2025 年【科學探究競賽-這樣教我就懂】

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Title: Bubbleology: The Starch Effect

I. Abstract

This research focuses on how the different properties of starches influence their taste. We took the ratio of the content of linear starch and branched-chain starch, gelatinization characteristics as the research entry points. To reach this point, we conducted a simplified elasticity experiment and toughness experiment, and analyzed the curvilinear relationship between these physical properties. The study found that the above factors will cause bubbles to show different gelation states and retrogradation properties, which will significantly affect their elasticity and toughness, impacting overall mouthfeel. Finally, we carried out a big data statistical survey, which showed that bubbles made of pure cassava starch are still the most popular.

(本次研究中，我們將聚焦於珍珠的性質對其口感產生的影響，以**直鏈澱粉和支鏈澱粉含量比例**、**凝膠化特性**等方面為研究切入點，探究何種澱粉製成的珍珠口感最好。我們設計了簡單的**韌性實驗**和**彈性實驗,並分析其中的曲線關係**。研究發現，以上因素均會導致不同的凝膠化狀態和抗回生性，從而導致口感不同。最後，我們進行**大數據統計調查**，結果顯示，呈現最佳口感，獲得大多數受試者青睞。)

II. Research topic and motivation

The wide variety of starches used to make bubbles on the market leads to significant differences in their texture, elasticity, overall taste. By studying the molecular structure of amylose and amylopectin and their performance in the gelation process, we hope to explore how different starches affect their elasticity and toughness in making bubbles, and further analyze the possibility of mixed starch ratio to improve taste.

III. Research purpose and hypotheses

Research Purpose:

A. Analyze and observe the appearances of bubbles made under the same cooking conditions

B. Test the physical properties of bubbles made of different starches

C. Analyze the causes of its formation from the molecular structure

D. To explore the taste of bubbles with different proportions of mixed starch

Hypotheses:

A. The amylose-to-amylopectin ratio is the primary factor affecting the texture of bubbles.

B. The gelatinization properties of starch influence the texture after cooking.

C. Differences in nutritional composition alter starch retrogradation, leading to variations in bubble texture.

D. Mixed starches in specific ratios can optimize the overall texture of bubbles.

IV. Research methods and verification steps

(I) The process of making equipment:

A. Bubble Holding Container:

Use B-7000 adhesive to attach a petri dish to the outer lower measuring jaw of the vernier caliper. Petri Dishes (Diameter 60mm)

B. Force Application Surface:

Attach two 5g weights and an acrylic plate to the outer upper measuring jaw of the vernier caliper using B-7000 adhesive.

C. Data Recordings

(A) Vernier Caliper:

Record the pressing and rebound distances

(B) Electronic Scale:

Measure the applied force and reflect the natural state (reading set to zero initially).

Figure 1:The Experimental Equipment

(II)Physical property determination experiment

Experiment I—Experiment of elastic recovery and rebound properties

A. Conducting the Experiment:

(A) Evenly spread 15 bubbles in the petri dish, cover them with the acrylic plate and set the vernier caliper to zero.

(B)Place the setup on the electronic scale (already zeroed), and vertically compress the bubbles until deformed by 5.0mm. Hold the pressure for 5 seconds.

(C)Observe the stabilized caliper readings and record the pressing and rebound values, the force value from the electronic scale (taking the most frequent value), and the rebound time.

(D) Repeat the experiment 5 times and record the data.

B. Retrogradation time curves of various starches

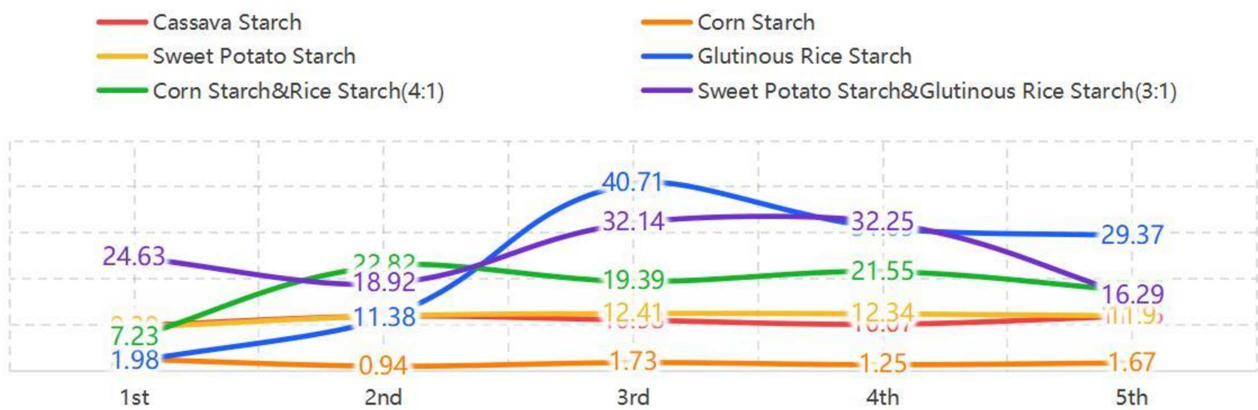

Figure 2: Retrogradation Time Curves of Various Starches

From the figure 2,the rebound time reflects the elastic recovery ability of the bubble's gel structure.Different curves indicate variations in the internal structure of gels formed by different starches. Gels with good elasticity, stable structures, and moderate stickiness are prone to quickly returning to their original shape. In contrast, starches with longer rebound times have gels with poorer elasticity or excessive viscosity, leading to slower recovery.

C. Mean force curves of various starches

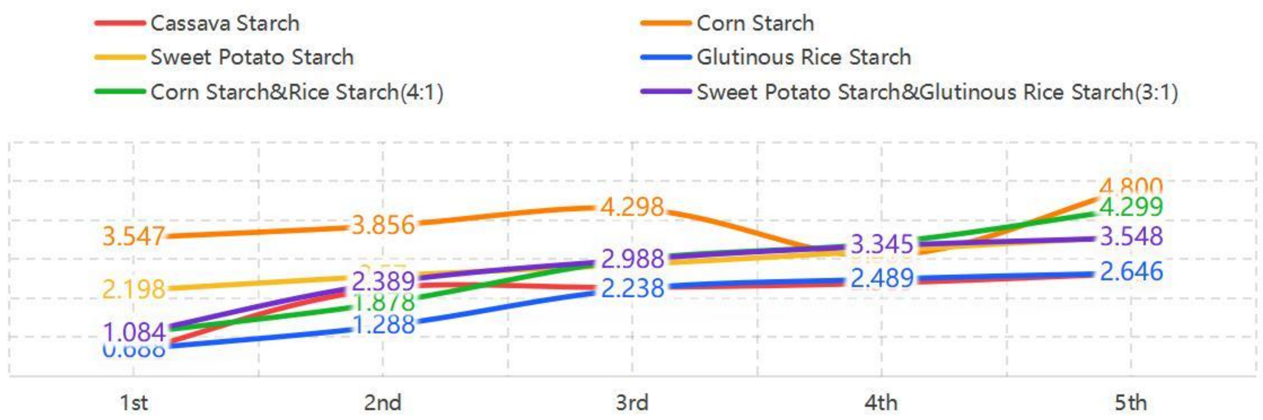

Figure 3: Mean Force Curves of Various Starches

From the figure 3, it can be observed that the average applied force increases with the number of presses. This is because, during the compression process, the intermolecular distances within the bubbles continuously decrease, causing the attractive and repulsive forces to gradually increase, so greater force is required to overcome the intermolecular interactions. As the number of presses increases, the internal structure of the bubble is gradually damaged, which leads to the onset of plastic deformation. Additionally, each press expels more air from inside the bubble.

D. Deformation profiles of various starches

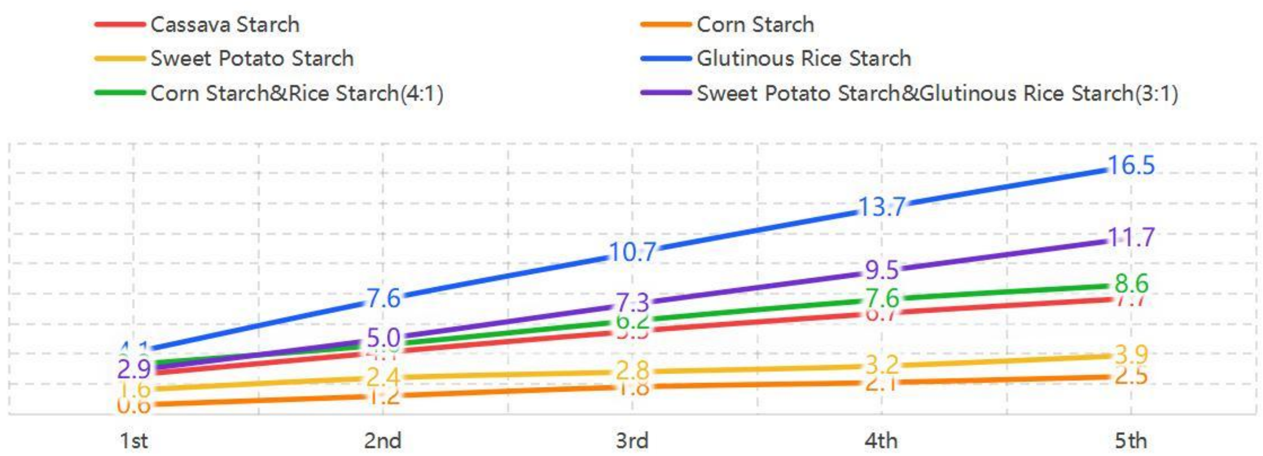

Figure 4: Deformation Profiles of Various Starches

From the figure 4,the chart shows that the deformation curves of bubbles made from different starches follow a similar trend. Glutinous rice starch is almost entirely composed of amylopectin, whose molecular chains can easily slide and shift under external pressure, allowing for a greater degree of deformation to adapt to the applied force. On the contrary, corn starch contains a higher proportion of amylose, where molecular chains are bound together by hydrogen bonds and other forces, which makes it more difficult for molecular chains to slide under external pressure. It allows bubbles made from corn starch to better resist deformation.

Experiment II—Deformation Resistance and Toughness Metrics Measurement Experiment

A. Conducting the Experiment

(A)Place 6 bubbles evenly in the center of a Petri dish, cover them with an acrylic plate, and zero the vernier caliper.

(B)Place the setup on an electronic scale (already zeroed) and apply the same amount of force, maintaining steady pressure for 5 seconds.

(C)Repeat the experiment multiple times and record the peak force value (toughness limit) on the electronic scale when the bubbles break.

B. Toughness experimental data

Table 1 :Toughness Experiment Data

Table of Measurement Results for Deformation Resistance and Toughness Indicators of Various Starch			
Item / No of Trials	rebounds or not	the reading of vernier caliper	rebound amount
Tapioca Starch	☑	11.3mm	5.8mm
Corn Starch	☒	9.8mm	-
Sweet Potato Starch	☒	12.2mm	-
Glutinous Rice Starch	☒	4.1mm	-
Corn Starch&Rice Starch(4:1)	☑	13.1mm	1.9mm
Sweet Potato Starch&Glutinous Rice Starch(3:1)	☑	11.4mm	2.4mm

From the table 1,bubbles made from glutinous rice starch are excessively sticky and do not break under the same applied force, but they also do not rebound. Bubbles made from sweet potato starch and corn starch have lower stickiness and form less stable gel structures. This results in poor toughness and breaking during force application.

Bubbles made from cassava starch and mixed starches still exhibit rebound, with those made from cassava starch demonstrating the best rebound performance.

(III)Molecular structure analysis

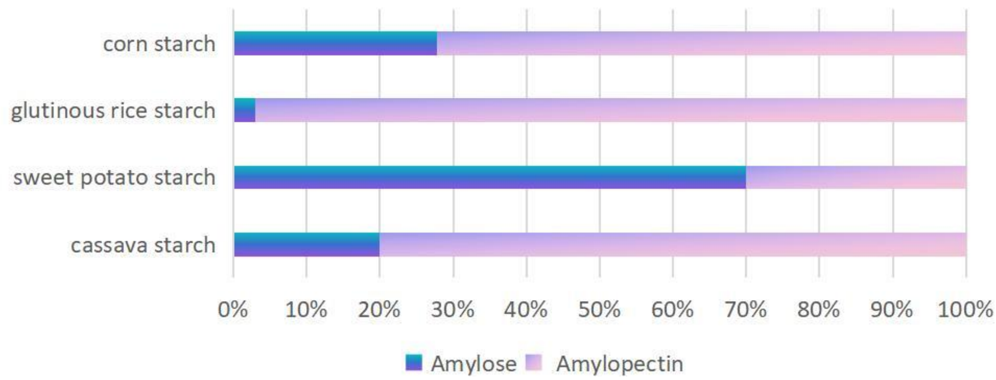

Figure 5: The Content of Amylose and Amylopectin in the Four Types of Starches

A. The amylose-to-amylopectin ratio

From the figure 5,in the molecular structure of starch, amylose is formed by glucose with α-1, 4-glucoside bond, and shows a linear structure. On the basis of the α-1,4-glucoside bond, there are also α-1,6-glucoside bonds in amylopectin, which form a branched tree structure. The differences directly determine the basic physical and chemical properties of starches.

Due to the high content of amylopectin in cassava starch, a strong and elastic gel network structure will be formed. The taste is smooth and chewy, and capable of withstanding pressure without being easily broken .

The content of glutinous rice starch is almost all amylopectin. Amylopectin molecules are branched and always form a tight and viscous gel network structure. In the gelatinization process, these connections interact with each other to form a network to hold a lot of water, making the bubbles soft and sticky. Because of its tight,its elasticity is weaker than cassava starch.

The content of amylose in corn starch is relatively high. The cross-linking points are few so that the network structure is loose when the gel network is formed. Therefore, bubbles made of corn starch have poor elasticity and viscosity, leading to their hard taste, lack of chewy, and easy to break during chewing.

B. Gelatinization profiles of various starches

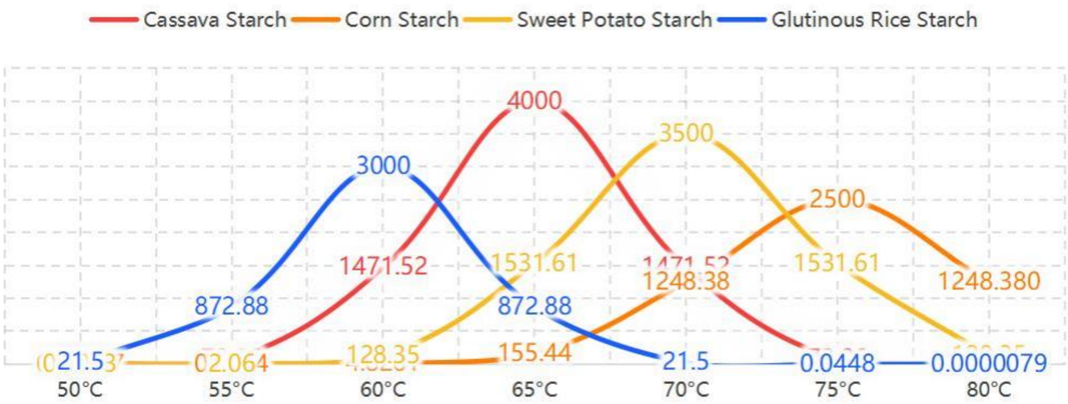

Figure 6: Gelatinization Profiles of Various Starches

From the figure 6,the ratio of amylose and amylopectin in cassava starch is moderate, and the gelation temperature is generally 59-70℃. The gel structure formed after gelation is compact and has certain elasticity and toughness. After cooking, the taste is more resilient and chewy.

The amylose content in corn starch is relatively high, and the gelation temperature is usually 62-72℃. Gelation requires a higher temperature, a longer time, greater gel strength, and lower transparency. So the taste is thick and solid, with a certain powder texture, which is prone to recovering after cooling and becomes more dry and hard.

The amylose content of sweet potato starch is also higher, and the gelation temperature is generally above 70℃. High strength gel structure but weak elasticity will be formed after gelation. The taste of sweet potato bubble after cooking is not as obvious as cassava toughness,but has a more dense mouthfeel, sometimes there are some filaments.

The content of glutinous rice starch is almost amylopectin, so the gelation temperature is low, generally 55-65℃. After gelation, a very soft, viscous and elastic gel structure. will be formed so that the taste is soft and sticky with strong stickiness.

(IV)**Big data survey**

From the figure 7,this study employed a questionnaire survey method to evaluate the taste of bubbles, involving 20 faculty members and 80 students. The statistical results show that approximately 80% of respondents rated the bubbles made from cassava starch 4 or higher out of 5, which indicates that they best match consumer preferences.

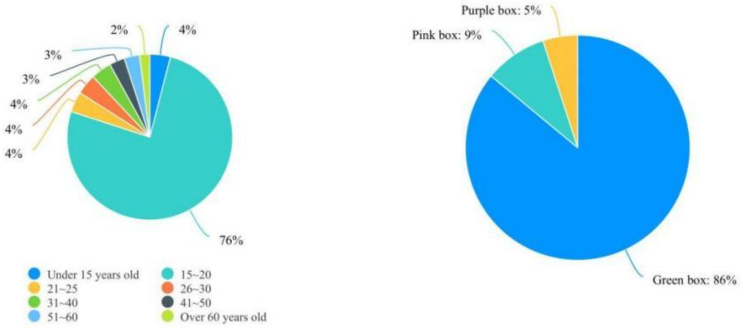

Figure 7: Age Distribution Chart and Taste Preference Chart

V. Conclusions and life application:

(I)Conclusion and life application:

This experiment aimed to explore the factors affecting the properties and texture of starch. The amylose-to-amylopectin ratio is indeed one of the factors influencing starch properties and texture, but it is not the primary determinant.

During the gelatinization process, the intrinsic gelatinization properties significantly influence the gel network structure. This structure affects the molecular connection points during gelatinization, and leads to differences in elasticity and resilience after cooking.

In summary, the properties and texture of starch are influenced by multiple factors. In practical applications, it is essential to consider these factors comprehensively to achieve the desired texture.

(II)Future Prospects

In the future, we will continuously investigate the effects of adding edible agents or adjusting nutritional components on starch gelatinization and the texture of bubbles.
We hope that our research and effort in improving the texture of bubbles can further enhance product and bring significant market value.

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