EFFECTS OF DRYING CONDITIONS ON THE PROPERTIES OF DRIED PARTICLES OF POWDERED STEEP LIQUOR

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ABSTRACT

Starch is manufactured in Hashimiya factory in the general company of chemical industries. The waste water from the factory has the following specifications: pH; 3.5-4, phosphate; 1000-2000 mg/liter, suspensions; 5000-7000 mg/liter.

The waste water from the starch factory (steep water) becomes a source of water pollution and must be treated. It is suggested to dry the steep water and study the optimum conditions of the drying process as well as utilizing the material product in the anti-biotic industry and also as animal food.

The effect of temperature of hot air on the moisture content and produced protein concentration and the feed flow rate were studied. Steep water concentration was varied from 10% to 30% to maintain the animal food prepared with the standard specification and the temperature was kept not to exceed 150°C to protect the materials.

The product material was examined and it is found that it has a high food value can be used as animal food since it contains 40.6% protein, 3% phosphor and 10% moisture.

The above process is very economical in utilizing above 1 ton/day of solid materials contained in the steep water which is disposed out of the Hashimiya starch factory.

INTRODUCTION

The commercial separation of pure starch from maize is achieved by the standard wet milling process. The process is common throughout the world.

The maize wet milling operation is undoubtedly the most efficient process, it is contains the following steps [1]: (1) cleaning, (2) steeping, (3) coarse milling, (4) degermirnation, (5) oil extraction, (6) separation fibers from gluten and starch, (7) separation the gluten and starch, (8) drying the starch.

Table (1) Shown a typical analysis of maize grain[1]

Moisture	16.2%
Starch	59.4%
Protein	8.2%
Fat	4.0%
Fiber	2.2%
Ash	1.2%
Sugars	2.2%
Remainder	6.6%

The first step in the process is the dry cleaning of the maize and the removal of dust, broken grain and foreign matter. The equipment used for this operation is much the same as in wheat treatment prior to flour milling. The maize is sieved to remove impurities, broken grain and foreign seeds smaller than the whole maize, and it is also aspirated to lift out the dirt and dust. The broken grain from this operation is used in compounded cattle feed and can amount to 1% of the original shipment of corn.

Steeping

The cleaned maize is conveyed in known weight into steeping vessels where it is soaked in warm steep acid for a lengthy period of between 36 and 50 hours. The steeping vessels dished at the bottom and are commonly arranged in batteries of twenty or more, each vessel holding about 60 tons of maize. The steep acid is circulated continuously through the battery of steeping vessel and this movement provides the only agitation.

The steep acid is a weak solution of sulphurous acid prepared by absorbing sulfur dioxide in process water. The sulfur dioxide is usually prepared by burning sulfur in air in a conventional sulfur burner and this also produces a small amount of sulfur trioxide. The proportion of trioxide must be kept at a minimum because the resulting sulphuric acid produces undesirable reactions in the steeps.

The temperature of the steep acid is kept at about 50 °C but this can vary, whilst the period of steeping depends on the age of the corn, its moisture content and its treatment after harvesting. The purpose of steeping is soften the corn kernel and break down the protein structure within the endosperm. This loosens the starch granules and facilitates efficient separation.

The steeping process achieves the following: (1) removal of apportion of the solution in the maize, (2) softening of the kernel, so that in the further process all the loss of starch, (3) reduction in the activity of micro-organisms brought into the mill by the grain.

The steeping process is a very important step in the complete extraction process because if the maize is not correctly conditioned at this stage, the subsequent separations and the quality of the finished products can be affected. A good example of this is the effect on the finished starch of oversteeping. A serious loss of viscosity and thickening power is produced. During this process there is a small gaseous loss due to the production of volatile compounds. The corn kernels swell appreciably at this stage and when fully softened contain about 50% moisture.

Corn steep liquor [1,3,4]

When the period of steeping is completed the steep liquor is drawn off and concentrated into "Heavy Corn Steep Liquor". The dilute liquor contains about 6% solids and is rich in protein and minerals. After concentration the solids content is as high as 50% with protein accounting for half of the total solids. This liquor is used by the pharmaceutical industry as a nutrient in antibiotic growth. Although the pharmaceutical technicians can find no better nutrient than corn steep liquor, neither they nor maize starch manufacturers can complete understand the function of this material and consequently cannot precisely specify the requirements for a good corn steep liquor.

Corn steep liquor is a useful protein supplement and can be used in the brewing industry and in the preparation of animal feeding compounds.

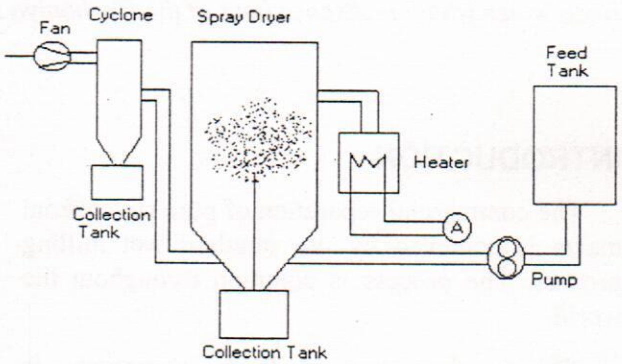
Spray drying [5]

Spray drying is definitions by the transformation of feed from a fluid state into a dried particulate form by spraying the feed into a hot drying medium. It is a one-step continuous particle- processing operation involving drying.

Spray drying consists of four process stages: (1) Atomization of feed into a spray, (2) spray-air contact (mixing and flow), (3) drying of spray (moisture volatiles evaporation), and (4) separation of dried product from the air.

Pilot Plant Description

Fig. (1) shows the main item of a spray dryer used.



Drying plant description

made of stainless steel AISI 316, well insulated and covered with mild steel sheeting . The drying chamber is provided with service door, side-light, and observation pane for inspection during the operation. All mild steel parts of the chamber and its supporting irons are given a coat of grey-colored hammer lacquer. The lower part of the cone of the drying chamber is provided with a flange to which various bottom parts can be mounted. Furthermore, the lower part is provided with rapping studs for the manual rapping.

Air duct

In stainless steel AISI 316, for transportation of exhaust air and powder to the cyclone separation of powder and air. The individual parts of the duct are assembled by means of quick-release fasteners, ensuring easy disconnection and reassembling.

Cyclone

Made of stainless steel AISI 316, and designed with a special view to highly effective separation of powder and air. The cyclone maybe dismantled for cleaning by means of swing bolts and hand wheels. In the bottom the cyclone is provided with a butterfly damper.

Collecting bucket

In stainless steel AISI 316, placed in a convenient position under the cyclone, tightly fitted to the cyclone by means of a bayonet fitting permitting replacement of the bucket without interrupting the during process. 1 extra bucket.

Fan

For transportation of the drying air through the plant, complete with squirrel-cage motor (2 HP , 2800 r.p.m.), V-belt drive, and belt-guard.

Instrument panel

With sundry instruments and thermometers, showing the inlet and outlet temperatures of the drying air. Various manually operated motor starters of Siemens manufacture.

Air header

For heating of the drying air by means of electricity, max consumption 30 Kw.

Collecting bucket

In stainless steel AISI 316, placed in a transport cart with built-in lifting to the cylindrical bottom part of the chamber.

Feed pump arrangment

Consisting of feed pump with infinitely variable gear and motor (0.75 HP , 900 r.p.m.).

EXPERIMENTAL WORK

Range of Different volumetric flow rate 4-7 l/h with different air inlet temperature 120-220 °C and different concentration 10 – 35% has been examined to obtain the optimize conditions. Where moisture content, crude protein, and ash content examined .

The experimental procedure was carried out as follows:

1. The fan was switched on.
2. The heater was switched on and bring the air inlet temperature up to 120 °C and the outlet air temperature reached about 110 – 120 °C .
3. The pump is slowly started up with water.
4. Heating of the plant was continued until the inlet during air temperature reached the required temperature (if higher than 120 °C required) .Then the feed to the atomizer was changed water to the liquid feed. The rate of liquid feed is adjusted by regulating the speed of rotation of the feed pump.
5. The product was taken from cyclone separater and from the powder bucket.
6. At the end of the experiments, the feed was changed from liquid feed to water for about 10 minutes in order to clean the nozzle.
7. The pump is turned off and the air heater as well as the pump is stopped.
8. For some time cold air is sucked through the plant in order to cool it.

RESULTS AND DISCUSSION

Spray drying of steep liquor with different concentration was investigated and with different air inlet temperature to study the best conditions for operation which may be used in design and operate a spray dryer for AL-HASHIMY Factory. Beside examine the powder produced to investigated it is component as animal feeding compounds .

Effect of Operating Conditions Concentration of the Feed

Effect of operating conditions Figures (2,3,4,5,6,7) shown that feed concentration had a marked influence on particle properties the data for 35% solids, however, showing anomalous behavior compared with 10% to 20% . The effect of solid concentration of the feed is to decrease moisture content of the powder produced with increasing the feed solid concentration as shown in figs (2,4,6).

The moisture content of the powder must be less than 12% to excpted as feeding animal compounds. [(8),(9)]

Spray drying of solutions with low concentration needs more heat than with high concentration as shown in fig (2,4,6) therefore it economically to operate at concentration (35%)%.

Feed Rate

The effect of feed rate on moisture content of the product. These fig(2,4,6) indicate that the moisture content is increased with increasing the feed rate . This is due to that at high feed rate, the air temperature will decrease inside the dryer and the air humidity will increase more than at low feed rate and this will cause more accumulation of moisture inside the particle.

Inlet Air Temperature

A high inlet air temperature causes more evaporation due to the higher temperature difference and hence lowers product moisture. Inlet air temperature should be less than 150 °C to maintain the concentration of protein as high as possible where it is found than increase inlet air temperature decrease protein percentage due to effect of high temperature, on degradation of protein . Fig (3,5,7)

The powder produced had been examine in agriculture ministry, quality control for animal feeding and it is had specification below:

Moisture	11%
Crude Protein	40.6%
Phosphorus	3.09%
Ash	4%
Ether ext.	0.9%
Calcium	0.15%

CONCLUSIONS

1. Steep liquor cause a damage to the area a round the factory where the liquor usually throw out, amount of solid throw about 1000kg per day.
2. Steep liquor contents rich a compounds which may be considered valuable for using either as nutrient for antibiotic for antibiotic pharamatical firms or as animal feeding compound.
3. Using spray dryer is a single step operation from liquor feed to dry product, it is possible to regulate operation variable to control product qualities ,it is used successfully in product powder steep liquor.
4. The best condition may be obtained when the concentration of steep liquor 35% rather than 10% , 20% due to effect of heat on moisture contents to minimize the dryer size, for low cost.
5. The protein percentage 40-38% is some how high so the powder to be used as animal feeding compound it is may mixed with hulls produced from other units to maintain protein percentage between 20-12%. [(8),(9)]

REFERENCES

1. Knight S.W. "The starch industry" 1st edition pergamon press 1969
2. Radley J.A. " Starch production technology " 1st edition applied science publisher London.
3. Kerl R.E " Chemistry and industry of starch " 2nd edition 1950 Academic press N.Y.
4. محمد عبد السعيدي " تكنولوجية الحبوب " رقم الايداع في المكتبة الوطنية بغداد 1960- لسنة 1982
5. Master K " Spray drying handbook " 4th edition 1985 New York and sons.
6. Greenfield R.E., Cornea G.N " Industrial wastes corn starch processes " Ind. and Eng. Chem. " May 1947.
7. Puiferey A.L. Kerr R.W and Reintjes H. " Wet milling of corn " Ind and Eng. Chem. Nov. 1940, 1483-1487.
8. الجهاز المركزي للتقييس والسيطرة النوعية المواصفة العراقية رقم 925 لعام 1990 .
9. الجهاز المركزي للتقييس و السيطرة النوعية المواصفة العراقية 924 لعام 1990 0

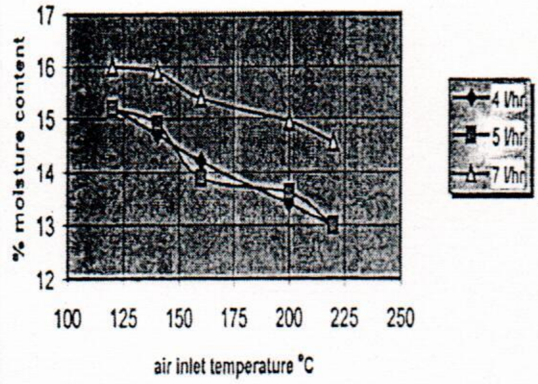


Fig. (2) Effect of initial air temperature on properties on dried steep liquor powder concentration 10%

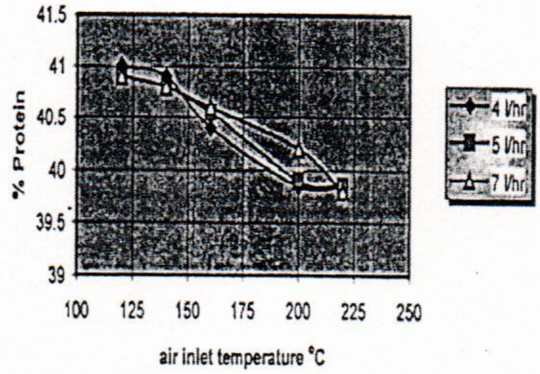


Fig. (5) Effect of initial air temperature on properties on dried steep liquor powder concentration 20%

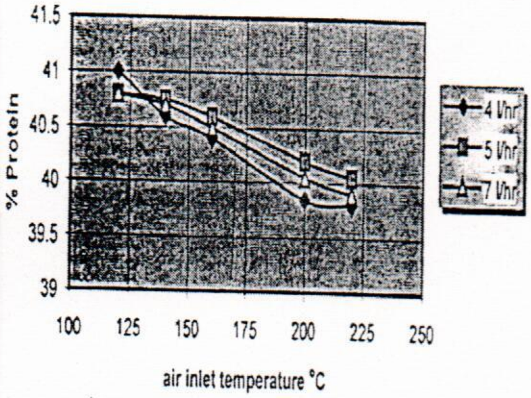


Fig. (4) Effect of initial air temperature on properties on dried steep liquor powder concentration 10%

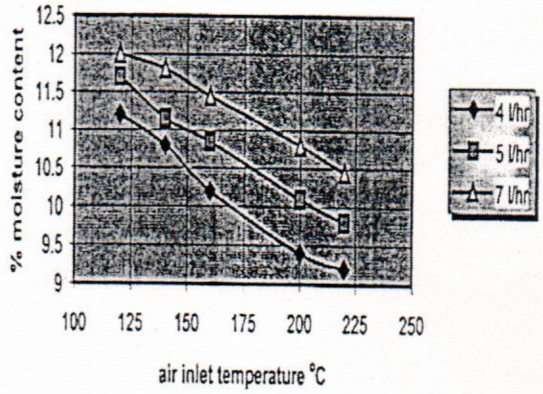


Fig. (6) Effect of initial air temperature on properties on dried steep

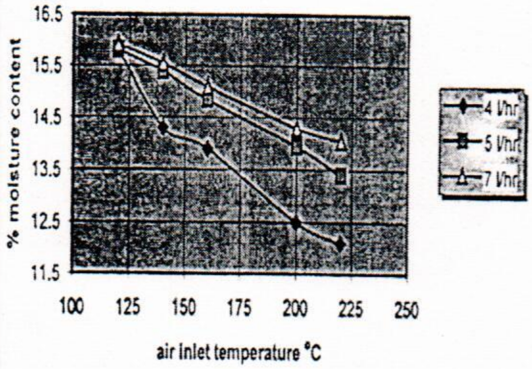


Fig. (4) effect of initial air temperature on properties on dried steep liquor powder concentration 20%

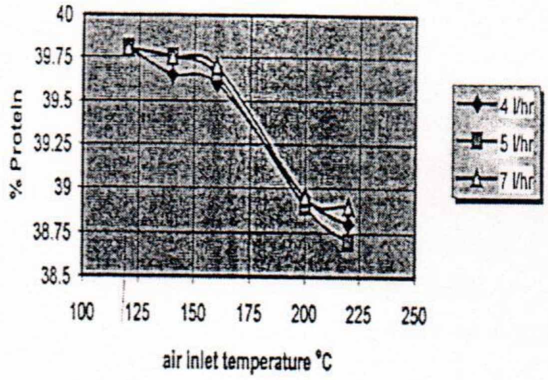


Fig. (7) Effect of initial air temperature on properties on dried steep liquor powder concentration 35%