RESEARCH ARTICLE

Corn Starch in Pharmaceuticals Isolation, Characterization, and Applications

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ABSTRACT

Starch is one of the most widely used excipients in the manufacturing of solid dosages in the pharmaceutical product field. Generally, the most widely used is corn starch. Corn starch was isolated from maize seeds that were grinded and precipitated to obtain starch deposition. The characterization of physicochemical properties of corn starch can be done through color testing, solubility test, water absorption capacity (WAC) and oil absorption capacity (OAC), chemical composition, amylose content, swelling and solubility index, bulk density, and using scanning electron microscopy (SEM) device. Applications of corn starch in the pharmaceutical field can be used as a binder-disintegrant tablet, binder, and tablet filler.

Keywords: Amylose content, Bulk density, Corn starch, Oil absorption capacity, Solubility index, Swelling index, Water absorption capacity.

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INTRODUCTION

Excipients are substances other than the active substance added to the formulation of the pharmaceutical preparation. Excipients are useful for improving the properties of active substances so as to facilitate the production process of pharmaceutical preparations. The excipients used must be non-toxic, pharmacologically inert, both stable physically and chemically either alone or in combination with active substances, and relatively inexpensive. Excipients include fillers, binders, disintegrants, and lubricants. One of the excipients used in the manufacture of pharmaceutical preparations is starch.[1]

Starch is a natural polymer composed of a branched structure called amylopectin and a straight structure called amylose. Plants that are high in carbohydrates, such as sago, cassava, corn, wheat, and sweet potatoes, can provide starch. Starch can also be extracted from fruit seeds such as jackfruit seeds, avocado seeds, and durian seeds.[2] There are several methods for extracting starch, including the alkaline steeping method, wet milling, protein digestion, and high-intensity ultrasound.[3]

Starch is a carbohydrate in plants, stored in the stems and seeds. It is also found in the cells of plastids, which are separated from the cytoplasm.[4] Starch is a big source of energy for people. Corn and rice are the two main sources of starch. Starch is a powder that is white in color and has no sweet taste. It is a type of carbohydrate. This material is insoluble in water, alcohol, and ether.[5] Starch will undergo a variety of physical changes during the thermal process. When starch is heated in water, it expands and changes its crystal structure.[6]

Uses of starch from various plants to function as pharmaceutical excipients.[7] Starch is widely available and useful in tablet production because of its inert, inexpensive nature and its use as fillers, binders, disintegrants, or glidans.[8] Because it is inert and can be mixed with most medicinal ingredients, starch is an advantage as an excipient.[1] Although corn starch is the maximum regularly used excipient inside the manufacture of tablet arrangements; researchers have attempted to broaden starch from flora for excipient use in tablet preparations.[9]

Starch is made up of two different types: natural starch and modified starch. Starch derived from tubers is considered natural because it has not been altered in physical or chemical properties. Starch is a natural excipient used in tablets. It has two negative effects on the physical properties of the granules: Poor flowability and compactibility. This is because starch

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contains a lot of amyloses, making it dry and less sticky, and it tends to absorb a lot of water.[11]

One of the starch-producing plants is corn. Corn has various types of starch, ranging from low to high amylose and amylopectin. Starch is the main component in corn kernels, accounting for 72–73% of the total weight.[12] After harvesting, corn kernels then go through post-harvest processes such as cleaning, drying, and storage. Several studies have revealed the effect of drying temperature on the properties of corn kernels drying temperature up to 100°C, causing changes in paste properties and gel texture and reducing the extraction yield and starch purity.[13]

This review article aims to gather knowledge about the corn starch, including its isolation method, its physicochemical properties, and its application in the pharmaceutical field.

METHOD

Corn Seed Storage

Corn is harvested and then dried in the sun or an oven. The seeds are harvested mechanically, then dried at a temperature of 35°C until a humidity of 14 % is reached. Finally, they are cleaned using aluminum phosphide to prevent insect disturbance. Drying corn kernels to a safe level of humidity helps to prevent the growth of microorganisms and ensures a safe food product. Corn kernels were stored in three polyethylene bags, each with a capacity of 0.9 kg, at five different temperature levels (5, 15, 25, 35°C). The bags were stored for a total of twelve months.
Cover the seeds with aluminum foil to avoid light.[14]

Corn Starch Isolation

A 1-kg of corn kernels was soaked in 4 L of distilled water and then stored at 4°C for 12 hours. The skin from the seeds was then removed by manual abrasion. The seeds' cotyledons were blended with water for 5 minutes using a blender mixer. The slurry obtained was then diluted to ten times (v/v) with distilled water and the pH was adjusted to 10 by adding 0.5 M NaOH. The slurry was continuously mixed using a magnetic stirrer for one hour, then filtered using a 75-mesh sieve to remove the fibers. The centrifuge was set to 3000 g and rotated for 30 minutes at 10°C. The aqueous phase was collected for the protein recovery phase, while the precipitate was scraped off the surface, and the bottom white portion was washed three times using distilled water and left at a cold temperature (4°C). The precipitate obtained is composed of starch. The starch was dried at 40°C using an oven.[15]

Characterization of Physicochemical Properties of Corn Starch

Color

The color of the starch was determined using a color spectrophotometer after being standardized using the Hunter Lab color standard. The 'L' (lightness), 'a' (redness to greenness), and 'b' (yellowness to blueness) values were measured.[16]

Solubility Test

The starch solubility test was conducted at a temperature of 20 to 35°C. A starch sample (0.5 g) was placed into a beaker, then moistened with ethanol. A 40 mL of distilled water was then added. The mixture was stirred at the desired temperature for 30 minutes, then centrifuged and filtered. The filtrate obtained was evaporated to dryness at a temperature of 105°C, and the residue was weighed to determine how much was dissolved.[17]

Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC)

Cornstarch was mixed with distilled water/oil in a centrifugation tube and then mixed for 2 minutes using a vortex mixer. The mixture was allowed to stand for 30 min at 25°C, and the supernatant was discarded. The increase in weight is due to the increase in water absorption capacity.[16] Water absorption capacity (WAC) is a measure of how well a substance can bind with water under water-limited conditions. Meanwhile, oil absorption capacity (OAC) is the ability of dry starch to bind oil with capillary attraction physically.[18]

Chemical Composition

Moisture, protein, fat, and ash were determined using the AOAC method. Starch was calculated by subtracting 1000 grams of moisture, protein, fat, and ash from the total weight of the food.[19]

Amylose Content

The sample (20 mg) was weighed and then added with 10 mL of 0.5 M KOH. The mixture was mixed to form a suspension. The sample was dispersed into a 100 mL volume and added to distilled water until the volume reached 100 mL. A 10 mL sample of the solution was taken and placed into a 50 mLvolumetric flask. Then add 5 mL 0.1 M HCl and 0.5 mL test agent. The diluted solution was allowed to stand for 5 minutes. Next, the absorbance was measured at 625 nm. Amylose was quantified from a standard curve using amylose and amylopectin standards.[19]

Swelling Index and Solubility

The swelling and dissolving ability of starch was tested using a 2% dwb solution (w/v) of starch suspension at 90°C.[20]

Compressed Density

Thirty grams of the powder sample was carefully added to a 100 mL tube. The volume and density of the granules were read, and the sample was tapped fifty times from a height of 2 cm. The tapped density was then calculated.[21,22]

Scanning Electron Microscopy (SEM)

The morphology of the starch was examined using a scanning electron microscope. The starch sample was mixed with acetone at a 1% (w/v) suspension and left in ultrasound for 15 minutes. The sample was spread on the stub's surface and dried in an oven at 32°C for one hour. Then all samples were coated with gold and tested for accelerating voltage at 15kV and magnifications of 1500x and 3000x.[14]

Table 1: Comparison of the composition of the two varieties of corn[18]

Parameter	Corn Varieties	
	PS-43	Shalimar corn
Humidity (%)	6.06 ± 0.29	8.45 ± 0.32
Protein (%)	0.40 ± 0.10	0.35 ± 0.05
Fat (%)	0.67 ± 0.19	0.69 ± 0.15
Ash (%)	0.20 ± 0.01	0.38 ± 0.03
Amylose (%)	7.52 ± 0.29	8.09 ± 0.07

RESULT

The results of isolation, characterization of physicochemical properties, and applications of corn starch shown in tables and figures are summarized below:

DISCUSSION

Chemical Composition

Corn starch has a maximum moisture content of 10%, as determined by SNI 01-3727. Differences in moisture content can be caused by different drying times and methods. A food must have a low water content so that it can be stored for a relatively long time. Flour to be stored for a long time must have a moisture content below 10 %.[23] The maximum ash content of corn starch is 1.5 %, per the SNI 01-3727 setting. While the protein content of corn flour is almost equivalent to low protein flour, which is between 8 to 11 %.[23] Amylose is a polymer of glucose molecules linked together by single bonds. The higher the amylose content of the product, the denser the texture will be. Higher levels of amylose in flour make it less absorbent and elastic, resulting in increased hardness (Table 1).[24]

Color

According to the research of Ali *et al*., 2016. The measured values of L, a, and b for maize starch varieties PS-43 and Corn Shalimar are (84.30, -0.25, 3.47), as shown in Table 2. The color values indicate that corn starch is yellow. The differences between starches come from the unique genetic makeup of each type of starch. The presence of pigments such as carotene and other polyphenolic compounds in corn kernels also dramatically affects the starch quality.[18]

Solubility Test

Most natural starches are insoluble in cold water and organic solvents, including acetone, alcohol, and ether. However, the dispersion will become soluble in water when it reaches a certain critical temperature called the gelatinization temperature. Starch is a type of molecule that is characterized by changes in physical and chemical properties. This is due to the process of gelatinization, which takes place when the starch molecules are heated. The gelatinization process is characterized by significant swelling, increased viscosity, translucency, solubility, and a loss of birefringence.[25] This change is often caused when the starch granules break and water is able to enter the granules, causing them to swell. As the temperature increases, the viscosity of the dispersion also increases until a stable gel is formed. Stirring can help increase the viscosity of a dispersion, especially if the temperature of the dispersion is increasing. Gelling is a process characterized by high viscosity and total destabilization of the crystal structure of the granules, followed by retrogradation (a cooling-induced return to the original crystal structure) that occurs on the cooling of the gel.

Table 2: Physicochemical components of corn starch[18]

Parameter	Corn Varieties	
	PS-43	Shalimar Corn
Color value		
L	80.72 ± 0.05[a]	84.30 ± 0.25[c]
a	0.45 ± 0.01[d]	-0.25 ± 0.01[b]
B	8.60 ± 0.10[d]	3.47 ± 0.18[b]
Inflated index (g/g)	8.50 ± 0.17[a]	8.33 ± 0.21[a]
Solubility index (%)	8.00 ± 0.00[d]	6.00 ± 0.00[c]
Water absorbing capacity (g/g)	1.10 ± 0.02[bc]	1.01 ± 0.01[a]
Oil absorbing capacity (g/g)	0.80 ± 0.08[a]	0.85 ± 0.07[a]
Bulk density (g/mL)	0.52 ± 0.00[b]	0.58 ± 0.01[c]

Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC)

Water absorption capacity is the ability of a substance to bind with water under limited water conditions. Proteins can absorb water and to bind it to their structure. The water absorption capacity affects the amount of water available for starch gelatinization during heating. If the amount of water is less than the gel formation threshold, the gel will not form optimally. The water absorption capacity (WAC) of PS-43 corn and Shalimar corn was 1.10 and 1.01 g/g, respectively (Table 2). Previous studies have found that similar water absorption capacity exists among maize cultivars.[12,26] The different starch structures found in different types of flour can be due to the variations in their molecular composition. The involvement of hydroxyl groups in starch chains can reduce the WAC.[27] The loose association of amylose and amylopectin molecules in starch granules is responsible for the high WBC.[28] The ability of dry starch to bind fat physically by capillary attraction is an important factor in weight control. Oil absorption capacity is affected by the protein and fat content of the food. The more fat or protein in a food, the more oil the food will absorb. The ability of oil to be absorbed into the skin is related to the physical oil-trapping phenomenon and the role of protein hydrophobicity. Oil absorption capacity is also affected by the structure of starch molecules. Corn starch can help to absorb oil during soaking, as it breaks down complex molecules into simpler ones.

Corn Starch Chemical Composition

The chemical composition of corn starch varies depending on the variety of corn used. Table 1 shows the chemical composition of two different varieties of corn starch. The average moisture content of starch was 6.06 to 10.62%, protein content was 0.35 to 0.52%, and fat content was 0.25 to 0.67%. The moisture content of these starches falls within

Table 3: Morphological parameters of corn starch[18]

Parameter	Corn Varieties	
	PS-43	Shalimar Corn
Average granule length (µm)	11.8	12.0
Long-range (µm)	6.6–19.25	5.5–19.25
Average granule width (µm)	11.4	11.7
Wide range (µm)	6.05–18.15	6.05–16.5

the generally accepted range for dry products to achieve the desired shelf life. There is a difference in the moisture content of starch and protein in the two corn varieties. The genetic differences between the two maize varieties may account for the differences in their food properties.

Swelling Capacity

Swelling capacity resulted in the low swelling power of corn starch. The relationship between swelling capacity and fat content shows that when the fat content in starch is reduced, swelling occurs more quickly.[29] The swelling power of food is affected by the breakdown of starch granules, amylose, and amylopectin, which can bind to water during the heating process. Many factors can affect the binding capacity of starch, including the ratio of amylose and amylopectin, the molecular weights of these molecules, the distribution of molecular weights, the degree of branching, and the length of the outermost branch of the amylopectin molecule. Playing a role in group bonding can be beneficial.[30]

Bulk Density

The results of the bulk density of corn starch (PS-43 and Shalimar corn) are shown in Table 2 and 3. The obtained bulk densities were 0.52 and 0.58 g/mL. The size of the particles influences density; the smaller the particles, the more tightly the powder will bond. This is due to the homogeneous particle size in the powder, so the particles do not fill each other in it. The value of poor compressibility is directly proportional to the flow rate.

Scanning Electron Micrograph (SEM)

The results of scanning electron micrographs of corn starch (PS-43 and Shalimar corn) are presented in Figure 1. The size of the granules varies from small to large and oval to polyhedral in shape. The average granule length, length range, average granule width, and width range of PS-43 and Shalimar corn starch were (11.8 and 12.0 m), (6.6–19.25 and 5.5–19 .25 m), (11.4 and 11.7 m) and (6.05–18.15 and 6.05–16.5 m) respectively. There may be variations in the amylose and amylopectin content and structure of starch, affecting the starch's size and granule shape.[31]

Application of Corn Starch in the Pharmaceutical Field

Pregelatinized corn starch is commonly used as a binder-disintegrant in immediate-release tablet formulations, but it is also used in sustained-release tablet formulations. Pregelatinized corn starch is a type of starch that has been treated with a process that makes it harder and more brittle. This makes it a good choice for use in sustained-release tablet formulations because it helps keep the tablet intact over a longer period. According to the results of research conducted by Zamostny *et al*., 2012, pregelatinized corn starch can be used as a binder-disintegrant in drug formulations, and this can significantly change the release profile of the active substance of the drug. This essay aims to explore the various implications of the current political climate on the academic community. Different corn starch-based drug solubilizers showed significant differences in their effects on drug dissolution.[31]

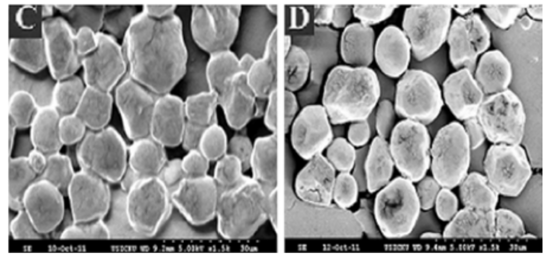

Figure 1: Scanning electron micrograph results (C) corn starch PS-43 and (D) corn starch Shalimar[18]

In addition, according to research by Oyi, Allagh, and Olayemi (2009). Corn starch can be used as a binder in the manufacture of chloroquine phosphate tablets with a concentration of 2.5–7.5% (w/v). However, the hardness of tablets with corn starch binder was lower when compared to tablets with a wheat starch binder. In addition, the use of corn starch as a binder in tablet formulation caused the tablet disintegration time to be longer but not more than 15 min for uncoated tablets. This is due to a reduction in the capillary space between the particles, which reduces the penetration of water into the tablet to cause bond separation so that the tablet disintegration time becomes longer.

Corn starch gel can be used as a tablet matrix, has good stability, and controls drug release. Retrograde heat affects the morphology and drug release characteristics of gel formulations. Retrogradation makes the gel denser, less pliable, and more resistant to digestive enzymes. The gel's cooling effect was increased when it was retriggered under cycling temperature (4/30°C) compared to isothermal conditions (4 °C). Retrogradation at cycling temperature slows the release of theophylline, forming a stable amorphous network.[33]

StarLac, a coproduced filler binder, consists of 85% a-lactose monohydrate and 15% natural corn starch. This excipient shows the lowest elastic recovery with a high binding capacity compared to other starches, and corn starch forms a filler with lactose monohydrate with excellent ductility. Another advantage of this product is that it can be used as a binder and disintegrant. To create products with good flow properties, compatibility, and disintegrant properties, only two components (a-lactose monohydrate and corn starch) have been successful.[34]

CONCLUSION

Corn starch is obtained from ground corn kernels which are then precipitated to form a corn starch precipitate. This precipitate is then dried using an oven. The physicochemical properties of corn starch were tested by measuring color, solubility, water absorption, oil absorption, chemical composition, amylose content, swelling and solubility index, compressibility and using a scanning electron microscope. Corn starch can be used as a binder-disintegrant tablet, binder, and filler in tablet preparations.

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