Developing natural film for seasoning packaging of instant noodles

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Abstract

This research aims to develop films from natural materials to be used as seasoning packaging for instant noodles. Natural materials such as bananas and konjac are used as raw materials for film-forming. There were 27 formulations of film-forming, including 9 formulas from the banana starch film, 9 formulas from banana starch blended with konjac powder 0.5% w/w, and 9 formulas from banana starch blended with konjac powder 1.0% w/w. The mechanical and physical properties of various formulation films were tested. When selecting a formulation film that meets the packaging requirements for 2 formulations by selecting one banana starch film and one banana starch film blended with konjac powder, it was found that the film formula B4Gly20 (banana 4% W/V and glycerol 20% V/V) and formula K05/4Gly20 (konjac 0.5% W/V blended with banana 4% W/V and Glycerol 20% V/V) have the best fit. They had properties close to specifications such as thickness and water permeability, not significantly different at 0.05%, and high tensile strength of 4.015 and 5.172 N.mm⁻². The flexibility was 27.67 and 22.22 percent, and the water vapor permeability was 0.0063 and 0.0021 g.hr⁻¹.cm⁻², respectively., resistance to acidic solutions, and can be formed into strong packaging film, etc. When applying these two film formulas to the seasoning packaging of instant noodles, it was found that both film formulations did not prevent moisture in the air. The film formula B4Gly20 effectively prevented oil leakage. And also, B4Gly20 was more resistant to oxygen penetration into the cooking oil than K05/4Gly20 formulation film, but film formulation B4Gly20 was dissolved in hot water 100 ± 10 °C slower than K05/4Gly20. The results showed that the film formulation B4Gly20 was suitable for application in the seasoning packaging of instant noodles.

1. Introduction

Nowadays, the use of plastics and foam as packaging has played a huge role in human daily life. This causes environmental problems which are caused by non-degradable materials causing pollution, especially from materials used for various packaging, including food packaging. Plastic film is commonly used in food packaging today. But the plastic film is difficult and takes a long time to decompose. Therefore, one possible solution is to reduce the number of plastics used in packing or wrapping food by using other materials with had similar properties to plastic and could be used for food packaging also. In the same way, it could have a special property that is soluble in water and could be eaten to replace plastic deposal [1, 2]. At present, there has many studies and the development of methods for producing packaging made from biodegradable raw materials. And it is also a staple that is easily available locally and produced as edible film, which is a thin sheet material that is edible and can be used for managing food by various methods such as enrobing, dipping, brushing, or spraying to prevent oxygen, odor, fat, moisture and microorganisms passes out from food. It can be used to prevent food deterioration. Moreover, they are used to prevent the loss of preservatives or rancidity and extend the shelf life of food [3]. The use similar to plastics includes slowing the penetration of moisture and gas. Prevents the loss of essential oils, wraps food free from microbial contamination, and prevents breakage and damage, etc., the production process of edible film is similar to general film production, such as casting, extrusion, compression,
etc. The factors that affect film-forming are (1). The structure of the polymer which most polymers are semi-crystalline, and semi-amorphous: a small fraction of them are all crystals. The lattice of high-crystalline polymers is stronger than the lattice of low-crystalline polymers. (2). The type of solvent suitable for the dissolution of each polymer is according to the nature of the polymer any polymer with a high dielectric constant will dissolve well in a solvent with a high dielectric constant. Polymers with low dielectric constants are highly soluble in solvents with low dielectric constants. Polymers of highly charged cellulose derivatives are highly soluble in highly polar solvents, such as water, glycol, and alcohol. (3) Solvent evaporation temperature which heated the polymer solution to evaporate the solvent. While heating, the molecules move without direction (Brownian motion), after which the solution cools, this slows down the movement of molecules and forms a bond between the polymer. This bonding between the polymer and the polymer may form a lattice in addition to the polymer and the solvent, most film-forming had added plasticizer resulting in the physical properties of polymer changes. This is due to the bonding between the polymer and the plasticizer. As a result, the bond strength between the polymer and the polymer is reduced. When the increased movement of the polymer chain, the tensile strength of the film decreases. Therefore, the addition of plasticizers results in a film that for not brittle and has greater flexibility [4]. (4) Plasticizers, which according to IUPAC means substances that are combined with plastic or elastomer to help increase flexibility. Durability and elongation are divided into two types: Internal Plasticizer, which is a substance that is added as part of the polymer and acts as a copolymerization matter. The bonds between the plasticizer molecules and the polymer are covalent, not easily broken. An external plasticizer is a substance added to the polymer structure and then weakens the bonding force between the polymer chain molecules that are close together, resulting in a weakened structure. A good plasticizer must be homogeneous with the film-making polymer (compatibility) colorless, high boiling point, volatile, non-toxic, non-flammable and resistant to heat. If the plasticizer used is qualified, it will prevent separation during film drying [5]. Many types, such as mono, di and oligosaccharides. Most of which are glucose, fructose, and polyols, including glycerol, sorbitol, and polyethylene glycol. Fats and fat derivatives generally used plasticizers about 10 – 60 per cent of dry weight. If too much plasticizer is used, the water vapor permeability and mechanical properties will deteriorate. (4.1) Glycerol or Glycerine is a substance named Polyhydric alcohol is chemically known as 1,2,3-propanetriol (1,2,3-Propanetriol) and has the molecular formula C₃H₈O₃. It is a colourless, odourless, thick liquid with a sweet taste, soluble in water and alcohol. Slightly soluble in some organic solvents such as ether and Dioxane, insoluble in hydrocarbons. Glycerol has a molecular mass of 92.09 g. mol⁻¹, a melting point of 17.9 °C, a boiling point of 290 °C, and a specific gravity of 1.26. Glycerol is a by-product of hydrolyzing oils or fats to produce soap or fatty acids salt. Glycerol can also be synthesized from Propylene, a hydrocarbon derived from petroleum. Glycerol is divided into 4 quality classes, namely chemical grade, dynamite grade, technical grade and pharmaceutical grade. Glycerol is used as a solvent in the manufacture of explosives (Dynamite), cosmetics (Liquor soup), candy (Candy), liquor (Liqueurs), Ink (Ink), and Lubricants. Glycerol is also a food source in the production of antibiotics [1]. (4.2) The role of plasticizers in edible films, the addition of plasticizers during the preparation of edible films, a dissolving method is used where both plasticizers and polymers are dissolved in the same solvent. During the mixing process, the mixture is stirred and heated to the appropriate temperature and time, thus forming a film. The solvent is then evaporated under mild conditions. The use of plasticizers in this manner is external, that is, when the plasticizer is added, it binds to the polymer by covalent bonds. The formation of polar or mild hydrogen bonds weakens the intermolecular forces of the polymer chains, that are close together. This is caused by two reasons: the influence of heat during the preparation of the film solution allows the plasticizer to penetrate easier to get between the polymer chains and the hydrogen bonds and other forces between the polymer molecules broken down due to the strong attraction between polymer and plasticizer. This prevents the polymer molecules from binding to each other, resulting in a more flexible film. On the other way, the tensile strength is reduced. In addition, the energy used to separate the polymer chains that are close together is related to the energy that stimulates the diffusion of gas and water vapor through the film. As the attraction between the chains decreases, that energy decreases, and gas permeability and the water vapor through the film increase. Types of edible films and their uses, edible films can be classified according to the material used to make the film. Most of them are substances natural polymers such as proteins, lipids, and polysaccharides, etc may be used as single polymer or blended polymer characteristics (1) Protein film generally, protein films have better mechanical and permeability properties than those prepared from polysaccharides. Protein films are produced from various proteins such as collagen, gelatin, corn protein, wheat protein, and soy protein (2) Lipid film, Lipid films are mainly used for forming coatings on such as fruit and vegetable coatings. Lipid coating for food is to prevent moisture transfer. Reduce the abrasion of the fruit skin during transportation. Prevent browning of some fruits. Examples of lipid films are wax films, their permeability is very low, especially paraffin waxes and waxes. Another type of lipid film is a surfactant. Coating food with surfactants reduces surface water activity and water evaporation rate. The most effective coating is fatty alcohol containing 16 to 18 carbons, such as glycerol monopalmitate and glycerol monostearate [6]. (3) Polysaccharide film, a polysaccharide is a carbohydrate in which one molecule contains 10 or more monosaccharide molecules
to hundreds or thousands of units. Polysaccharides found in nature have large molecular masses and have a high molecular weight. It is an amorphous compound, colorless and mostly tasteless. Some polysaccharides can be used. In the production of edible films or coatings such as alginate, pectin, carrageenan, chitosan, cellulose derivatives, starch, etc., due to the nature of these polymers, they have hydrophilic properties, therefore it is not suitable to use this type of film to prevent moisture penetration. that causes the food to become rancid. Properties that should be considered for edible films include film translucency. The smoothness of the film responds to moisture and water solubility, etc. The resulting film is colorless, odorless, non-toxic, strong and flexible, low oxygen permeability. Food such as coffee, seasonings for instant noodles, instant soups, artificial fillings for sausage products, and various coating applications such as prunes, tomatoes and fruit candy, etc. Types of polysaccharides used in the preparation of edible films (3.1) Alginate is a substance extracted from brown seaweed, commonly used in the form of sodium alginate. Sodium alginate film formation is a result of gelling. When alginate reacts with polyvalent cations, calcium ions are the most effective gelling ions. It is usually used in the form of calcium chloride salt because of causes good quality agar gel, coated with alginate film is mainly used in meat products such as beef, pork, and chicken parts to reduce water loss. In addition, this gel film also reduces the number of microorganisms on the meat surface that could be maintained the red color of the meat to last longer than normal meat. It prevents lipid oxidation in food and improves the texture of the product. (3.2) Pectin, is a complex group of polysaccharides found in the lamella layer, the central part of plant cells. The pectin is used as a coating with a low methoxyl group, which forms a gel. When the pectin solution reacts with calcium ions after drying the gel. They will form a pectinate film and are usually used to coat directly on the food surface. This film acts as a scattering agent, preventing the packaged food from losing water. Due to a pectinate film having high vapor permeability, therefore, the film must be adjusted to have reduced water vapor permeability. By coating the lipid film over the pectinate film first, therefore, it can be used with a wider range of food products. (3.3) Carageenan is a group of polysaccharide sulfate extracted from red algae. When the hot carrageenan solution cools to form a gel. The carrageenan gel used to coat food acts as a scattering agent, preventing encapsulated food from losing water. It is often used to coat the semi-moist margarine slices (intermediate moisture cheese analogue) due to the gel containing carrageenan and agar (agarose) containing sorbic acid. It prevents microorganisms from growing on the surface of the product (3.4) Chitosan Chitin - Chitosan is a fiber extracted from the hard shells of shrimp and crabs, tasteless and insoluble. Chitosan film is prepared in an organic acid solution. It is a hydrophilic film with a clear, colorless appearance, toughness, flexibility, and high tensile strength, and prevents the penetration of oxygen and carbon dioxide well but less water vapor permeability. Chitosan film is used to coat vegetables and fruits to extend shelf life as it can control moisture transfer between food and external conditions. Moreover, it could control the gas transfer rate and can control temperature. It is also used to control drug release. (3.5) Cellulose derivatives are a direct-chain homopolymer of glucose found in plant cell walls. By combining with xylan and lignin, the cellulose molecule has a free hydroxy group remaining makes it possible to be replaced by methyl, ethyl, hydroxymethyl, hydroxyethyl, carboxymethyl, and hydroxypropyl methyl to methylcellulose (Methylcellulose, MC), hydroxyethylcellulose (Hydroxyethylcellulose, HEC), carboxymethyl cellulose (Carboxymethyl cellulose, CMC) and hydroxypropyl methylcellulose. (Hydroxy propyl methyl cellulose, HPMC), etc. These cellulose derivatives can be used to produce edible films. The appearance of the film is colorless, flexible, moderately strong, and good resistance to penetration of fats, oils, oxygen, or odors. But it is a film with high vapor permeability, therefore, the lipid film must be coated over another layer of film (3.6) Starch is a polymer of glucose and is a type of homopolysaccharide found mainly in plants obtained from the process of photosynthesis. Plants are stored in parts such as tubers, roots, stems, fruits and seeds. Most of the starch is obtained from grains such as rice, maize, wheat, and sorghum and some are obtained from tubers and roots of plants such as sweet potatoes, potatoes, and cassava, and some are derived from fruits such as bananas, apples, guavas, etc [15–17]. Starch derived from each plant is unique, is having a different chemical structure in molecules and will have a shape and physical properties that are also different. Starch can be made into an edible film but it is a film that is not sticky, inflexible, and easily soluble in water, therefore it is a film that has limitations in use. That has been separated (fractionation) amylose from starch to prepare the film. Characteristics of this amylose film are colorless, odorless, non-toxic, strong, flexible, glossy, with high grease resistance and low oxygen permeability but there is a disadvantage in the problem of dissolving amylose to prepare the film. This preparation must use high temperature under pressure; therefore, amylose derivatives are commonly used, which are more soluble in water. Applications of amylose films, such as for food packaging used to coat fruit [7]. In this research, the researcher is interested in (1). Starch from bananas is the reason that bananas contain highly nutritious nutrients, consisting of water, starch, protein, fat, fiber, vitamins and minerals. To high content of starch, calcium, iron and potassium. Banana is a tropical plant, native to Southeast Asia especially the Malay Peninsula, which Thai people have known and been familiar with for a long time. Bananas are currently one of the most important economic crops of the country and could be produced products for the market throughout the year. It is widely cultivated in almost every region, covering an area of approximately 8 hundred thousand rai.
There are many varieties of bananas grown in Thailand, including wild bananas and cultivated bananas could be classified into 59 species. The most popular and widely consumed varieties are Nam Wa, Hom Thong and Khai. It is a plant that has been planted a lot because it can be used in every part of the tree. The fruit of the banana can be eaten when ripe and can be cooked in a variety of dishes. Including products that can be sold both domestically and internationally in millions of tons. With more production expansion in different regions, it was found that the growth rate of bananas increased every year. In addition to being consumed in the country, it is also an export product. It is also used in the processing industry. At present, if there is an improvement in quality and increasing the production volume to meet the market demand would be able to generate more income for the country. Kluay Nam Wa is known by the locality such as Banana Tai (Chiang Mai and Chiang Rai), Banana Tani Ong (Ubon Ratchathani), Banana Mali Ong (Chanthaburi), Kluai Ong (Chaiyaphum) than the egg banana, it has a square shape, a long stem, and the peel is thicker than the peel of the egg banana. There are many uses for bananas. From raw to ripe, such as making banana starch, banana chips, baby food, dried bananas, scrambled bananas, etc.

In unripe bananas, the starch content is about 20%–25% and during ripening, starch is hydrolyzed to sucrose, glucose, and fructose. When ripe, there will be about 1%–2% starch remaining during the ripening process. When ripe, the starch content in bananas is reduced. As the sugar content increases, bananas become sweeter. In bananas containing the AA AAA genome, such as Kluay Nam Wa and Kluay Hom, banana starch content decreases significantly as the banana ripens. It will start to reduce when the bananas start to change color. The amount of acid from raw to cooked is relatively low. As for the bananas containing the ABB genome, such as Kluay Nam Wa, and Kluay Hak Muk, the starch content decreased and the sweetness increased with the degree of ripeness. But this change was not as dramatic as in bananas in the AA AAA genome group and the acid content was relatively high. So, it could seem that these bananas tend to have a lot of starch, both raw and ripe. This creates a sticky and slightly sour taste. Banana starch is a product obtained by processing raw bananas into starch, for food preservation and can be used as an ingredient in various food products such as baked goods and Thai dessert products. Raw bananas are highly nutritious, consisting of water, starch, protein, fat, fiber, vitamins, and minerals with a high content of starch, calcium, iron, and potassium higher than many types of starchy corn starch, cassava starch, etc. There are other substances such as enzymes, pectin, tannins, etc, and raw bananas are used as medicine. When it is dried and ground and mixed with water or honey to prevent and treat stomach ulcers, and diarrhea. It also has anti-fungal and antibacterial properties. Banana starch has a unique smell. It has good physical properties. It combines well with water, that is, when heated, it swells and clears. When it is cooled, it looks like jelly because it is starch with high amylose. Therefore, it has special properties, it is a good substitute for wheat starch in baked goods. Some products can be substituted for up to 50 percent quality banana starch. It depends on the production process, cleanliness, and ripeness of bananas. Raw bananas are high in starch and tannins but have low sugar content. The ripening of bananas provides nutritional value Changes, especially starch will be reduced to more sugar that makes bananas taste sweet, especially Kluay Khai bananas, starch will be greatly reduced. When the bananas are ripe and have relatively low acid content but Kluay Hak Muk bananas tend to have a lot of starch when raw. When cooked, the amount of starch is still very high. This makes bananas look tough and have a slightly sour taste. Raw bananas that are suitable for starch production must have a percentage of ripeness in the range of 70%–80%. If overripe bananas are used, they will have a high tannin content. When the banana starch is mixed in the product, it will have a tart taste. In case bananas are overripe, they have a high sugar content that will affect the starch production process and affect the smell product taste. Banana starch is produced by drying process or dried in the Sun until the temperature of 55 °C–60 °C, the colored starch will not turn white like the starch from tubers because it has not undergone the bleaching process. Normally, it could be used as an ingredient in baked goods or Thai desserts. The resulting food products are somewhat darker in color; which consumers will be more satisfied with than using bleached banana starch food products with good physical characteristics are considered healthy food. In addition, raw banana starch can extend the shelf life of food products longer than wheat starch or rice flour alone because raw banana starch has antifungal and antibacterial properties [8–11] (2). In many countries, konjac starch is produced, in particular, Japan has been producing konjac starch for breakfast for a long time and called this starch–produced konjac flour. The United States began to use konjac starch as a food ingredient in many types of food around the year 1900. Konjac flour has been verified to be safe and can be used in food products. Thailand began to study the production and use of konjac. The cultivars found with high glucomannan content were the A. oncophyllus konjac tubes are quite spherical, 100 – 500 microns in size, and vary in color depending on the variety and production method, for example, rather white. white to yellow and has a light brownish white color, etc. Elements that can be found in konjac flour is glucomannan, which is a type of carbohydrate-containing substance, mannose, and glucose in a ratio of 3:2, are connected by a beta (1→4), (β(1→4)), glycosidic bond with a molecular weight of more than 300,000 and an acetyl group widely distributed on the glucomannan molecular chain, which affects its water solubility when mixed with this starch. When dissolved in water, it forms a viscous solution and can form a gel when used with alkaline solutions or some hydrocolloids such as xanthan gum and carrageenan. In general, fresh Konjac tubers contain about 80–90 percent water and 10–20 percent solid parts. Particles with a diameter of approximately 2 × 10^{-2} mm, approximately
60–80 percent, mostly glucomannan, and the part with particles less than 1 × 10⁻² mm in diameter, about 20%–40%. The latter particle is classified as a Sachiko component that needs to be removed, including starches, proteins, and a substance that is irritating (Irritant), etc. Methods for producing konjac flour could be divided into 2 methods: A. Dry production (Traditional method) by grinding dry konjac disc with a thickness of 5 mm., and moisture content of 15% by stamp mills. The grinding part is separated from the impurities by using air classification, the yield of this method is quite low due to partial loss of konjac flour in the process of air blowing. Furthermore, the dry konjac discs are very stiff, making them inconvenient for particle separation. B. Improved wet method by grinding the konjac head in a water-soluble organic solvent such as ethyl alcohol and adding sodium sulfite to prevent discoloration, after that, sift through a sieve of 100 – 200 mesh. Washed the konjac flour with the above solution until white flour is obtained or, if it is produced on an industrial scale, some tools are used to increase production efficiencies, such as a grinder (Hammer mill), centrifuge (centrifugal) and sedimentation tanks (differential specific gravity settling tank) has a system to recover ethyl alcohol again. Konjac flour has many properties depending on the purpose of use and the nature of the product. There are some important properties as follows: (1.1) Increase the viscosity (water thickening) when the konjac starch is dissolved in water. The starch particles absorb water and swell, resulting in a solution with increased viscosity. The appearance of the konjac flour is Pseudoplastic, the rate of water absorption (Hydration) depends on temperature and time. When the temperature is increased, the water absorption rate will occur rapidly. Likewise, increasing the shear rate also increases the water absorption rate (1.2) Gel formation: the gel formation of konjac talc is important. Generally, gels are derived from common polysaccharides, when heated to a certain temperature, the gel breaks or breaks down the polymer network, resulting in a loss of gelling. In weakly alkaline conditions such as potassium carbonate, konjac powder gives a gel that is heat resistant (Thermal stability) and is very strong and stable, even boiled in boiling water. Re-heating of the gel contributes to increased strength and stability of the gel (1.3) Film formation when the konjac starch solution causes water loss or is a dried tough film: The resulting film is stable in hot water, cold water, or even in acidic and alkaline systems well. And the film is highly stable even after several hours of boiling in boiling water. The film obtained from konjac flour has a softness (supplesness) and can be made in transparent, translucent and opaque films. Increasing the amount of humectant such as glycerol results in a decrease in the strength of the film. But it has the effect of weakening the film and water permeability increased. Film characteristics depend on the additives whether they are hydrophilic or hydrophobic material, and decrease when using a non-polar additive (Hydrophobic substance) such as corn oil. (1.4) Viscosity: Konjac starch together with starch, or in combination with other gums and stabilizers can increase the viscosity of the product without causing a change in the smell or taste. Konjac flour affects the viscosity of the starch or hydrocolloid used in conjunction with the value increased greatly in maintaining system viscosity in both heating and cooling processes, e.g. Using konjac starch with modified waxy maize starch or using konjac starch with corn starch, etc. (2) Utilization of konjac flour (2.1) Direct use as food: The Japanese are a group of consumers who have known konjac flour products for a long time. Konjac flour is commonly used to produce strands (Vermicelli) or lumps. Therefore, before eating it should be washed with clean water several times until the alkalinity is gone and then scalded with boiling water again, drain and dry before eating or cooking. (2.2) Use in various food products: (2.2.1) Use in jams and jellies because konjac starch has a viscous property and can gel in combination with alkali or used with some hydrocolloids such as kappa-carrageenan or xanthan gum. Konjac flour is used to make jams and jellies. The resulting product will have a gel texture that varies depending on the method used. In combination with the alkali, the resulting gel will cause problems such as residual odour and sometimes unwanted appearance of the gel. The use of konjac flour in combination with hydrocolloids in the production of jams and jellies is a popular method because it can solve the problem of alkali odour and is able to produce both gelatin type and pectin type (2.2.2) processed meat products, konjac flour can be used to reduce fat content and add more fibre in the product. Products using konjac starch to replace fat have been recognized as sensory in terms of texture, appearance and flavour, etc. (2.2.3) Processed products without gel: Konjac flour can be used as a thickening agent and stabilizer in non-gelatinized processed products, especially emulsion products such as ice cream, whipped cream and milk (Milk drink), etc. In the production of ice cream will greatly reduce the cost because konjac flour is cheaper and can also be used in smaller quantities. The product has a sensory acceptance within the consumer acceptance criteria. Popularity used konjac flour, about 0.1–0.5 per cent. (2.2.4) Processed products from starch, and pasta products have different shelf-life stability depending on the heat treatment process before consumption: This can often result in texture issues or unwanted appearance. Using konjac flour with other flours can improve its texture and retain the mouthfeel of the product after being heated several times. In addition, konjac flour is used to make low-calorie noodles. There will be a sensory acceptance value that is within the range [12].

In this research, the researcher is interested in studying the optimum ratio for film-forming from Kluay Nam Wa starch blended with konjac powder which is a natural raw material that can be biodegradable and it is also a staple that is easily available locally. By using raw bananas and konjac powder to produce raw materials used in film-forming. Banana starch and konjac powder are naturally derived polymers and therefore can be molded using a single polymer or a copolymer. Furthermore, the researcher is interested in producing films made from...
naturally polymers that are banana starch and konjac powder in order to be used as seasoning packaging for instant noodles instead of plastic.

2. Research methodology

2.1. Experimental materials: bananas and konjac tubes

2.2. Preparation of raw materials

Banana Starch and Konjac Powder, Banana starch is prepared by cutting bananas into thin strips, soaking in 0.1% sodium metabisulphite solution (Sodium metabisulphite; Na2S2O5, Lab grade, % Assay 98.0%, MW 190.10, Northern Chemicals And Glasswares, Thailand) for 10–15 min, then baking at 60°C for 24 h, then ground them thoroughly. Konjac powder can be prepared by cutting fresh konjac tubes into thin strips, soaking in 0.1% sodium metabisulphite solution for 10–15 min, spinning and extracting with soluble organic solvents, and baking at 60°C for 12 h, then ground thoroughly.

2.3. Study of the optimal ratio for film-forming

2.3.1. Study to determine the optimum ratio for banana starch film forming

By mixing the prepared banana starch with distilled water in the ratio in different concentrations were 2%, 4%, and 6% W/V and heated to 70°C and stirred further by a magnetic stirrer until the solution was gelled. The gelatin (food grade) solution had been added. (With a concentration of 3% W/V) with a concentration of 30% V/V of banana starch solution. Continue stirring for 3 h, then filter the mixed solution to separate the undissolved parts with a thin white cloth. Until a fine solution without sediment is obtained, then add glycerol (Glycerol; C3H5(OH)3, Lab grade, MW 92.09 g. mol⁻¹, Northern Chemicals and Glasswares, Thailand) in the amount of 20%, 40%, and 60% of the banana starch weight. Then, continue stirring for about 1 h. Weigh the mixed solution about 125.00 ± 0.05 g and pour it into a 20 cm diameter plastic tray. Place it in a hot air oven at 40°C for 20 h, gently peel off the film, and store it in a desiccator for at least 24 h before being subjected to mechanical and physical testing.

2.3.2. Study to determine the optimum ratio for film-forming banana starch blended with konjac powder. Konjac powder 0.5% and 1.0% by weight of banana starch were mixed with distilled water and stirred by a magnetic stirrer for 3 h. The banana starch was mixed with distilled water in a ratio with different concentrations (2%, 4%, and 6% W/V) and heated to 70°C, and stirred by a magnetic stirrer until the solution was gelled. Add gelatin solution. (With a concentration of 3% W/V) 30% V/V content of banana starch solution Continue stirring for 3 h, then mix the two solutions and continue stirring for another 1 h. The mixture is filtered to separate the undissolved parts with a thin white cloth. After that glycerol is added in the amount of 20%, 40%, and 60% of the banana starch weight then continue stirring for about 1 h. Weigh approximately 125.00 ± 0.05 g of the mixed solution and pour it into a 20 cm diameter plastic tray, bake in a hot air oven at 40°C for 20 h, gently peel off the film, and store. Keep them in the desiccator for at least 24 h before being tested for mechanical and physical properties further. For example, film abbreviations, B2Gly20 means a film containing 2 g of banana starch and 20% glycerol by weight of banana starch, while K05/2Gly60 is a film containing 0.05% of konjac powder by weight of banana starch, 2 g of bananas and 60% glycerol by weight of banana starch, etc.

2.4. Film properties test

2.4.1. Thickness measurement

The film was tested using a micrometer, each condition was tested at 5 points and the mean was determined.

2.4.2. Measurement of tensile strength and elongation at break

The film had cut to a width of 2.00 cm and a length of 5.00 cm. By clamping two ends of film to a simple mechanical test kit, 1 cm long on each side. The film was broken with a weighted pendulum and record the length of the film and the weight of the pendulum used as shown in figure 1, the film elongation distance and the weight of the pendulum used were recorded by testing the formula 3 times each, and using the data obtained to calculate the average tensile strength and elongation at the break of all film conditions.

2.4.3. Study on hygroscopic properties

The film was cut to size 3.00 ± 3.00 cm², and record the weight value (W0), but the film in the test can close the lid tightly. Open the lid of the test can and place it in a humidity-controlled cabinet at 75 ± 0.5% RH at room temperature. Remove the test can from the cabinet, close the lid tightly and weigh the film to determine the weight of the film. The sample weight (W1) was recorded at 30 min, 1, 2, 4, 6, 24, 48, and 72 h. Weight gain per area and thickness were calculated. film (adapted according to the method of Y J Wei et al 2011) [13].

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2.4.4. Steam permeation rate study
Add 20 ml of distilled water into a beaker with a diameter of 4.00–4.50 cm, cover the beaker with film and cover with adhesive tape and weigh the exact weight. Then placed in a hot air oven at a temperature of 60 °C, with humidity at 20 ± 0.5% RH. The weight of the beaker was recorded every 1 h for 5 h. The relationship between the water weight was graphed versus time to determine the slope and calculate the WVTR.

2.4.5. Study of water resistance properties
The film had cut into a square shape, size 3.00 × 3.00 cm², then place it on a watch glass and drop 5 drops of water on the film and observe and record the time that the water penetrated through the film to the surface watch glass. which is the water permeability value of the film by repeating the experiment 3 times on each condition (modified according to the method of Y J Wei et al 2011). [13].

2.4.6. Solubility test
2.4.6.1. Properties test in strong acid and strong base solutions
Soak the formed film in the acid solution. (Hydrochloric acid) with a pH of 1.0 ± 0.5 and a base solution. (Sodium hydroxide) at pH 14.0 ± 0.5 for 3 days, then the film characteristics were observed and recorded.

2.4.6.2. Hot water qualification test
The film had cut to size 3.00 × 3.00 cm², Weigh the film and filter paper. The weight values (W₀ and W₁) were recorded and the film was immersed in hot water at a temperature of 100.0 ± 10.0 °C for 1 h, then filtered by filter paper. Bake at 40 °C for 2 h, leave to cool in a desiccator for 30 min, then weigh and record the resulting weight (W₂) (modified according to the method of Y J Wei et al 2011) [13].

2.4.6.3. Coldwater qualification test
The film had cut to size 3.00 × 3.00 cm². Weigh the film and filter paper. The weight values (W₀ and W₁) were recorded and the film was immersed in cold water with a temperature of 0.0 ± 0.10 °C for 1 h, then filtered by filter paper. Bake at 40 °C for 2 h, leave to cool in a desiccator for 30 min, then weigh and record the resulting weight (W₂) (modified according to the method of Y J Wei et al 2011) [13].

2.4.6.4. Qualification test in room temperature water
The film had cut to size 3.00 × 3.00 cm². Weigh the film and filter paper. The weight values (W₀ and W₁) were recorded and the film was immersed in water with a temperature of 25.0 ± 10.0 °C for 1 h, then filtered by filter paper. Bake at 40 °C for 2 h, leave to cool in a desiccator for 30 min, then weigh and record the resulting weight (W₂) (modified according to the method of Y J Wei et al 2011) [13].

2.4.7. Casting film as seasoning packaging
The resulting film had cut to a size of 4.00 × 8.00 cm². Casting the film to form a packaging envelope by using a normal sealer. Wait for the film from the molding to cool, then observe the resulting package and record the results.

2.5. Utilization of the film obtained
2.5.1. Oil leakage test: the film had cut to size 4.00 × 8.00 cm²
Casting the film into a packaging envelope using a conventional sealer. Then instant noodle seasoning oil had packed in, Wai Wai brand, minced pork flavor. Observed and recorded the results every 5 days for a total of 15 days [1–4].
2.5.2. Dissolution test of seasoning
The film had cut to size 4.00 \( \times \) 8.00 cm\(^2\). Casting the film into a packaging envelope using a conventional sealer. Then instant noodle seasoning had packed, Wai Wai brand, minced pork flavor, then boiled in hot water at a temperature of 100.0 ± 10.0 °C. Observe and record the time the package melts.

2.5.3. Dissolution test of instant noodle seasoning packaging
The film had cut to size 4.00 \( \times \) 8.00 cm\(^2\). Cast the film into a packaging envelope using a conventional sealer. Then the instant noodle seasoning oil had packed, Wai Wai brand, minced pork flavor, and boiled in hot water at a temperature of 100.0 ± 10.0 °C. Observe and record the time the package melts. It will be tested every 5 days for a total of 15 days.

2.5.4. Packaged change testing of products
The film had cut to a size of 4.00 \( \times \) 8.00 cm\(^2\), the instant noodles seasoning oil had packed, Wai Wai brand, minced pork flavor, and then formed into a package by using a normal sealer. The control variable was PP plastic bag containing Wai Wai brand instant noodle seasoning oil, minced pork flavor, as well as film packaged in both formulas above. Variations of the packaged product had been tested by peroxide value (according to the AOAC method, 2000) \([14]\) of the instant noodles seasoning oil every 5 days, for a total of 15 days \([1–4]\).

3. Research results and discussions
According to research, the starch was prepared from unripe bananas by cutting the raw bananas into thin slices, drying them until they were dry, and then grinding them thoroughly. Sift with a 60-mesh sieve, the resulting banana flour will look like a white to yellow powder, smells of raw banana, and has a relatively smooth texture. But, konjac powder is prepared by extracting konjac tubers with soluble organic solvents. Washed and dried until dry, then ground finely and sifted with a 60-mesh sieve. The result is that konjac powder is fine, white, and odorless granules as shown in figure 2.

3.1. Characteristics of the casting films
The resulting film looked different. It depends on various factors in the molding process, such as the number of ingredients such as the concentration of a banana starch solution. And the amount of glycerol has a great effect on the appearance of the film, the heating temperature of the film solution and time for stirring the film solution, etc. From the results of film-forming experiments from various formulas, it was found that the formula for obtaining a film that meets the requirements for application as a seasoning package in instant noodles to further studies were conducted on several formulas such as B4Gly20, B4Gly40, B6Gly20, and K05/4Gly20, which were mostly formulated with low glycerol. Therefore, films with good properties and suitable for further study will be obtained. The results of the experiment are shown in table 1.

3.2. Film properties test
3.2.1. Thickness measurement
The film thickness is quite different. This may be due to the film solution used in film-forming. There are different concentrations of starch, 2%, 4%, and 6%, resulting in different film thicknesses. The average thickness was in the range of 0.11–0.22 mm. However, when applying the film thickness values obtained from this test statistically calculated using advanced statistical methods (ANOVA), it was found that the average thickness had no significant differences in film formulations (\( P \leq 0.05 \)), but this value exceeds the industry standard that the thickness of the plastic bag is not more than 0.10 mm.
3.2.2. Measurement of tensile strength and elongation at break

From the tensile strength test, it was found that the film formula K05/4Gly20 had the highest tensile strength, followed by formula B4Gly20 and formula K10/4Gly60 having the lowest tensile strength. The findings that the amount of Glycerol affects the tensile strength value. For the reason that a film formulated with a small amount of glycerol would have high tensile strength, and the formulated film containing a large amount of glycerol has a low tensile strength. It can be concluded that the amount of glycerol is inversely proportional to the tensile strength. As for the film’s elongation, it was found that film formula B2Gly20 had the highest elongation value, and film formula K05/4Gly60 had the lowest elongation. It can conclude that the amount of glycerol greatly influenced the film elongation value. Because if the film has a volume of too much or too little glycerol then it will result in less film elongation. Therefore, in film-forming, glycerol should be used in moderation so that the resulting has an appropriate elongation value to that film. Which can be calculated from the equation (1)

\[
\text{Breaking tensile strength (N/mm}^2\text{)} = \frac{\text{force (N)}}{\text{Width (mm) } \times \text{ Thickness (mm)}}
\]

From table 2, it can be concluded that the tensile strength and elongation values of the film depend on different film-forming compositions such as glycerol content, etc. Therefore, choosing the right formulation for film-forming depends on the utilization of the film. In this research, we want to apply the film to be used as seasoning packaging of instant noodles. Film formulas with properties that are close to the specifications are formulas B4Gly20 and K05/4Gly20, which have tensile strengths of 4.015 and 5.172 N. mm\(^{-2}\) and elongation at break values of 27.67 and 22.22%, respectively. Most suitable to be studied in the next step.

3.2.3. The study of hygroscopic properties

From testing values of the hygroscopic properties of various film formulations, it showed that the moisture content of the film at the beginning was quite high. The film is very moist and had much weighed. But when the film had stored in the dehumidifier for an extended period, the moisture contained in the film will decrease.

| Table 1. Characteristics of sample films prepared from konjac powder and/or banana flour in some conditions. |
|---|---|---|---|
| Formula | Components | Film Appearance | Picture of film |
| B4Gly20 | Banana Flour 4% | Thin film, smooth surface, glossy on one side, non-glossy on the others. | ![Picture of B4Gly20 film] |
| B4Gly40 | Banana Flour 4% | Thin film, smooth surface, glossy on one side, non-glossy on the others. | ![Picture of B4Gly40 film] |
| B6Gly20 | Banana Flour 6% | The smooth film, glossy on one side, non-glossy on the others. | ![Picture of B6Gly20 film] |
| K05/4Gly20 | Banana Flour 4% Konjac Powder 0.5% Glycerol 20% | The smooth film, glossy on one side, non-glossy on the others. | ![Picture of K05/4Gly20 film] |
gradually, and the weight reduced until the moisture in the film had gone. When the film is weighed, it had a relatively stable weight. When the average weight at different times had been brought to calculate the percentage of moisture, it was found that the percentage of moisture gradually decreased until the moisture in the film was exhausted. The percentage of moisture obtained is therefore constant.

3.2.4. Water vapor permeation rate study
When using the obtained data to graph the relationship between the weight of water lost and time to determine slope and calculate WVTR, it can be calculated as shown in equation (2). The experimental results are shown in table 3.

\[
\text{Water Vapour Transmission Rate; WVTR} = \frac{\text{slope}}{\text{film area}}
\]

3.2.5. The study of water resistance properties
From the study of the water-resistance properties of the film, it was found that the film formulations had the water permeability values so close that they could not be distinguished. Therefore, the water permeability values obtained from this test were statistically calculated to compare the differences using advanced statistical methods (ANOVA). The different formulas were not significantly different \((P \leq 0.05)\).

3.2.6. Solubility test

3.2.6.1. Properties test in strong acid and strong base solutions
From the test of properties in strong acid solution and strong base, it showed that most of the film formulations were not soluble in acid solution but soluble in base solution. From the experiment of soaking different formulations of film in hydrochloric acid solution with pH 1.0 ± 0.5 and sodium hydroxide solution with pH 14.0 ± 0.5 for 3 days, it appeared that film in acid solution contains only a fraction of the acid, slightly soluble in acid solution. On the other hand, the film in the base solution is highly soluble. Different formulations of banana starch films had better solubility than banana starch films blended with various formulas of konjac powder. Therefore, it could be said that the prepared films were more resistant to acidic solutions than to base solutions.

3.2.6.2. Hot water qualification test
From testing the properties in hot water of various film formulations, it was found that when the banana starch film and the banana starch film were blended with konjac powder, they had immersed in hot water at a temperature of 100.0 ± 10.0 °C for 1 h. The results showed that some formulations of the banana starch film were better soluble in hot water than banana film blended with konjac powder. Because there is a percentage of film that dissolves more than 80.00% or more in many formulas. However, only some formulations of

| Table 2. Summary of thickness and tensile strength test results. |
|---------------------------------------------------------------|
| Formula | Average Thickness (mm) | Average Tensile strength (N. mm\(^{-2}\)) | Formula | Average Thickness (mm) | Average Tensile strength (N. mm\(^{-2}\)) | Formula | Average Thickness (mm) | Average Tensile strength (N. mm\(^{-2}\)) |
|---------|------------------------|---------------------------------|---------|------------------------|---------------------------------|---------|------------------------|---------------------------------|
| B2Gly20 | 0.12                   | 2.215                           | K05/2Gly20 | ND                     | ND                             | K10/2Gly20 | ND                     | ND                             |
| B2Gly40 | 0.13                   | 0.763                           | K05/2Gly40 | ND                     | ND                             | K10/2Gly40 | ND                     | ND                             |
| B2Gly60 | 0.13                   | 0.702                           | K05/2Gly60 | ND                     | ND                             | K10/2Gly60 | ND                     | ND                             |
| B4Gly20 | 0.11                   | 4.015                           | K05/4Gly20 | 0.14                   | 5.172                          | K10/4Gly20 | 0.17                   | 1.661                          |
| B4Gly40 | 0.14                   | 1.424                           | K05/4Gly40 | 0.18                   | 0.921                          | K10/4Gly40 | 0.19                   | 0.434                          |
| B4Gly60 | 0.15                   | 1.049                           | K05/4Gly60 | 0.19                   | 0.478                          | K10/4Gly60 | 0.22                   | 0.337                          |
| B6Gly20 | 0.17                   | 2.250                           | K05/6Gly20 | 0.16                   | 1.817                          | K10/6Gly20 | 0.15                   | 2.329                          |
| B6Gly40 | 0.18                   | 1.059                           | K05/6Gly40 | 0.22                   | 0.943                          | K10/6Gly40 | 0.19                   | 1.048                          |
| B6Gly60 | 0.18                   | 0.873                           | K05/6Gly60 | 0.21                   | 0.632                          | K10/6Gly60 | 0.19                   | 0.522                          |
Table 3. Results of the packaging forming test.

| Formula | The nature of the packaging | Picture of packaging |
|---------|----------------------------|----------------------|
| B2Gly20 | Can be moulded into a package strong seams | ![B2Gly20](image) |
| B4Gly20 | Can be moulded into a package strong seams | ![B4Gly20](image) |
| B4Gly40 | Can be moulded into a package strong seams | ![B4Gly40](image) |
| K05/4Gly20 | Can be moulded into a package strong seams | ![K05/4Gly20](image) |
| K05/6Gly20 | Can be moulded into a package strong seams | ![K05/6Gly20](image) |
| K05/6Gly40 | Can be moulded into a package strong seams | ![K05/6Gly40](image) |
| K10/4Gly20 | Can be moulded into a package strong seams | ![K10/4Gly20](image) |
| K10/6Gly20 | Can be moulded into a package strong seams | ![K10/6Gly20](image) |

banana starch film blended with konjac powder had a film solubility greater than 80.00%. It could be concluded that the banana starch film was better soluble in hot water than the banana starch film blended with konjac powder.
3.2.6.3. Cold water qualification test
From testing the properties in the cold water of various film formulations, it was found that when the banana starch film and the banana starch film were blended with the konjac powder, they had immersed in cold water at a temperature of $0.0 \pm 10.0 \, ^\circ C$ for 1 h. The results showed that some formulations of banana starch blended with konjac powder were more soluble in cold water than banana starch films. Because the percentage of film that dissolves more than 50.00% or more in many formulas, However, only some formulations of the banana starch film had a film solubility greater than 50.00%, so it could be concluded that the banana starch film blended with konjac powder was better soluble in cold water than the banana starch film.

3.2.6.4. Testing properties in room temperature water
From testing the properties in room temperature water of various film formulations, it was found that when the banana starch film and the banana starch film were mixed with konjac powder soaked in room temperature water. The temperature was about $25.0 \pm 10.0 \, ^\circ C$ for 1 h. The results showed that some formulations of the banana starch film were more soluble in water at room temperature than the banana starch film blended with konjac powder. Because of the percentage of film that dissolves more than 70.00% or more in many formulas. However, only some formulations of banana starch film blended with konjac powder had a film solubility greater than 70.00%. It could be concluded that the banana starch film was more soluble in water at room temperature than that of the banana starch film blended with konjac.

3.2.7 Casting film as seasoning packaging
From the testing of forming packaging bags from the film, it was found that film formulations with low glycerol content, such as formulas B2Gly20, B4Gly20, B4Gly40, K05/4Gly20, K05/6Gly20, K05/6Gly40, K10/4Gly20 and K10/6Gly20. It will be able to form the packaging well and the seams will be stronger than the formula film that contains a lot of glycerol. And some formulations with too much glycerol, such as formulas K05/4Gly60 and K10/4Gly60, cannot be molded into packaging. When comparing different formulations of banana starch film and banana starch film blended with konjac powder, it was found that the banana starch film was better and stronger than the banana starch film blended with konjac powder. As shown in table 3.

3.3. The application of the films
From the study to determine the optimum ratio for film-forming and film had the test in various properties, then the film was selected. Two formulas that meet the requirements for the application of seasonings for instant noodles were the most. One formula of banana starch film and one formula of banana starch blended with konjac powder has been selected, namely formula B4Gly20 and formula K05/4Gly20 and casting the film according to the selected formula. Take the 2 formulas' film to form an instant noodle seasoning packaging and pack the seasoning of the instant noodles and test various properties of the seasoning packaged as follows.

3.3.1. Oil leakage test
From the oil leakage test, it showed that at the beginning of the casted package, the packaging is flexible and the seams were strong, there was no oil leaked out. But as time runs, the packaging had exposed to the air for a long time. The seams and the packaging became more and more stiff and crisp, so little oil leaked out. When comparing the two film formulations, it was found that the film formula B4Gly20 was slightly stronger than the film formula K05/4Gly20.

3.3.2. Dissolution test of seasoning flavor in seasoning packaging of an instant noodle
From the dissolution test of packaged sachets containing seasonings for instant noodles, minced pork flavor. By bringing the seasoning packaging from film formula B4Gly20 and formula K05/4Gly20 into hot water at a temperature, of $100.0 \pm 10.0 \, ^\circ C$, it was found that at the beginning the film packaging would absorb water until it was damaged. And over time, it would be broken into small pieces and begin to melt and the seasoning will gradually come out of the cling film and be mixed with water. Each film formulation took a different time to dissolve. The formula K05/4Gly20 is approximately 2 times more soluble than the formula B4Gly20 film, i.e., the formula B4Gly20 takes an average of $5.00 \pm 0.26$ min to dissolve while the formula K05/4Gly20 took $11.29 \pm 0.14$ min to dissolve.

3.3.3. Dissolution test of oil in seasoning packaging of an instant noodle
From the dissolution test of oil in seasoning packaging of instant noodles, minced pork flavor. By soaking the packaging bags from the film formula B4Gly20 and formula K05/4Gly20 in hot water temperature $100.0 \pm 10.0 \, ^\circ C$, the findings showed that when the test period increased, the packaging was exposed to the air for a longer time. This will make the packaging harder and crispier, and also increase the defrosting time.
The reason was that the film envelope would take a long time to absorb the water until the film bag was damaged and brake into small pieces and then began to melt and when comparing the packaging sachets from the two film formulations, it was found that the K05/4Gly20 formula film was better dissolved than the B4Gly20 formula film, with less melting time. As can be seen in table 4.

### 3.3.4. Packaged change testing of products

From the change test of the packaged product, the oil quality change test was measured by the rancidity of oil in seasoning change into the form of peroxide. By testing every 5 days for 15 days, it was found that the oil peroxide values in all three types of packaging, namely B4Gly20, K05/4Gly20 formulation film packed, and polypropylene plastic bags, had been tested. It tends to increase as the retention period increases. The K05/4Gly20 film sachets had a higher peroxide value than the B4Gly20 film sachets and the B4Gly20 film formula sachets had a peroxide value that was close to the control, indicating that the B4Gly20 film formula sachets showed that it has better oxygen permeability resistance than K05/4Gly20 formulation film packaging. Where (1) seasoning oil before being packed into different types of packaging has a POV of 0.016 mEq g⁻¹, therefore, every package will have the same POV on day 0, which is 0.016 mEq g⁻¹ (2) POV value means Peroxide Value (mEq g⁻¹), (3) the POV refers to the change in Peroxide Value compared to Day 0 (mEq g⁻¹). (4) Control means polypropylene plastic bags (Polypropylene: PP) When the test results for Peroxide Value of the oil in seasoning.

By plotting a graph showing the relationship between the peroxide value and the test date. As shown in the graph in figure 3, the peroxide value can be calculated as equation (3). Calculation of the change in peroxide value (the POV) on days 0 and 5 is as follows:

\[
\text{peroxide value (POV)} = \frac{1000 \times V \times N}{W}
\]  

(3)

where V is the volume of Na₂S₂O₃ used in titration (ml)  
N is the concentration of Na₂S₂O₃ used in titration (N)  
W is sample oil weight (g)  
The formula to find POV value was

\[
\Delta \text{POV (mEq g}^{-1}) = \text{Average POV (Day 5)} - \text{Average POV (Day 0)}
\]  

(4)

---

**Table 4. Dissolution test of oil in seasoning packaging of an instant noodle.**

| Test date | Formula B4Gly20 | Formula K05/4Gly20 |
|-----------|-----------------|--------------------|
| 0         | 18.29           | 11.72              |
| 5         | 20.95           | 15.06              |
| 10        | 23.31           | 15.95              |
| 15        | 27.02           | 19.07              |

**Figure 3. Peroxide Value test results of different in oil packaged.**
4. Summary of research results

The research aimed to find the optimum ratio for film-forming from natural materials, namely banana and konjac tuber. Moreover, to test the properties of the resulting films, it was found that the suitable formulations for film-forming of banana starch and konjac powder blended with banana starch were B4Gly20 and K05/4Gly20 due to their suitable mechanical and physical properties. For example, with high tensile strength, it is flexible enough, by having a smooth, glossy surface, and can be molded into a strong packaging. As for the study on the utilization of forming as seasoning packaging of instant noodles, it was found that when testing the properties of the packaging sachets obtained from the B4Gly20 and K05/4Gly20 film formulations, it appeared that the packaging sachets obtained from the film, the B4Gly20 formula had better properties than the K05/4Gly20 formula, such as preventing oil leakage and can resist oxygen to penetrate to the product better than others, etc. But the film formulation B4Gly20 still has disadvantages and could be studied further.

Data availability statement

The data generated and/or analysed during the current study are not publicly available for legal/ethical reasons but are available from the corresponding author on reasonable request.

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