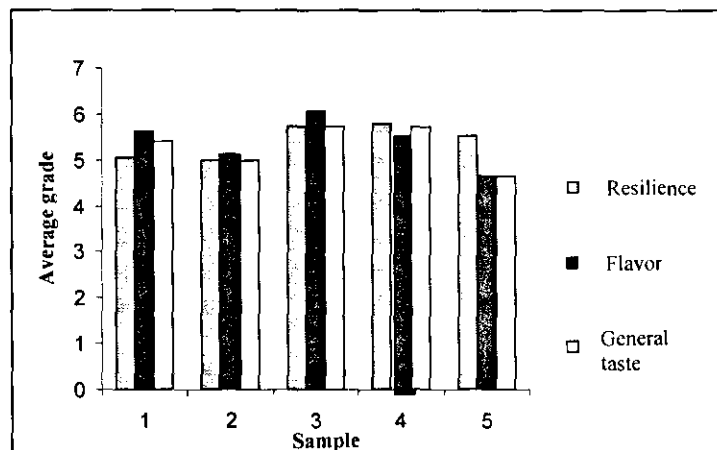


Figure 3.5. Graph of consumers' favourite according to average grade

3.3. Concurrent effects of variable phosphate starch content and sodium benzoate content on texture properties of pork pies using experimental programming TYT²

After examining the effects of phosphate starch content on texture of pork pies, we carried out the examination effects of combined variable phosphate starch content and sodium benzoate content on pork pie texture properties. The following properties are considered, Y₁ (cohesion mm²/mm²), Y₂ (gumminess, N), Y₃ (springiness, mm), Y₄ (compressive strain, mm/mm). The ranges of these properties are chosen from table 3.3 while the *basic values* are chosen from result of section 3.2 (phosphate content 0.33% and sodium benzoate 0.093%)

Table 3.3. Range of properties

Range	Properties			
	X ₁ , % (g/g pork pie)	Underivative	X ₂ , % (g/g pork pie)	Underivative
Basic range X _j ⁰	0.33	0	0.093	0
Variation range λ _j	0.13		0.067	
Upper range (+)	0.47	+	0.160	+
Lower range (-)	0.20	-	0.027	-

Result of experimental model and experiments are shown in table 3.4

Table 3.4. Experimental model TYT² and Measured results

No.	x ₀	x ₁	x ₂	X ₁ (%)	X ₂ (%)	Y ₁ (mm ² /mm ²)	Y ₂ (N)	Y ₃ (mm)	Y ₄ (mm/mm)
1	+	+	+	0.47	0.160	0.58878	110.54751	12.91728	0.48362
2	+	+	-	0.47	0.027	0.57915	111.13105	12.28128	0.46999
3	+	-	+	0.20	0.160	0.70608	110.75428	12.01296	0.46666
4	+	-	-	0.20	0.027	0.58265	103.47523	12.10923	0.47999
T ₁	+	0	0	0.33	0.093	0.59047	85.78221	12.17207	0.51333
T ₂	+	0	0	0.33	0.093	0.58736	87.13068	12.05039	0.57333
T ₃	+	0	0	0.33	0.093	0.56598	85.72169	12.05039	0.44999

The obtained recurrent equation describing effects of various factors on pork pie texture as following:

$$Y_i = b_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2$$

where: Y_i: function describing cohesion, gumminess, springiness and compression; b₀, b₁, b₂, b₁₂: coefficients of recurrent equation; x₁, x₂: variables describing contents of phosphate and sodium benzoate.

After computing and checking the meanings of coefficients b using the Student t -distribution as well as checking the compability of equations using Fisher F -distribution, the obtained recurent equations are as following:

$$Y_1 = 0,6141 - 0,0302 x_1 + 0,0332 x_2 \quad (3.1)$$

$$Y_2 = 108,9770 + 1,8623 x_1 - 1,9657 x_1 x_2 \quad (3.2)$$

$$Y_3 = 12,3302 + 0,2691 x_1 + 0,1831 x_1 x_2 \quad (3.3)$$

$$Y_4 = 0,4750 + 0,1594 x_1 x_2 \quad (3.4)$$

3.4. Concurrent effects of variable phosphate starch content and sodium benzoate content on pork pie quality based on consumers' preference survey

From equations 3.1 to 3.4, we can analyze various factors having effects on texture properties of pork pie and optimize the above two substances such that these texture properties achieve their optimal values. However, an open question is which properties have higher priority out of the above four criteria.

Therefore, in this section, we carry out sensory evaluation of samples in model of table 3.4. There are 7 samples and 5 out of these from model 3.4 indexed as sample 1 to sample 5, one sample from Vissan indexed as vissan and 1 sample from private manufacturer indexed as sample-cs. The sample-cs is put phosphate mix instead of phosphate starch in the same production process.

The survey method and the number of experimenters are as same as section 3.2. The processed results are plotted in graph 3.6

Comment: Results on graph 3.6 shows that sample 3 has the highest scores for all criteria and nearly as same as those values for sample-cs which is prominent for its general taste and resilience. Vissan sample and sample 5 have lowest average score. Hence, the experiments verify that the quality of sample 3 with phosphate starch is as equivalent as the quality of sample-cs with phosphate mix.

However, these results do not indicate clearly the relationship between the texture property measurements and sensory evaluation. Therefore, we continue to analyze the obtained numerical results using R-software to identify consumers' favourite taste.

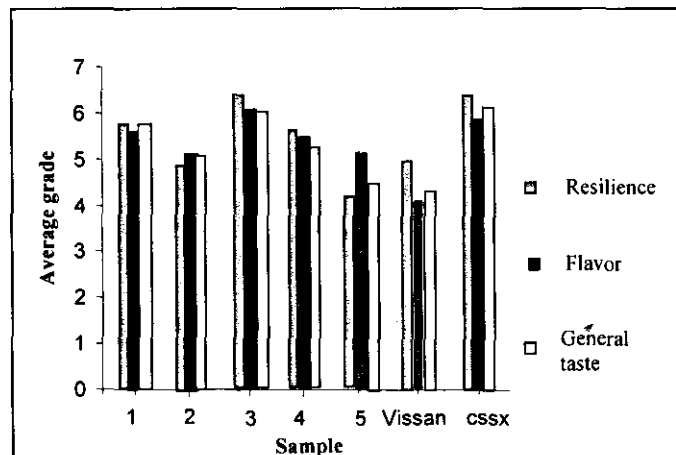


Figure 3.6 Graph describing consumers' vote based on average grade

3.5. Numerical analys using R-software

- Analyzed results by PCA

Analyzed results by PCA are depicted in figure 3.7 and 3.8.

The analyzed result by PCA on figure 3.7 shows that on the first major plane (including two major components PC 1 and 2 describing 87% of information), sample 1, sample 5, vissan and sample-cs are well plotted. The positions, which are near the center of the coordinate system 1 and 2, of sample 2, 3, 4 indicate that these samples are not clearly plotted on the first major plane. Vissan and sample-cs having opposite position with sample 1, 2 and 4. Sample 5 does not have any close relationship with the other investigated samples.

Figure 3.8 shows the texture properties of seven samples are well plotted on the first major plane of relative circle. The axe 1 (PC1) with deviation 58.82% could be considered as characteristic axe of gumminess. Axe 2 (PC 2) with deviation 28.1% characterizes for springiness. Cohesion and compressive strain are two properties that are not clearly described on the plane 1.

To determine the characteristics of the investigated samples, combining figure 3.7 and 3.8, we can classify the 7 sample as follows:

The first group consists of sample 3 and sample-cs charactized by cohesion; the second group includes sample 1,2 and 4 characterized by gumminess and springiness; the third group consists of only sample 5 characterized by comprehensive strain and the remaining fourth group contains only Vissan (figure 3.9) which is not characterized by any investigated property. So, most of our investigated samples are targeted into the second group which is preferred mostly due to springiness and gumminess.

- Analyzed Preference Mapping results

The sample favourite level according to consumers' favourite is expressed in figure 3.9. Most of our investigated samples are in 70% intrest region which are sample 1,2,3 and 4 while sample 5 is in 40% interest region. The sample-cs of private maunufaturer is in the most favourite interest region of 80% while the vissan is in 30% interest region.

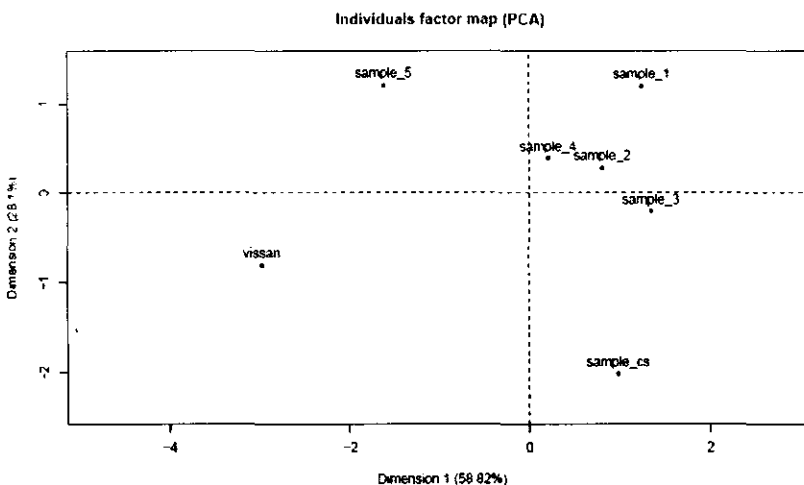


Figure 3.7. Projections of samples on first major plane (deviation of axe 1 – PC1: 58.82%, deviation of axe 2 –PC2: 28.1)

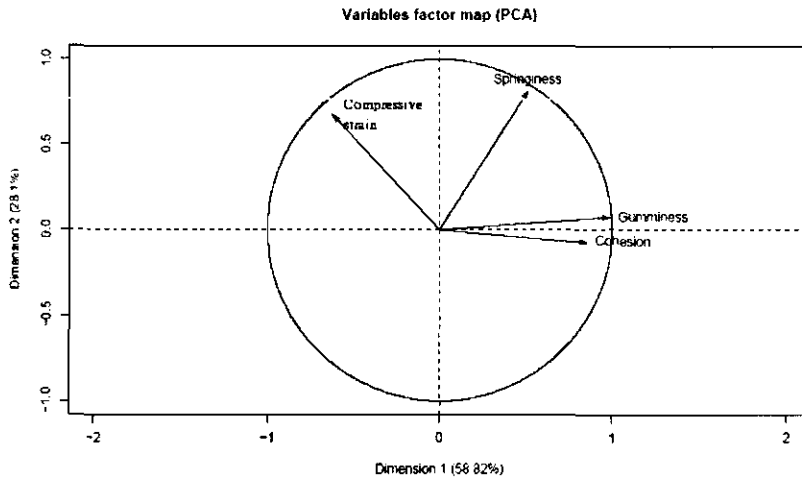


Figure 3.8. Relative circle and projects of texture properties of pork pie samples on the first major plane

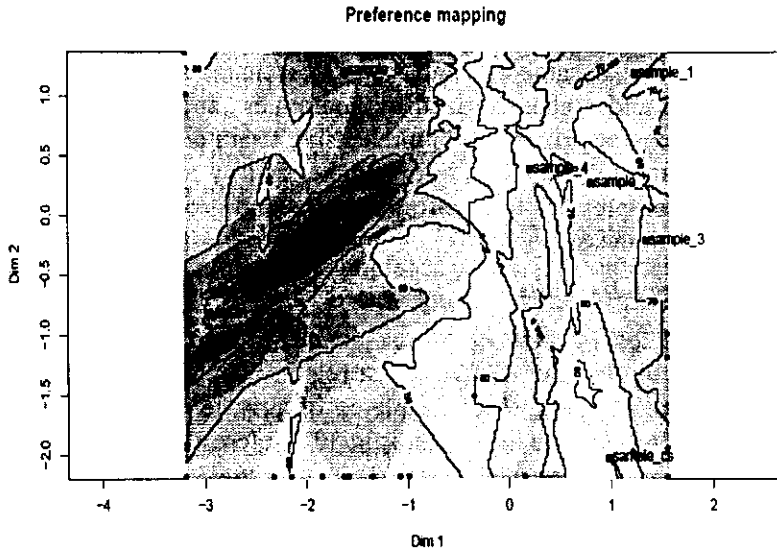


Figure 3.9. Interest region map of consumers

3.6. Optimization of phosphate starch and sodium benzoate content based on consumers' demands using Excel-Solver

Reviewing the analysis in figure 3.9, we carried on optimizing phosphate starch and sodium benzoate content which meet the consumers' demands using Solver tool with the following cost function:

$Y_1 \rightarrow \max$; $Y_2 \rightarrow \max$; $Y_3 \rightarrow \max$; $Y_4 \rightarrow \min$ with constrained equation sodium benzoate content below 0.1% We obtained the results emphasizing two conclusions:

- If the product aligns with the first group, such as sample 3 and sample-cs, characterized by cohesion, the corresponding phosphate starch and sodium benzoate contents per 1 kg of pork pie is 0.20% and 0.093%.

• If the product aligns with the second group, characterized by springiness and gumminess, the corresponding phosphate starch and sodium benzoate contents per 1 kg of pork pie is 0.47% and 0.027% or 0.47% and 0.099%

3.7. Determining the pork pie preservation period

In order to verify microbiological quality of pork pies, we determined the total number of microorganisms of each sample with the above optimal phosphate starch and sodium benzoate content (section 3.6) 0.47% and 0.027% respectively. The obtained result indicates that the pork pie sample could be preserved at room temperature for 3 days and at 5 - 7°C for two weeks.

4. CONCLUSION

In sum, phosphate starch has degree of substitution of phosphate root $DS = 0.0197$, according to FDA standard of the U.S.A (≤ 0.02), and very low metal content. So, phosphate starch meets the rigorous requirements to become a typical of food additive. We proved that the pork pie quality with phosphate starch is equivalent to the quality with phosphate mix. Thus, phosphate starch could replace phosphate mix.

We have established the recurrent equations describing the effects of phosphate starch content and sodium benzoate content on pork pie quality with the parameters cohesion, gumminess, springiness and compressive strain.

Thereafter, we optimized the phosphate starch content and sodium benzoate content according consumers' preferences using R-software and Excel cover. In particular:

- To produce pork pie being characterized by cohesion, the food additive for one kg is: phosphate starch content of 0.20% and sodium benzoate content of 0.093%

- To produce pork pie being characterized by gumminess and springiness, the food additive for one kg is: either phosphate starch content of 0.47% and sodium benzoate content of 0.099% or phosphate starch content of 0.47% and sodium benzoate content of 0.027%

Finally, the pork pie with the last combination of phosphate starch and sodium benzoate as above can be kept at room temperature for 2 to 3 days and at 5°C for 7 days.

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REFERENCES

1. Nguyễn Cảnh - Quy hoạch thực nghiệm, Trường Đại học Bách khoa TP. Hồ Chí Minh, 1993.
2. Nguyễn Hoàng Dũng- Thực hành đánh giá cảm quan, Nhà xuất bản Đại học Quốc gia, Thành phố Hồ Chí Minh, 2006.
3. Trương Thị Minh Hạnh - Nghiên cứu các dạng biến hình tinh bột hoa màu và ứng dụng trong công nghiệp thực phẩm, Luận án Tiến sĩ Kỹ thuật, Đà Nẵng, 2003.
4. Trương Thị Minh Hạnh, Nguyễn Thị Hoài Tâm - Nghiên cứu các yếu tố ảnh hưởng đến quá trình tinh bột bằng phương pháp phosphoryl hóa, Tuyển tập các bài báo khoa học, Hội nghị khoa học lần thứ 20, Phân ban Công nghệ Sinh học - TP, Kỷ niệm 50 năm trường Đại học Bách khoa Hà Nội, 2006, tr. 75-79.

5. Lê Ngọc Tú (chủ biên), Bùi Đức Hợi, Lưu Duẩn, Ngô Hữu Hợp, Đặng Thị Thu, Nguyễn Trọng Căn - Hoá học thực phẩm, Nhà xuất bản Khoa học và Kỹ thuật, Hà Nội, 1999.
6. Nguyễn Văn Tuấn - Phân tích số liệu và biểu đồ bằng R, Nhà xuất bản Khoa học và Kỹ thuật, Hà Nội, 2006.
7. Hà Duyên Tư - Kỹ thuật phân tích cảm quan, Tổng cục tiêu chuẩn đo lường chất lượng, Hà Nội, 1991.
8. A. A. Karim, L. C. Toon, V. P. L. Lee, W. Y. Ong, A. Fazilah, and T. Noda - Effects of phosphorus content on the Gelatinization and Retrogradation of potato starch, Journal of food science 72 (2) (2007).
9. Eduardo San Martin-Martinez, Miguel A. Aguitar-Méndez, T. Espinosa-Solares, Reynaldo C. Pless, Z. Delia Quintana - Starch phosphates products by extrusion: physical properties and influence on yogurt stability, Starch 56, Mexico, 2004, pp.199-207.
10. Kharid Muhamad, Feri Kusanandar, Dzulkifly Mat Hashim, and Russhy Abd.Rahman - Application of native and phosphorylated tapioca starches in potato starch noodle, International Journal of Food Science and Technology 34 (1999) 275-280.
11. O. B. Wurzburg - MS, Modified Starch: Properties and Uses, CRC Press, Inc. Boca Raton, Florida, 1986.
12. [<http://www.suutap.com/HuongViQueHuong/default.asp?id=715&nhom=2&so=17&trang=1>]
13. irv.moi.gov.vn/News/PrintView.aspx?ID=14469 - 11k -
14. (http://www.hatay.gov.vn/general_detail.asp?id=233&catid=LICHSU)
15. <http://www.vietnamnet.vn/khoahoc/suckhoe/2006/01/531629/>

TÓM TẮT

NGHIÊN CỨU ỨNG DỤNG TINH BỘT PHOSPHAT LÀM PHỤ GIA SẢN XUẤT GIÒ CHẢ

Bài báo này trình bày kết quả ứng dụng tinh bột phosphat làm phụ gia trong sản xuất giò chả. Các tính chất cấu trúc của giò chả như độ cố kết (cohesiveness), độ kết dính (gumminess), độ đàn hồi (springiness), độ nén ép (compression) và chất lượng sản phẩm đánh giá bằng phương pháp cảm quan thị hiếu đã được khảo sát trên các mẫu thí nghiệm sample 1,2,3,4,5 và 2 mẫu đối chứng là mẫu của cơ sở sản xuất (sample-cs) và mẫu của vissan (vissan). Kết quả phân tích bằng phần mềm R cho thấy các tính chất rất đặc trưng của các mẫu giò chả nghiên cứu là độ kết dính (gumminess), độ đàn hồi (springiness) và độ nén ép (compression). Mẫu ưa thích nhất là mẫu sample-cs chiếm tỉ lệ trong khoảng 80% - 90% có tính chất khá gần với các mẫu đem thí nghiệm. Các mẫu thí nghiệm từ sample 1 đến 4 được ưa thích trong khoảng 70%, còn mẫu vissan chỉ trong khoảng 20% - 30% có tính chất hoàn toàn đối lập với 4 mẫu nói trên. Kết hợp với xử lý số liệu bằng phương pháp qui hoạch thực nghiệm và tối ưu hóa, cho phép sản xuất một phụ gia từ tinh bột biến hình sử dụng cho giò chả một cách an toàn và hiệu quả.

Địa chỉ:

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