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The Use of Phosphates in the Meat Industry

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Abstract

In this research, physicochemical, rheological and sensory properties of the use of phosphate in low-fat meat prepared using hydroxypropyl distarch phosphate (E1442), which is a modified resistant starch (4RS), were studied. The modified starch of hydroxypropyl distarch phosphate in this study plays a significant role in the digestive system by being replaced in the formulation of phosphate application in low-fat meat. Fat of phosphate[1] was replaced at levels of 25%, 50%, and 75% using the modified starch of hydroxypropyl distarch phosphate. Sauce samples were labeled with (25%FR), (50%FR), and (75% FR), respectively. The sample containing 66% of the oil was considered as a control sample (Full-Fat). Calculations were done based on the chemical composition of formulated phosphate samples and showed that the calorie and fat content of all samples of phosphate applied in low-fat meat was significantly less than that of the (FF) control sample (P-value<0.05). By increasing the percentage of the modified starch (E1442) in low-fat phosphate formulation, the moisture content of the samples was higher than that of the control sample (FF). In terms of viscosity evaluation, the highest viscosity was observed for a sample that had a 25% replacement, which was significantly higher than that of the control sample, and the lowest viscosity was for a sample that had a replacement of 75%; however, the nearest and best viscosity was for the 50% replacement, which was not significantly different from the control sample (P-value<0.05). The results of the color evaluation of the samples showed that the color of all samples with replacement was lighter than that of the control sample and, in general, color of the samples was acceptable. In the case of the 5-point Hedonic scale for sensory evaluation, the most commonly accepted measure was 50% replacement. Finally, this study showed that the use of the modified starch of hydroxypropyl distarch phosphate (E1442) as a fat substitute in the formulation of phosphate application in low-fat meat has a good performance in terms of economic efficiency and consumer health.

Keywords: Modified Starch, Hydroxypropyl Distarch Phosphate (E1442), Use of Phosphate in Low-Fat Meat

Introduction

Growth hormone possesses large physiological roles like appetite control, ageing, body composition, growth, reproduction (Cobra et al., Phosphate is an emulsified sauce that is being used extensively throughout the world. This sauce has an effective role in providing the necessary nutrients and energy for humans, due to the fact that the ingredients like eggs, oil, and starch are its main ingredients, as well as its desirable taste as a seasoning in salads. No thermal process is applied to store these sauces, because due to their emulsion structure, heat causes the emulsion to break down. To prevent the sauces from rotting, their pH should be at 4-3.4. The starch in the formulation of phosphate application in meat acts as a stabilizer and thickener. On the one hand, it increases the viscosity of the continuous phase and prevents the breakdown of the emulsion, and on the other hand, acts as a stabilizing agent by forming strong interfacial layers around the oil droplets (Dehghan et al., 2008). One of the ways to reduce fat intake is to use low-fat foods. In this respect, low-fat sauces can be recommended for people who seek decreased calorie intake from fat for medical and health reasons. Therefore, today, customers tend to use low-calorie and low-fat foods, combined phosphate and yogurt products, and egg-free products (Maghsoudi, 2005). Hence, in this research, hydroxypropyl distarch phosphate (1442 E) modified starch was used as a fat substitute in the formulation of phosphate in meat in order to produce dietary meat along with maintaining texture and quality, so that in addition to a low-calorie diet for consumers, it is also economically important as a key parameter for manufacturers.

Literature Review

Importance of the use of phosphate in meat

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[1] The term "fat phosphate" was not found in Internet and scientific articles

In recent years, the use of products with reduced fat content has been very much taken into consideration in advanced countries. Fat substitutes are chemically similar to fats, proteins or carbohydrates, and are generally classified into fat replacers and fat mimetics (Marchal & Beeftink, 1999). As people's demand for fat reduction in the diet has grown, manufacturers of food products have begun to produce new substitutes for fat replacements, which are currently on the market and are used in a wide range of foods such as sauces, chips, frozen desserts, and dietary chocolate. The main goal of the production of all fat substitutes is to help reduce the calories produced by the fat in the food. Although most of these compounds contain less calories than fats, they are not stable at baking temperatures (which natural fats can withstand) (Diane, 1998; Helferich, Winter, 2001). Considering that the use of high-fat foods in the diet has a significant impact on the health of the society, the tendency to eat low-fat and low-calorie foods is of particular importance. Hence, the use of fat substitutes in the phosphate application in meat plays an important role in the production of the low-calorie product. On the other hand, the economic efficiency of the use of modified starch (1442E) is important in the prime price. The phosphate has phosphate-like compounds in the meat, and edible vegetable oil, vinegar, lemon juice, water, eggs (yolk or whole), dairy products, additives and various authorized flavors such as tomatoes, salt, sugar, spices and herbs are used in its production. It should be noted that the amount of edible vegetable oil of salad dressing is usually less than the use of phosphate in meat and its color may differ depending on the type of additive. Phosphate in meat is available in simple forms of salad cream, Thousand Island dressing, French dressing, Italian dressing, cheese, fruit, etc., in both normal and dietary types. Some phosphates are egg-free in meat (Maghsoudi, 2005).

Phosphate in meat

The phosphate in meat is in the group of fluid phosphate in meat. In the past, these products have poor quality, watery texture, and sharp acidity (due to the high amount of acid used to prevent microbial degradation), but at present, phosphate has a desirable quality in meat. To make the fluid sauce in the non-fatty group, it should contain less than 0.5 grams of fat in each 32-gram receive of the product. This amount is equal to 1.56% fat in the formulation of the product. Also, to make thick sauces in the group of these products, they should contain less than 0.5 grams of fat in each 16-gram receive of the product, which is equal to 3% fat in the formulation of the product. Various types of low-fat and non-fat products are produced by reducing fat and replacing it with synthetic fats such as carbohydrate-based fat, protein and muscle volumizer materials along with water. In these products, thickeners are used to compensate for the loss of physical properties due to the reduction or removal of oil. In this regard, Yelmar et al. (1991) examined the effect of propylene glycol and xanthan gum on the stability and sensory features of the phosphate in meat. These researchers showed that the addition of xanthan gum increases the viscosity and improves the phosphate texture in meat. (Yilmazer, 1991). Also, Netipramook et al. (1991) used xanthan gum to produce phosphate in low-fat meat with a suitable texture as a fat substitute.

Mun et al. (2010) also used the modified starch of rice as a fat substitute in the formulation of phosphate in low-fat and reported that this type of starch improves the rheological and texture properties of phosphate in low-fat meat (Mun, 2009).
In addition, Amirkavei et al. (2004) used xanthan gum and maltodextrin as fat substitutes for the use of phosphate in meat and Italian sauce. Their report indicated that the use of xanthan gum (hydrocolloid) increases viscosity and improves the properties of phosphate application in meat and Italian sauce (Amirkavei, 2005).

Dehghan et al. (2008) used corn and wheat pregelatinized starch by drum drier, and replace them with natural starch to produce salad dressing. They found in their experiments that pregelatinized starch shows better characteristics than natural starch in salad dressings and can well be replaced with sauce.

Amiri et al. (2010), while using hulless barley beta-glucan as a fat substitute at different levels, stated that all samples of phosphate in meat have a shear thinning behavior, and all of them are solid viscoelastic fluids. According to the preliminary studies, in this research, pectin and inulin were used as a fat substitute in the formulation of phosphate in meat. (Amiri, 2010).

Modified starch

Starch in plants is produced in components called amyloplast. Each amyloplast has one or more spherical shapes that are called starch granules. In fact, the starch storage site is inside the granules. The shape and size of the granules vary depending on the type of plant. Research has shown that although the overall structure of starch from different sources is the same, the differences in the length of the amylose and amylopectin chain, their molecular weight, the presence of other compounds such as fat and protein, cause significant differences in the yield and properties of starch derived from their sources (Dehghani et al., 2009).

Studies on the internal structure of starch granules have shown that full details of how the amino acids and amylopectin appear inside the granule have not yet been fully elucidated, although many realities have been clarified in this regard. For example, how to place these two polymers is not random, but quite regular. Most of the information available today on the internal structure of the granules is mainly obtained by electron microscopy. Since amylopectin forms a major part of starch (about 75%), the main internal structure of the granule is associated with how this molecule is placed in its joints (Dehghani et al., 2009).

Regarding the study of insignificant compounds in starch, research has shown that in addition to amylose and amylopectin, starch contains very low amounts of protein, fat, moisture and ash (minerals and salts). The amount of these compounds depends on the herbal origin of starch. The Starch in potato and tuberous crop, for example, contains little amounts of protein and fat. The amount of these compounds is also affected by the starch extraction method. Recent studies have shown an intermediate polysaccharide composition between amylose and amylopectin in some types of starches (such as starch of rice, corn, and some wheat varieties), which has the same structure as amylose, but has more branches than amylose, and the length of these branches is shorter than that of amylopectin. The properties of this compound are under investigation. Although the amount of this intermediate compound is negligible, it is likely to play a role in the development of some functional properties of starch (Dehghani et al., 2009).

Starch modified by chemical methods

The use of chemical methods is the oldest and most commonly used starch modification method. In this method, certain chemical groups, such as ester functional groups, specific ions, acetyl, etc., are placed on starch molecules, in which they create new properties. There are two terms to express the chemical modification of starch:

- ✓ Degree of substitution: The degree of substitution indicates the number of hydroxyl groups of glucose units that have been replaced by the desired chemical agent. Given that there are 3 free hydroxyl agents on each glucose unit in the polymer structure of starch, the maximum degree of substitution is 3.
- ✓ Degree of molar substitution: The degree of molar substitution indicates the number of molar substituents per molecule of glucose in the starch structure. This term is most often used when a polymer is replaced by glucose units. Therefore, the degree of molar substitution can be more than 3 (Dehghani et al., 2009)..

One of the most commonly used chemical terms for substitution in the food industry is the "dextrinization" process, which includes the breakdown of polymers and the formation of new joints and polymers, is caused by high temperatures in the presence or absence of catalysts. Their industrial production is carried out by heating at 110-180 °C for 3-24 h. In this method, acid can be sprayed onto starch. Due to reaction conditions such as temperature and duration, and the presence or absence of acid, various products are produced in terms of structure and properties. Depending on industrial conditions, dextrin is divided into three categories including yellow dextrin, white dextrin and English gums, producing each of them requires different conditions. There may be new joints in these types of starches. Dextrins can be used as ingredients and edible coatings, as well as to replace some of the most expensive gums or alternatives to fats (Dehghani et al., 2009).

Fat substitute

The key issue with low-fat products is to produce them with sensory and physical characteristics that are as close as possible to the characteristics of the standard fat-containing products that people are accustomed to. Over the past 10 to 15 years, the food industry field has been working hard and has invested heavily in this area (Mahdiani and Kadivar, 2010). Because of the important role of fat in food, it has been determined that the development of low-fat foods should be matched to the quality of their fatty counterparts, which is important in the use of appropriate substitute compounds. For this purpose, numerous combinations have been developed to replace fat (Mahdani & Kadivar, 2010). The general consensus is that the type of consumed fat is one of the most important factors in relation to chronic diseases, and an increase in the proportion of unsaturated fats in the diet, for example, by the consumption of fish oil, can have a protective role against the patient with CHD. Therefore, the optimal fat intake, with a ratio higher than HDL or a lower proportion of LDL, such as diets in which the oil or fat ratio is higher in polyunsaturated fatty acids (such as herbal sources or fish) or monounsaturated fatty acids (olive oil), reduces the risk of CHD. Physiologically, fats have 3 basic applications in foods: they act as a source of essential fatty acids (linoleic and linolenic acids). They act as carriers of lipid soluble vitamins (K, E, D, A), and are an important source of energy. From the nutrition point of view, only two first functions seem necessary because other nutrients (such as carbohydrates and proteins) can also act as sources of energy. Typically, any diet that contains very little fat can meet these needs. Changes in people's lifestyles over the years have led to a significant reduction in the need for food energy, but at the same time, the proportion of energy derived from fat is still high. The nutritional function of fat in food is not complete without referring to the physiological and psychological aspects. Research shows that fat intake is associated with the sensation of satiety, and fat loss may increase food intake to compensate for energy. However, it should be noted that most studies have been conducted on the creation of satiety using non-energy and non-absorbable alternatives (such as sucrose polyesters). Such substitutes have not been used in foods (Mahdani & Kadivar, 2010). Reducing fat can have a profound effect on the physical stability of the product. Therefore, one of the important roles of fat replacement compounds is their ability to maintain physical stability, while providing acceptable sensory quality simultaneously. The significance of this issue became apparent when some products in the early 1990's experienced physical instability and, as a result, returned from the market. Little published data is available on the physical and stability characteristics associated with reducing the fat content of food, and no attempt has been made to find out the relationship between fat content, physical characteristics, and stability with sensory properties. On the subject of physical stability, it becomes more complicated when moving from the discussion of liquid products whose permanent phase is water towards the discussion of the semi-solid products whose permanent phase is oil (Mahdiani & Kadivar, 2010). The most important thing for a manufacturer who wants to use fat substitutes is to look at whether the fat substitutes are authorized for use in food. A wide range of fat substitutes is available in the market. Depending on the nature and components of these compounds and the product in which they are used, legal control may vary for each one. Among other things to be considered is the general classification of fat substitutes. The distinction between those authorized compounds as components of food and those known as additives is very important at this stage. If the fat substitute is used as a component of the food, its use is generally acceptable, unless there are rules and regulations that restrict their use and prevent the use of these compounds as food components. This means that the combination must have qualitative and safe conditions for use in food (Mahdiani & Kadivar, 2010).

Method

In this study, the materials used in the formulation of phosphate in meat are shown in the table below.

Table 1- The amount of compounds used in the formulation of different samples of phosphate in meat

No.	Raw material	Control (FULL FAT)	25% fat replaced	50% fat replaced	75% fat replaced
1	Soybean oil	66	49.5	33	16.5
2	Vinegar 11%	10	10	10	10
3	Yolk	4	4	4	4
4	Sugar	5	5	5	5
5	Salt	1.5	1.5	1.5	1.5
6	Mustard powder	0.3	0.3	0.3	0.3
7	Xanthan and guar gum stabilizer	0.2	0.2	0.2	0.2
8	Modified starch E1442	0	1.5	2.5	3.5
9	Potassium sorbate and sodium benzoate	0.075	0.075	0.075	0.075
10	Water	12.925	27.925	43.425	58.925
	Total	100	100	100	100

In this research, in order to prepare each of the treatments, the raw materials of the formulation of the dressing were weighed using a digital scale. Then, for the preparation of the sauces, the eggs were first poured with vinegar and water into the mixer, and then, after mixing, the powder materials were gradually added to the mixer and were blended well. After forming the emulsion and creating the proper texture, the mixer was turned off and the sauces were poured into glass containers. It should be noted that for each treatment, 800 g of test sample were prepared.

AOAC Official Method 900.02 were used to measure moisture and ash of phosphate samples in meat. The protein and fat content of the samples were measured using the Kjeldahl method and the Bligh and Dyer method (1959), respectively. The carbohydrate content was also measured by subtracting the percentage of all compounds (ash, moisture, protein, and fat) from 100%.
All experiments were carried out under completely identical conditions with temperature control at about 25°C and a rate of 150 rpm, and the viscosity of the samples was reported in centipoise. In the sensory evaluation of the samples of phosphate application in meat, a 10-person evaluation group was used.

In this research, data analysis was done in a completely randomized design with all the tests in 3 replications. To compare the mean of treatments, the least significant difference (LSD) test was used at a probability level of 5%. Data analysis was performed using GraphPad Prism 5.0 software.

Analysis of the Results

1. Chemical composition and calorie content

Table 2: Results of the chemical composition of the samples for phosphate application in meat

Replacement ratio	Fat	Protein	Ash	Moisture	Carbohydrate	Calorie
Control (Full-Fat)	68.40±0.05a	0.71±0.03a	0.766±0.002d	24.62±0.13d	5.50±0.11b	640.5:±0.8a
25% fat replaced	55061±0.06b	0.69±0.02a	0.817±0.004c	39.17±0.09c	3.71±0.10c	518.1±0.4b
50% fat replaced	37047±0.12c	0.76±0.03a,b	0.864±0.003b	54.52±0.30b	6.40±0.09a	365.8±3.1c
75% fat replaced	25056±0.14d	0.78±0.02b	0.879±0.001a	69.97±0.11a	2.80±0.16d	244.4±d

As the results of the chemical composition table show, the highest fat content is related to the control sample, and by increasing the substitution percentage, the fat content of the samples is reduced. All samples have a significant difference in probability level of $P \geq 0.05$ compared to control. The amount of calories in the samples decreases with increasing substitution percentage such that the highest calorie intake was observed for the control sample and the lowest caloric intake was associated with 75% fat replaced. Also, increasing the amount of substitution and reducing the fat content, the moisture content increased. On the other hand, due to the increased moisture content of phosphate application in meat and the use of hydroxypropyl distarch phosphate (E1442) modified starch, which is classified as an RS4-type resistant starch.

2. Results of moisture in phosphate application in meat

Table 3- Results of moisture in phosphate application in meat

Replacement ratio	Moisture	Dry material
Control (Full-Fat)	24.62±0.13d	75.28±0.06a
25% fat replaced	39.17±0.09c	60.83±0.09b
50% fat replaced	54.52±0.30b	45.38±0.17c
75% fat replaced	69.97±0.11a	30.03±0.11d

3. Results of fat measurements for the samples of phosphate application in meat

Table 4- Fat content of the samples of phosphate application in meat

Replacement ratio	Fat
Control (Full-Fat)	68.40±0.05a
25% fat replaced	55.61±0.06b
50% fat replaced	27.47±0.12c
75% fat replaced	25.56±0.14d

4. Viscosity of the samples of phosphate application in meat

Table 5- Viscosity of the samples of phosphate application in meat

Replacement ratio	V_0	T_0	V_1	T_1
Control (Full-Fat)	3963.00±121.24b	14.60±0.20b	3458.00±81.50b	12.97±0.31b
25% fat replaced	4958.00±384.00a	18.03±1.075a	4187.00±288.44a	15.73±1.10a
50% fat replaced	3920.00±27.00b	14.07±0.59b	3280.33±46.19b	12.30±0.17b
75% fat replaced	2978.00±85.86c	10.80±0.44c	2549.00±136.17c	9.53±0.50c

The highest viscosity (4187 cp) was found in the sauce sample with a 25% fat replaced, which was significantly higher than that of the control sample. The viscosity of the control sample (3458 cp) was the closest viscosity to the sauce sample with 50% fat replaced (3280.33), which had no significant difference ($P \geq 0.05$) with the control sample, and the viscosities were close. The lowest viscosity was reported for sauce with 75% fat replaced, which was 2549. The results show that the substitution of modified starch E1442 by 50% in the formulation of phosphate application in a low-fat meal with water absorption and viscosity provides a very good performance in the texture and viscosity of the sample.

5. Stability test

Table 6- Stability of the samples of phosphate application in meat

Replacement ratio	Stability
Control (Full-Fat)	Completely stable and no diphasing
25% fat replaced	Completely stable and no diphasing
50% fat replaced	Completely stable and no diphasing
75% fat replaced	Completely stable and no diphasing

After 56 hours of storage at 55 °C, the sauces were examined in terms of the breakdown of emulsions, rising oil droplets to the liquid surface, and integration of separated phases, and no changes were observed, indicating complete stability of the samples.

6. Physical and chemical characteristics

Table 7: The pH and acidity of the samples of phosphate application in meat

Replacement ratio	pH	Acidity (grams acetic acid)
Control (Full-Fat)	3.71±0.02a	1.11±0.01a
25% fat replaced	3.71±0.01a	1.11±0.01a
50% fat replaced	3.73±0.02a	1.11±0.01a
75% fat replaced	3.77±0.02a	1.10±0.01a

There was no significant difference between formulations of the samples of phosphate application in meat in terms of pH and acidity. As seen in Table 7, the lowest pH was observed for the sample with 75%. It can be stated that the pH of all samples of phosphate produced are within the standard range and there was no significant difference. The acidity of the samples did not differ significantly and according to ISIRI 2454, which has declared the minimum acidity of the sauce is 0.6%, is in the standard range.

7. Sensory evaluation

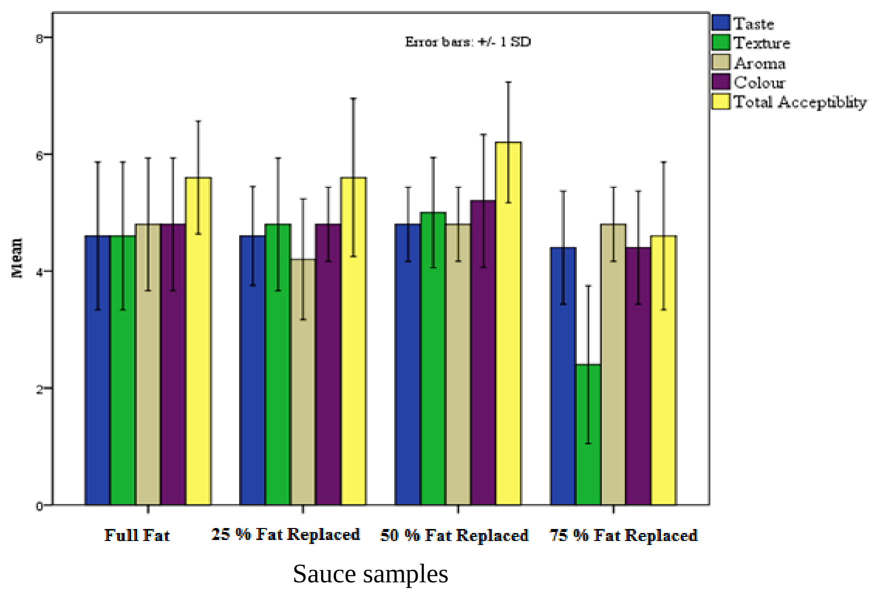

Fig. 1: Sensory evaluation results of the samples of phosphate application in meat

The mean sensory evaluation results show that from the evaluators' point of view, the highest points were in terms of overall acceptance, flavor, odor, texture, and color of the sample of phosphate application in meat with 50% fat replaced, and there was no significant difference in comparison with the control sample. In some cases, such as the sample texture, the 50% fat replaced had a higher score than the control sample. From the viewpoint of evaluators, in terms of texture, the lowest score was for the sauce sample with a replacement of 75%, which had a significant difference compared to the control sample.

Discussion and Conclusion

The results of this study showed that hydroxypropyl distarch phosphate modified starch can be used as a suitable substitute for fat in the formulation of using phosphate in low-fat meat without altering the tissue and organoleptic properties of the product. Modified starch (E1442), in addition to fat substitution, can increase the low-fat viscosity. In the meantime, it is also very effective in reducing the amount of fat and calorie content. Modified starch (E1442) will have an effective role in the stability of the emulsion, as it can bond the water in the continuous phase. By adding modified starch as a fat substitute, the L factor, which represents the lightness of the samples, was the highest in the 50% substitution. Sensory evaluation, general acceptance of the product, and other sensory evaluation parameters were not significantly different from the control sample.

Suggestions

1. Regarding the knowledge about the effect of modified starches, other modified starches including dextrin starch, acrylic starch, etc. can also be used in the formulation of sauces.
2. Some modified starches have a function similar to emulsifiers, which can be used both as a substitute for fats and as alternatives to other ingredients in the formulation of using phosphate in meat.
3. Regarding the structure and function of hydroxypropyl distarch phosphate modified starch, it is recommended to use this type of starch so as to reduce the fat content of other foods such as cheese, cream, etc.
4. It is recommended to use hydroxypropyl distarch phosphate modified starch combined with other stabilizers for the use of phosphate in meat.

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