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CHANGES IN THE DIGESTABILITY OF STARCH DURING INTERACTION WITH FATS IN THE COMPOSITION OF STARCH-FAT SUBSTRATES

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Abstract: The work studied in vitro changes in the digestibility of starch when interacting with fats in the composition of starch-fat substrates. As a result of the study, it was found that with increasing time of the joint presence and interaction of corn, rice or wheat starch with sunflower oil, there is a decrease in the digestibility of starch under the influence of salivary amylase and an increase in its content in starch-fat substrates. In addition, using a substrate containing corn, rice or wheat starch together with sunflower oil and increasing the interaction time of salivary amylase and sunflower oil, there is no decrease in the digestibility of starch under the influence of salivary amylase and an increase in its content in the composition of starch-fat substrates. These changes are due to the fact that when salivary amylase acts on starch-fat substrates, the resulting starch-fat complexes may be factors preventing the hydrolysis of starch, and the inhibitory ability of salivary amylase by fats is not observed.

Key words: starch, corn, rice, wheat, sunflower oil interaction, digestion.

Аннотация: В работе изучались in vitro изменение перевариваемости крахмала при взаимодействии с жирами в составе крахмально-жировых субстратов. В результате исследования установлено, что с увеличением времени совместного присутствия и взаимодействия кукурузного, рисового или пшеничного крахмала с подсолнечным маслом отмечается снижение перевариваемости под влиянием слюнной амилазы крахмала и увеличение содержание его в составе крахмально-жировых субстратах. Помимо этого, с использованием субстрата, содержащего кукурузный, рисовый или пшеничный крахмал совместно с подсолнечным маслом и увеличении времени взаимодействия слюнной амилазы и подсолнечного масла, не отмечается снижения перевариваемости под влиянием слюнной амилазы крахмала и увеличения содержания его в составе крахмально-жировых субстратов. Эти изменения связаны с тем, что при воздействии слюнной амилазы на крахмально-жировые субстраты

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факторами, препятствующими гидролизу крахмала, могут являться, образующиеся крахмально-жировые комплексы, а ингибирующей способность слюнной амилазы жирами не отмечается.

Ключевые слова: крахмал, кукурузный, рисовый, пшеничный, подсолнечное масло взаимодействие, переваривание.

Annotatsiya: Ish kraxmal-yog'li substratlar tarkibidagi yog'lar bilan o'zaro ta'sirlashganda kraxmalning hazm bo'lishining in vitro o'zgarishini o'rgangan. Tadqiqotlar natijasida makkajo'xori, guruch yoki bug'doy kraxmalining kungaboqar yog'i bilan qo'shma mavjudligi va o'zaro ta'siri vaqtining oshishi bilan kraxmalning tupurik amilazasi ta'sirida hazm bo'lishining pasayishi va uning ko'payishi aniqlandi. kraxmal-yog'li substratlar tarkibidagi tarkib. Bundan tashqari, kungaboqar yog'i bilan birga makkajo'xori, guruch yoki bug'doy kraxmalini o'z ichiga olgan substratdan foydalanish va tuprik amilazasi va kungaboqar yog'ining o'zaro ta'sir qilish vaqtini oshirish, tuprik amilaza ta'sirida kraxmalning hazm bo'lishining pasayishi va uning tarkibining oshishi kuzatilmaydi. kraxmal-yog'li substratlar tarkibida. Bu o'zgarishlar so'lak amilazasi kraxmal-yog'li substratlarga ta'sir qilganda, hosil bo'lgan kraxmal-yog' komplekslari kraxmalning gidrolizlanishiga to'sqinlik qiluvchi omillar bo'lishi mumkinligi va so'lak amilazasining yog'lar tomonidan inhibitiv qobiliyati kuzatilmasligi bilan bog'liq.
Kalit so'z: Kraxml,(makaron,guruch,bug'doy),kungaboqar yog',hazm bo'lishi,ta'sirlashishi

Introduction: Starch is the most important carbohydrate in cereal-based products, contributing to the characteristics of many products such as moisture retention, viscosity, texture, mouthfeel, and shelf life during processing and in finished products [6]. The qualitative characteristics of many products are the result of specific gluing, gelatinization and starch retrogradation, which can be strongly influenced by additives [3]. Lipids or emulsifiers are commonly used in the formulations of many products to improve the processing and quality of final foods. Starch, especially its linear amylose fraction, can interact with endogenous or added lipids, forming complexes with a single helix, which have been well characterized at different molecular levels [7, 8]. During the processing of starchy foods, the formation of an amylose and lipid complex can reduce the solubility of starch in water, change the rheological properties of pastes, reduce swelling, increase the gelatinization temperature and reduce retrogradation and gel hardness [3]. From a nutritional point of view, lipids in starchy food systems affect the digestibility of starch in processed foods. On the one hand, the presence of lipids slows down starch retrogradation, thereby suppressing the formation of resistant starch. On the other hand, the formation of an amylose and lipid complex may contribute to resistance to enzymatic digestion [2].

The main starch fraction, amylopectin, can also interact with some suitable ligands, although the mechanism of interaction is still unclear. Limited experimental data have shown that amylopectin can interact with flavors, surfactants, emulsifiers, lactone and lipids [1, 4]. It is believed that the complexing ability of amylopectin is much weaker than that of amylose, since numerous short branches prevent or impede the necessary spiral conformation of the backbone. With the development of new starches and their increasing use in food, a good understanding of the interaction between amylopectin and lipids and its effect on starch functionality is becoming increasingly important for food processing and nutrition [5].

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The purpose of the study: to study the change in the digestibility of starch when interacting with fats in the composition of starch-fat substrates.

Material and methods. The saliva obtained by spitting from volunteers was studied in the work. The effect of the preliminary interaction of sunflower oil and corn, rice and wheat starches on the change in their content in the composition of starch-fat substrates under the influence of salivary amylase was studied in vitro. At the same time, 0.5% starches in sunflower oil were used without their pre-incubation, also with 30 minutes before incubation and with 60 minutes before incubation with sunflower oil. In addition, the effect of the preliminary interaction of sunflower oil and salivary amylase on the change in the content of 0.5% of the substrate of corn, rice and wheat starches in sunflower oil under the influence of salivary amylase was studied in vitro. Under these conditions, sunflower oil with salivary amylase was used without pre-incubation, with 30 minutes before incubation, and 60 minutes before incubation of sunflower oil with salivary amylase. The content of residual starch under the influence of salivary amylase was studied by blue coloring with an iodine reagent, as well as the content of residual starch in the presence of fats under the influence of salivary amylase, which was expressed as a percentage of the starch content without the influence of salivary amylase.

Statistical processing was carried out by the method of variational statistics with the calculation of average values and their average errors, the determination of the reliability coefficient of the Student-Fisher difference (t). Differences at $p<0.05$ and less were considered statistically significant.

Results. Based on the data obtained, it was found that when studying the effect of the interaction of starch and sunflower oil on the parameters of starch hydrolysis under the influence of salivary amylase (Fig. 1). Using a substrate containing only corn starch under the influence of salivary amylase, the residual starch index was 58±5.6%. This result was significantly ($P <0.001$) lower in relation to a similar value of corn starch without the effect of salivary amylase. At the same time, under the influence of salivary amylase on a substrate containing corn starch together with sunflower oil without pre-incubation, the residual starch index was 65 ± 5.9%, which was reliable relative to a similar value of corn starch without the influence of salivary amylase. This result was not significantly higher than the similar indicator of the use of kukruz starch as a substrate under the influence of salivary amylase. Meanwhile, under the influence of salivary amylase on a substrate containing starch together with sunflower oil after their 30 min pre-incubation, the amount of residual starch was 72 ± 6.8% relative to the similar result of starch without the influence of salivary amylase. This result was significantly ($P<0.05$) higher than the similar value of using corn starch as a substrate under the influence of salivary amylase. At the same time, under the influence of salivary amylase on a substrate containing starch together with sunflower oil after 60 minutes of pre-incubation, the residual starch index was 79 ± 7.3% relative to a similar value of corn starch without the influence of salivary amylase. These changes were significantly ($P<0.001$) higher than the similar result of using starch as a substrate under the influence of salivary amylase (Fig. 1).

At the same time, it was found that under the influence of salivary amylase on a substrate containing only rice starch, the amount of residual starch was 52 ± 4.7%. And in

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combination of rice starch with sunflower oil without pre-incubation, the value of residual starch was 59±5.5%, which was significantly (P<0.001) lower in relation to

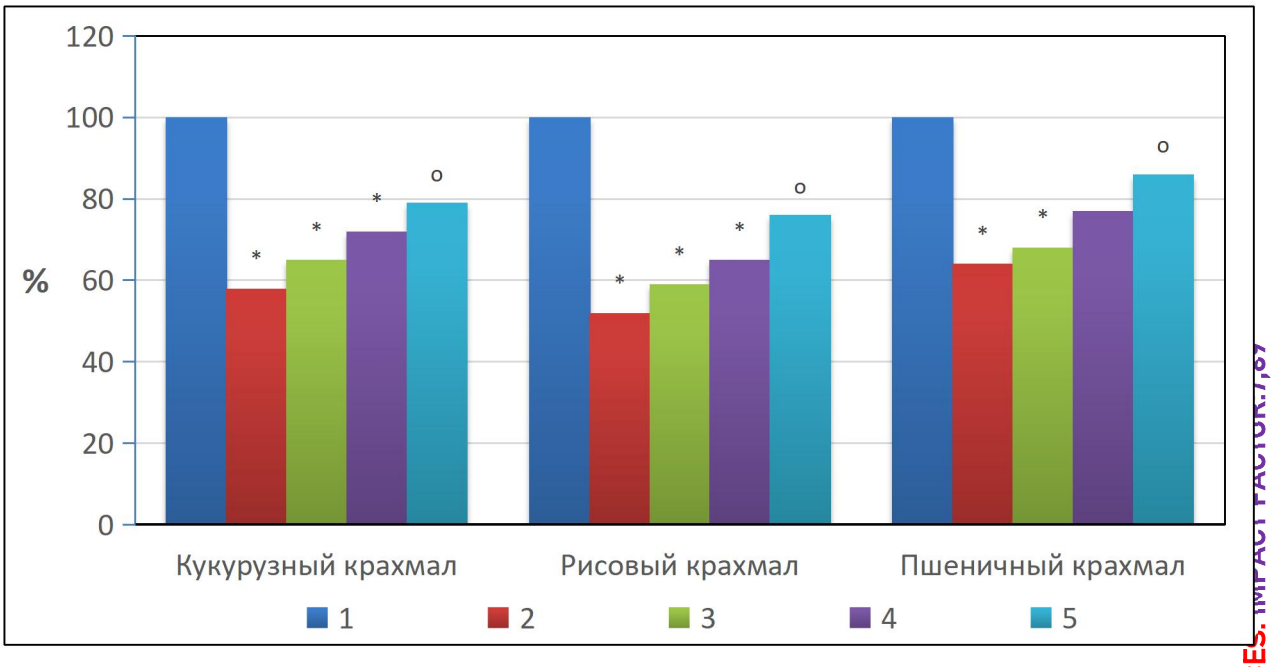

Figure 1. Investigation of changes in starch content under the influence of salivary amylase when using only starch as a substrate, as well as a mixture of starch and sunflower oil. 1- starch, 2 – starch + salivary amylase, 3 – starch + sunflower oil without pre-incubation + salivary amylase, 4 - starch + sunflower oil with 30 min pre-incubation + salivary amylase. 5 - starch + sunflower oil with 60 min pre-incubation + salivary amylase.

* - significantly different values of the change in starch content in relation to a similar indicator of using only starch as a substrate without the influence of salivary amylase.

o - significantly different values of the change in starch content in relation to a similar indicator of the use of starch as a substrate under the influence of salivary amylase to a similar result of rice starch without the influence of salivary amylase. This result was also not significantly higher than the similar indicator of the use of rice starch as a substrate under the influence of salivary amylase. At the same time, when salivary amylase was exposed to a substrate containing rice starch together with sunflower oil after 30 minutes of pre-incubation, the result of residual rice starch was at the level of 65 ± 6.2%, which was significantly lower relative to rice starch without the influence of salivary amylase. In addition, this indicator was not significantly higher than the similar value of using rice starch as a substrate under the influence of salivary amylase. In addition, under the influence of salivary amylase on a substrate containing rice starch together with sunflower oil after 60 minutes of pre-incubation, the residual rice starch index was 76 ± 7.1%. Relative to the similar result of rice starch without the influence of salivary amylase, the indicator was not reliable. At the same time, it was significantly (P<0.01) higher than the similar result of using rice starch as a substrate under the influence of salivary amylase (Fig. 1).

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In addition, it was found that under the influence of salivary amylase on a substrate containing wheat starch together with sunflower oil without pre-incubation, the residual result of wheat starch was 64±6.1% compared to a similar result of wheat starch without salivary amylase was significantly (P<0.001) lower. In addition, the indicator was not significantly higher than the similar result of using wheat starch as a substrate under the influence of salivary amylase. Meanwhile, when salivary amylase is exposed to a substrate including wheat starch together with sunflower oil after 30 minutes of pre-incubation. The residual index of wheat starch was 68±6.4% and was significantly (P<0.05) lower than the similar results of wheat starch without the influence of salivary amylase. At the same time, this indicator was not significantly higher than the similar value of using wheat starch as a substrate under the influence of salivary amylase. At the same time, under the action of salivary amylase on a substrate containing wheat starch together with sunflower oil after 60 minutes of pre-incubation, the residual index of wheat starch was at the level of 86 ± 7.6% and was not significantly less relative to similar results of wheat starch without the effect of salivary amylase. At the same time, this result was significantly (P<0.01) higher than the indicator of the use of wheat starch as a substrate under the influence of salivary amylase (Fig. 1).

From the obtained results of the study of the effect of the interaction of salivary amylase with sunflower oil, it was found that under the influence of salivary amylase on a substrate containing corn starch together with sunflower oil without pre-incubation, the result of residual corn starch was 63± 5.8%. This result was significantly (P<0.001) lower relative to the corn starch index without the effect of salivary amylase. This indicator was also not significantly higher than the similar result (58± 5.6%) of using corn starch as a substrate under the influence of salivary amylase. At the same time, when salivary amylase was influenced by a substrate containing corn starch together with sunflower oil after 30 minutes of pre-incubation of salivary amylase with sunflower oil, the residual corn starch index was 65 ± 6.2% and reliable with respect to a similar result of corn starch without the influence of salivary amylase. This result was also not significantly higher than the similar result of using corn starch as a substrate under the influence of salivary amylase. Meanwhile, under the influence of salivary amylase on a substrate containing corn starch together with sunflower oil after 60 minutes of pre-incubation of salivary amylase with sunflower oil, the result of residual corn starch was 68±6.5% relative to the similar result of starch without salivary amylase. This indicator was not significantly higher than the similar result of using starch as a substrate under the influence of salivary amylase (Fig. 2).

According to the results of studying the effect of the interaction of salivary amylase with sunflower oil, it was also found that under the influence of salivary amylase on a substrate containing rice starch together with

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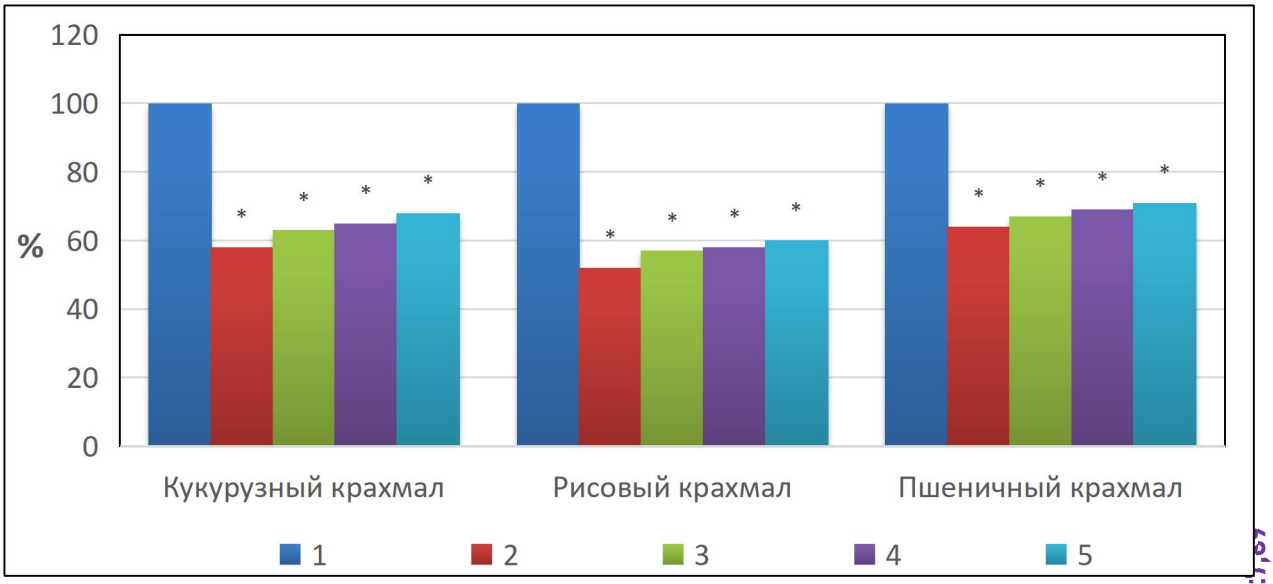

Figure 2. Investigation of changes in starch content under the influence of salivary amylase when using starch as a substrate, as well as a mixture of starch and sunflower oil. 1- starch, 2 – starch + salivary amylase, 3 – starch + sunflower oil without pre-incubation of salivary amylase and sunflower oil, 4 - starch + sunflower oil with 30 minutes before incubation of salivary amylase and sunflower oil, 5 - starch + sunflower oil with 60 minutes before incubation of salivary amylase and sunflower oil.

* - significantly different values of the change in starch content in relation to a similar indicator of using only starch as a substrate without the influence of salivary amylase.

sunflower oil without pre-incubation of salivary amylase with sunflower oil. The result of residual rice starch was 57± 5.2%, which was significantly lower in relation to the result of rice starch without the effect of salivary amylase. Also, this indicator was not significantly higher than the similar result (52 ± 4.7%) of using rice starch as a substrate under the influence of salivary amylase. In addition, when salivary amylase was influenced by a substrate containing rice starch together with sunflower oil after 30 minutes of pre-incubation of salivary amylase with sunflower oil, the result of residual rice starch was 58 ± 5.3% and reliable in relation to a similar result of rice starch without the influence of salivary amylase. This indicator was also not significantly higher than the similar result of using rice starch as a substrate under the influence of salivary amylase. At the same time, under the influence of salivary amylase on a substrate containing rice starch together with sunflower oil after 60 minutes of pre-incubation of salivary amylase with sunflower oil, the residual rice starch index was 60 ± 5.7% and reliable in relation to the similar result of rice starch without the influence of salivary amylase. This result was not significantly higher than the similar result of using starch as a substrate under the influence of salivary amylase (Fig. 2).

In addition, when studying the effect of the interaction of salivary amylase with sunflower oil, it was found that under the influence of salivary amylase on a substrate containing wheat starch together with sunflower oil before incubation of salivary amylase with sunflower oil. The result of residual wheat starch was 67±6.5%, which was significantly ($P<0.001$) lower in relation to the result of wheat starch without the effect of salivary amylase. Also, this

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result was not significantly higher than the similar result (64± 6.1%) of using starch as a substrate under the influence of salivary amylase. At the same time, when salivary amylase was exposed to a substrate containing wheat starch together with sunflower oil after 30 minutes of pre-incubation of salivary amylase with sunflower oil, the result of residual starch was 69 ± 6.5% and reliable in relation to the similar result of wheat starch without the influence of salivary amylase. This indicator was also not significantly higher than the similar result of using wheat starch as a substrate under the influence of salivary amylase. At the same time, under the influence of salivary amylase on a substrate containing wheat starch together with sunflower oil after 60 minutes of pre-incubation of salivary amylase with sunflower oil, the residual starch index was 71± 6.5% and significantly lower in relation to the similar result of wheat starch without salivary amylase. Also, this indicator was not significantly higher than the similar result of using wheat starch as a substrate under the influence of salivary amylase (Fig. 2).

Discussion of the results. The obtained research results showed that with the use of corn, rice or wheat starch as a substrate under the influence of salivary amylase, there was a significant decrease in their content in relation to the result of using these starches without the influence of salivary amylase. At the same time, under the influence of salivary amylase on these starches together with sunflower oil without pre-incubation. The result of residual starch was not significantly higher in relation to a similar indicator of the corresponding starch under the influence of salivary amylase and significantly higher in relation to starches without the influence of salivary amylase. Along with this, under the influence of salivary amylase on a substrate containing corn, rice or wheat starch together with sunflower oil at 30 minutes before incubation, the result of residual corn and rice starch, except wheat, was significantly lower in relation to starches without the effect of salivary amylase. At the same time, under the influence of salivary amylase on a substrate containing corn, rice or wheat starch together with sunflower oil at 60 minutes before incubation, the result of residual starches was significantly and significantly higher relative to the similar value of starches under the influence of salivary amylase. These changes show that the starches used, when interacting with sunflower oil, reduce their ability to digest salivary amylase. To a greater extent, this is manifested in rice, to a lesser extent in corn and even less in wheat starch. It is known that the interaction of starches occurs due to amylose with both mono, diglycerides and fatty acids included in vegetable oils. Since less amylose is included in rice starch, more in corn starch and even more in wheat starch. This may be due to the effect of sunflower oil on the digestibility of starches to a lesser extent on rice starch, to a greater extent on corn starch and even more on wheat starch.

At the same time, in addition to the effect of the interaction of sunflower oil with starches on reducing the digestibility of starches by salivary amylase. It can be assumed that the interaction of sunflower oil with amylase has an effect on reducing the digestibility of starches by salivary amylase. Therefore, studies have been conducted on the effect of the interaction of sunflower oil with amylase on reducing the digestibility of the substrate of corn, rice or wheat starches with salivary amylase. At the same time, it was found that under the influence of salivary amylase on a substrate containing corn, rice or wheat starch together with sunflower oil without pre-incubation of sunflower oil and salivary amylase. The result of residual starch was not significantly higher in relation to a similar indicator of starch under the influence of salivary amylase. It is also significantly lower than starch without the effect of salivary amylase. At the same time, under the influence of salivary

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amylase on a substrate containing corn, rice or wheat starch together with sunflower oil at 30 and 60 minutes before incubation of sunflower oil and salivary amylase. The result of residual starch was also not significantly higher than the result of starch under the influence of salivary amylase. At the same time, both indicators were significantly lower than the results of starch without the effect of salivary amylase.

These changes demonstrate that with an increase in the time of pre-incubation or the joint presence and interaction of salivary amylase with sunflower oil, there is no significant decrease in the digestibility of corn, rice or wheat starch and an increase in its content in starch-fat substrates. These changes can also be explained by the fact that the interaction of sunflower oil with salivary amylase does not affect the digestibility of starch by salivary amylase.

Conclusions: The results obtained show that with an increase in the time of the joint presence and interaction of corn, rice or wheat starch with sunflower oil, there is a decrease in digestibility under the influence of salivary starch amylase and an increase in its content in starch-fat substrates. In addition, using a substrate containing corn, rice or wheat starch together with sunflower oil and increasing the interaction time of salivary amylase and sunflower oil, there is no decrease in digestibility under the influence of salivary starch amylase and an increase in its content in starch-protein substrates. These changes are due to the fact that when salivary amylase is exposed to starch-fat substrates, starch-fat complexes may be formed, and the inhibitory ability of salivary amylase is not noted by fats.

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