Pakistan J. Sci. Ind. Res., Vol. 31, No. 6, June 1988

A PROCESS FOR THE PILOT PLANT PRODUCTION OF TEMPEH

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(Received December 23, 1987; revised July 14, 1988)

Pilot plant studies for the production of tempeh have been carried out. A room having specific dimensions has been designed and set up with insulated foam concrete walls, angle iron stands with holding capacity of 100 stainless steel trays producing 100 kg tempeh in 24 hours. The room was fitted with automatically controlled system having electric steam generators, heating and cooling system and proper exhaust. *Rhizopus oligosporus* NRRL-2710 was used for fermentation process. Factors effecting the pilot plant production of tempeh were optimized.

Key words: Fermented soy products.

INTRODUCTION

Production of soybean is increasing in our country. Government is very keen to develop it as a commercial crop. Pakistan is deficient in animal protein i.e. milk, meat, eggs, fish etc. To combat this deficiency we are left with the only alternative to utilize vegetable protein and to apply scientific methods to draw maximum benefit from the available resources. Soybean offers a high quality, low cost and rich source of protein as compared with conventional animal protein. Fermentation is one of the methods of vegetable protein utilization. Various fermented soybean products have been supplementing the diet of the oriental people for centuries [1]. Tempeh is one of such products used for its bland taste, palatable nature, and high nutritional properties, it provides inexpensive and good dietry source of protein.Apart from these tempeh fermentation has many other advantages. During the course of investigations carried out by C.W. Hesseletine [2] on the proteolytic system of *Rhizopus* sp. it has been found that the mould produces an antibacterial compound especially active against some gram positive micro-organisms. Conceiveably ingestion of this material may confer disease resistance. The beneficial effects of tempeh on patients with dysentry in the prison of world war II have also been reported [3]. Another advantage of tempeh lies in control over flatulence. Pulses cause flatulence when ingested, resulting in serious discomforts. It is now established that galactosides which are present in legume seeds are responsible for producing gas in intestine due to their fermentation by bacteria present therein. Tempeh when fed to patients resulted in no flatulence and caused no accumulation of gas in the abdominal region of the patients [4]. The fresh tempeh has pleasent dough like aroma. The taste of the fried tempeh is bland, with a slightly nutty flavour and taste and is acceptable to nearly every one. Unlike other ways of soy processing the finished product here comes out with more of riboflavin, niacin and vitamin B_6 than there is in the original bean, plus an extra bonus of vitamin B_{12} the richest vegetarian source of this important vitamin for both young and old [4].

Present studies were carried out for the production of tempeh on pilot plant scale. A room of the given dimensions has been set up with automatically controlled system, having electric steam generators (Fig. 1) fitted with controlled flow of water from a tank, heating and cooling system, (Fig. 2) exhaust system, shelves of angle iron which has got the capacity of holding 100 specific stainless steel trays [7]. Under these controlled conditions the optimum conditions of humidity time and temperature, have been determined for the production of 100 kg tempeh/day.

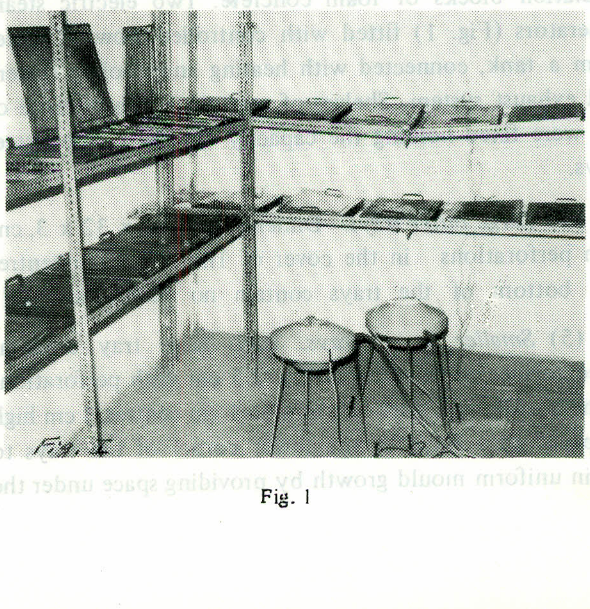

Fig. 1

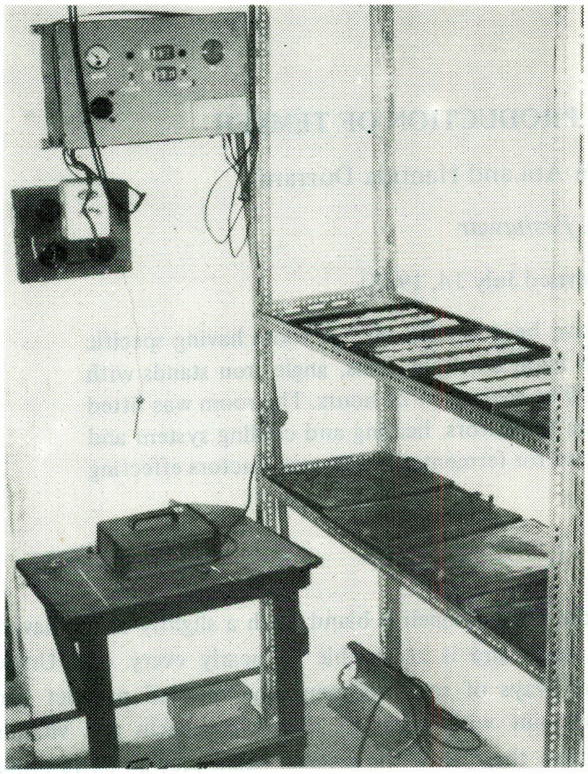

Fig. 2

MATERIAL AND METHODS

(1) The soybean used were of lee variety cultivated at Swat, during 1985. The moisture content of soybean varied from 5.2 to 6.6 %, contained 22 % oil and 44 % protein [5].

(2) The inoculum was prepared by growing a pure culture of *Rhizopus oligosporus* NRRL-2710 on malt extract agar slants for 2-3 days at 31^{o}.

(3) A room 7′ x 12′ was selected and insulated using insulation blocks of foam concrete. Two electric steam generators (Fig. 1) fitted with controlled flow of water from a tank, connected with heating and cooling system and exhaust system, Shelves of angle iron at a distance of 1.5 were fixed holding the capacity of 100 stainless steel trays.

(4) *Large outer trays.* Dimensions 39.5 x 32 x 3, cm with perforations in the cover of 1mm on 1 cm centre. The bottom of the trays contain no perforation [6].

(5) *Smaller inner trays.* Each large tray contains three smaller trays of 35 x 8 x 2.5 cm with perforations at the bottom and sides of 1 mm on 1 cm centres. I cm high supports were fixed at the lower corner of the trays to attain uniform mould growth by providing space under the smaller trays for the supply of air to the lower surface of the substrate.

(6) Bean were sorted to remove stalks, sand and demaged grains.

(7) The sorted beans were coarsely ground in stone grinder. (Fig. 3) and the hulls were removed by repeated soaking in water and decanting.

Fig. 3

(8) Soybean were soaked in tap water for an overnight drained and the beans were cooked for one hour in boiling water containing 0.5 % lactic acid. The boiling water was drained off and beans were cooled to room temperature.

(9) The beans were inoculated with the tempeh mould NRRL-2710, in the ratio of 25 g. of the sporulated mass for each thousand gram of the processed soy-bean. Thoroughly mixed, loosely packed into containers and incubated for 24 hours at 31^{o}.

RESULTS AND DISCUSSION

For the pilot plant production of tempeh various factors effecting the fermentation such as pH, humidity and time were studied. It was observed that during the hot days of summer, cooking of soybean in tap water results in bacterial contamination, which when inocculated with tempeh culture the resultant product gets spoiled with putrid odour, slimy texture and fungal inhibition. To avoid such bacterial contamination the beans were cooked in 0.25 %, 0.5 %, 0.75 % and 1.0 % lactic acid and acetic acid. It was observed that 0.5 % lactic acid and 0.25 %

Table 1. Effect of acid concentration on fermentation.

Concentration of acid in cooking water	Condition of growth	Moisture content (%)	Total protein in tempeh % (on wet basis)	Soluble amino nitrogen % (in tempeh)	Taste of the product
Lactic Acid					
0.25 %	Growth normal	51.8 %	21.9 %	1.0 %	Taste acceptable
0.50 %	Thick white mycelial growth	55.0 %	22.2 %	1.5 %	– do –
0.75 %	Growth normal	52.9 %	22.0 %	1.2 %	Slightly sour taste.
1.00 %	Growth normal	52.5 %	21.8 %	1.0 %	Taste more sour
Acetic Acid					
0.25 %	Thick white mycelial growth	52.0 %	22.0 %	1.48 %	Taste acceptable.
0.50 %	Thick white growth	53.8 %	22.1 %	1.45 %	Taste slightly sour
0.75 %	Growth normal	52.90 %	21.9 %	1.35 %	Taste sour
1.00 %	Growth normal	52.75 %	20.8 %	1.29 %	Taste more sour.

acetic acid were sufficient for the inhibition of bacterial growth and slightly acidic pH resulted in rapid mould growth and excellent tempeh product (Table 1).

Total protein content of tempeh prepared by cooking the soybeans in different concentrations of lactic and acetic acid is almost the same i.e. 22 %. Soluble amino nitrogen is maximum when there is thick white mycelial mould growth which also improves the taste of the product.

Temperature control device was set at 31°. In the initial stages of fermentation the temperature is 31° but as fermentation proceeds, the temperature rises, the system is so adjusted that the heating system stops and cooling starts keeping the temperature constant.

Effect of humidity on the process of tempeh fermentation was studied by varying the % age of humidity from 70-90 % at 31°. The whole unit is so adjusted that when the humidity exceeds the desired humidity level, steam generators are turned off and exhaust system starts functioning thus keeping the humidity constant. It was observed that excellent growth occurs at 75 % humidity at 31° after 22 hours. At 70 % humidity there is slight growth and product was not acceptable. At 80 % humidity spore formation starts and is maximum at 90 % humidity (Table 2).

Effect of time on the mould growth was studied on the pilot plant production of tempeh at optimum temperature and humidity. It was noted that white mycelial growth

Table 2. Effect of humidity on growth at 31° after 22 hr.

Humidity	Growth	Acceptability of product
70 %	Slight growth	Not acceptable
75 %	Pure thick white mycelial growth	Highly acceptable
80 %	Greyish white growth with indication of spore	Partially acceptable
90 %	Black spore formation	Not tested

is visible after 18 hours and reaches its maximum after 22 hours.

After 24 hours the surface of the tempeh becomes greyish white, which indicates the formation of spores (Table 3).

Table 3. Effect of time on mycelial growth.

Fermentation time in hours	Growth	Wt. in kg Whole soyabean wt. (Dry)	Tempeh
18	White mycelial growth visible	2 kg	4.0 kg
20	Slight mycelial growth.	2 kg	4.5 %
22	Thick white mycelial growth	2 kg	4.8 %
24	Slightly greyish growth.	2 kg	4.4 %

It was observed that starting from 45 kg of dry soybean, 100 kg of tempeh is obtained with 21-22 % protein and 52-55 % moisture and 3.5-4.0 % ash content (Fig. 4).

This product can be used as such, after slicing the tempeh cake and deep fat frying or mixed with spices and used for the preparation of tempeh kabab.

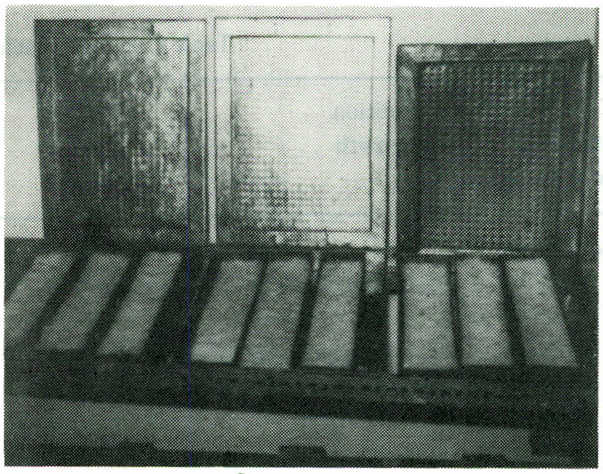

Fig. 4

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