# The Effect Of Fermentation On Adsorption Isotherm Corn Flour And Corn Crackers

Andi Sukainah, Abu Bakar Tawali, Salengke, Amran Laga

**Abstract:** Fermentation is one of the food material processing techniques to improve the nutritional value of a product. The purpose of this study was to examine the effect of fermentation on isotherm sorption in corn flour and corn crackers. The varieties of corn used were BISI 2 and POP obtained from Cereal Crops Research Institute of Sulawesi Selatan. Steps involved in this study include flouring, fermentation, analysis of nutrient content and isothermic sorption at 30ºC and 40ºC with humidity of 50%, 60%, 70%, and 80%. The results showed that the fermentation of all corn flours can improve nutritional value which were observed in both corn varieties. Likewise, isothermic sorption with type II (sigmoid) on all types of corn were observed (fermented and unfermented) in corn flour and corn crackers. Based on the volume of water absorbed during the storage process, it appeared that there was an effect of the fermentation on corn flour either at a temperature of 30ºC or 40ºC, particularly humidity at humidity of <60%. Whereas, the fermentation treatment on corn crackers showed a positive influence at the storage temperature of 30ºC in all corn varieties. At storage temperature of 40ºC, fermentation treatment affect only the BISI 2 varieties.

**Keywards:** Fermentation, adsorption, isotherm, corn flour, corn crackers

## INTRODUCTION

Fermentation is one the widely used techniques in food industry. Many fermentation techniques have been tested on food materials with the aim to find the fermentation technique that is applicable to produce a product with desired characteristics [1-6] ). Fermentation can be applied on corn flour, with the resulting nutritional improvements, particularly for the protein and essential amino acids lysine that far has a low level in corn **[3, 7].** One of the most important parameters in the application of fermentation treatment to corn flour is the ability of the flour to absorb water during storage. Isothermic sorption of a food material is unique because it is affected by many factors including the humidity and storage temperature. Many authors have reported isothermic sorption in various corn powder by observing the humidity and storage temperature parameters **[8-11].** Given the importance of isothermic sorption application in food materials, the subject of this study was to examine the sorption capability of fermented corn flour compared to unfermented control using four mathematic models to predict the sorption capability.

## MATERIAL AND METHOD

### *Sample*

Corn samples of BISI 2 and Pop varieties were obtained from Cereal Crops Research Institute of Sulawesi Selatan. The milling process of the corns followed Bolade **[12, 13]** The selected corn grains are intact, free from fungus and other dirts. The milling process was done by first detaching the peel and embrio, immersed for 24 hours, hulled, dried, and sieved.


- [1]Agricultural Technology Education Program Universitas Negeri Makassar 90 222 Indonesia
- [2]agricultural Technology Program Hasanuddin University Makassar 90245 Indonesia
- [3]Agricultural technology program Hasanuddin University Makassar 90245 Indonesia
- [4]Agricultural technology program Hasanuddin University Makassar 90245 Indonesia


The fermentation method followed Amankwah, **[14]** Selection of seed corn. The selected seed corn is whole, free from mold and other impurities, penyosohan corn kernels off the skin and body, soaking for 24 hours, milling, fermentation 2 days, drying, milling

### *Obtaining The Adsorption Isotherms Of Corn Flour*

The sorption capability of corn flour was observed based on Chisté, Silva [9] by placing 2 g of fermented and unfermented corn flour samples on chamber at 30$^{o}$C and 40$^{o}$C with humidity of 50%, 60%, 70%, and 80%. The samples were observed on daily basis until reached equivalent water level.

Table 1. Comparison of Nutritional Value of Corn, Corn Flour, Corn Flour Fermentation Results

| No | Type of corn | Carbohydrate (%) | Protein (%) | Fat (%) | Water (%) | Ash (%) | amylose (%) | Starch (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | BISI 2 | 68.195 | 7.995 | 1.750 | 14.000 | 1.280 | 5.390 | 60.870 |
| 2 | BISI2 flour | 70.995 | 7.740 | 0.330 | 16.336 | 0.250 | 17.345 | 73.810 |
| 3 | Bisi 2 fermented | 70.165 | 9.730 | 0.199 | 13.618 | 0.170 | 15.145 | 69.470 |
| 4 | POP | 67.075 | 9.960 | 2.515 | 10.546 | 1.240 | 6.910 | 56.860 |
| 5 | POP flour | 72.205 | 8.115 | 0.740 | 10.630 | 0.345 | 18.430 | 75.120 |
| 6 | POP fermented | 70.290 | 8.035 | 0.117 | 14.025 | 0.200 | 11.310 | 74.305 |

## RESULT AND DISCUSSION

### *Nutrient Content*

Table 1 indicates that the most abundant nutrient contained in corn is carbohydrate, either in processed or unprocessed corns with milling and fermentation. In addition, Table 1 shows that in all observed corn types, there is an increase in carbohydrate and amylose level from corn grain to corn flour, which was then decreased from corn flour to fermented corn flour. Each of the treatment applied to a food material will influence the nutritional content including starch, protein and fat [15]. Whereas, the decreased carbohydrate and amylose levels in flour after fermentation was due to the fermented starch that will degrade into sugar, thus increasing its sugar content and decreasing starch level [16]. In contrast, the protein level of BISI 2 variety decreased from corn grain to corn flour and there was an in increase in protein level from corn flour to fermented corn flour. For POP variety, there was a decrease in protein level from corn grains to corn flour and then to fermented corn flour. The same trend was observed for fat level, which was decreased from grain to flour and then to fermented flour, either for BISI 2 or POP variety. The ash content also decreased from grain to flour and then to fermented flour. Basically, all the treatments will have influence on the nutritional content of the food materials. The changes resulted includes increase or decrease in nutrient elements, depending on the processing condition and structures of each the processed food materials [17-20]. However, studies reported that fermentation will increase the protein level [7, 21] and will increase the solubility and palatability of protein In addition, the fermentation process in corn will also increase the minerals concentration [22]

### *Sorption Isotherms Of Corn Flour*

Isothermic sorption of corn flour is shown in Table 2 and 3 and Figure 1 and 2. Adsorption type indicated in Figure 2 and 3 can be classified into type II (sigmoid) at two temperatures (30°C and 40°C). This type is suggested to be possessed by general crop such as corn, potato, and wheat starches (dried peas, soya beans, dehidrated carrots, onions and tomatoes, Brazilian nut, cashew and pistachio kernels) according to the data reported by Yannitois and Blahovec (2009) in Chiste [9]

Table 2. Corn flour adsorption at 30ºC

| Humidity (%) | Equivalent water content (% db) | | | |
|---|---|---|---|---|
| | BISI 2 | POP | BISI 2 fermented | POP fermented |
| 50 | 8.84 | 9.09 | 9.07 | 8.42 |
| 60 | 9.41 | 9.04 | 9.09 | 10.35 |
| 70 | 11.39 | 10.49 | 11.05 | 11.04977647 |
| 80 | 11.07 | 9.79 | 11.30 | 10.49801762 |

Table 3. Corn flour adsorption at 40ºC

| Humidity (%) | Equivalent water content (% db) | | | |
|---|---|---|---|---|
| | BISI 2 | POP | BISI 2 fermented | POP fermented |
| 50 | 8.25 | 8.47 | 8.11 | 8.43 |
| 60 | 8.79 | 8.90 | 8.56 | 8.81 |
| 70 | 11.24 | 11.60 | 13.23 | 14.7036 |
| 80 | 9.42 | 9.71 | 12.12 | 12.3909 |

In the table 2 and 3 above, it can be seen that the volume of water absorbed at 40°C is smaller than those at 30°C. Hidrophylic bonds in corn flour will be broken in bigger number at higher temperature. However, at the temperature it was observed that the higher the humidity level the more the water absorbed by the corn flour, either in the fermented or unfermented corn flour. This is due to the fact that the higher the storage humidity, the bigger the chance for the flour to bind to the water. The influence of fermentation treatment on isothermic absorption of corn flour involved the decreased trend in water absorption for the observed two corn varieties in each of the humidity level 50% and 60% and increased water absorption at humidity level of 70% and 80%. Therefore, the fermented corn flour is better stored at humidity of <60%.

### *Isothermic sorption of corn crackers*

Isothermic adsorption for corn crackers is indicated in the above Table 4 and 5. Whereas Figure 3 and 4 indicates the type II adsorption. Therefore, the adsorption type of the fermented and unfermented corn flour indicated sigmoid type. The water content absorbed at 40°C tended to be higher compared to those at 30°C, even though with uneven distribution in all observed humidity levels. This indicates that the hydrophilic bonds in crackers became irregular due to high fat content as a result of frying process. Therefore, the formed bonds in crackers are hydrophobic bonds which are more readily to break at higher temperature [8] Despite these, the water content continue to increase with increased humidity percentage in the storage of corn crackers, either at 30°C or 40°C.

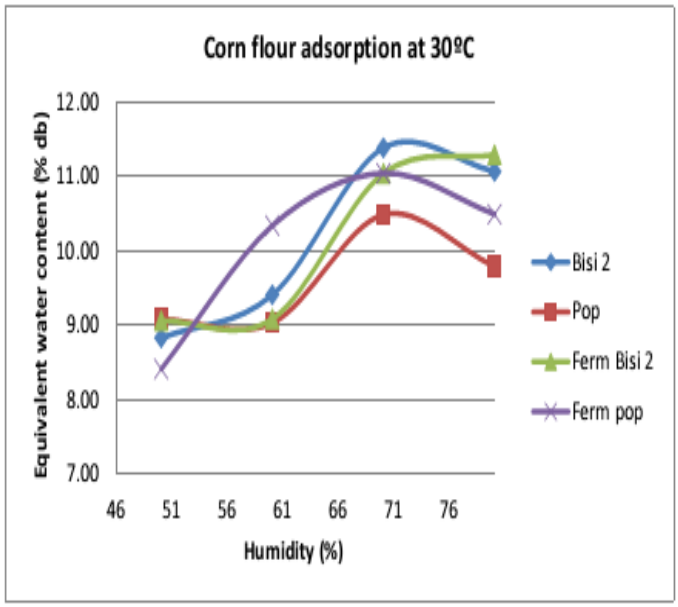


Figure 1. Corn flour adsorption at 30ºC

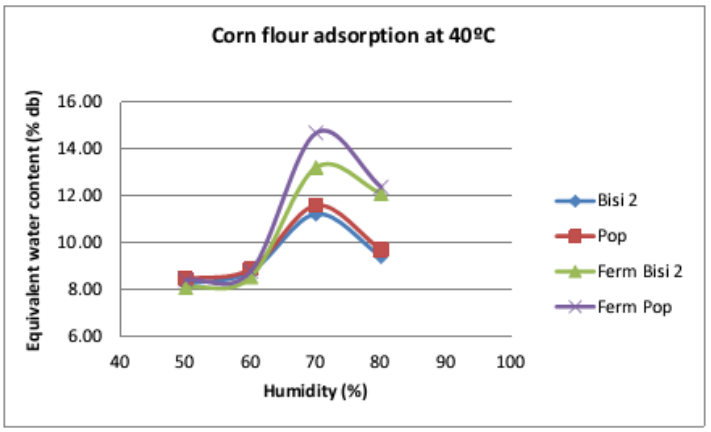


Figure 2. Corn flour adsorption at 40ºC

In addition, Table 4 and 5 indicates that fermentation treatment is capable of decreasing the absorption capability of water in each of humidity level at storage temperature of 30°C for all corn varieties. At storage temperature of 40°C, the fermentation had only influence on BISI 2 variety. Therefore, the storage of corn crackers of fermented corn flour from BISI 2 and POP varieties is suggested at humidity of <60% and temperature of 30°C.

Tabel 4. Corn crackers adsorption at 30ºC

| Humidity (%) | Equivalent water content (% db) | | | |
|---|---|---|---|---|
| | BISI 2 | POP | BISI 2 fermented | POP fermented |
| 50 | 3.88 | 3.54 | 2.91 | 4.19 |
| 60 | 4.72 | 5.23 | 4.92 | 4.66 |
| 70 | 6.67 | 6.80 | 6.10 | 6.177001318 |
| 80 | 4.82 | 4.54 | 4.08 | 4.08 |

Tabel 5. Corn crackers adsorption at 40ºC

| Humidity (%) | Equivalent water content (% db) | | | |
|---|---|---|---|---|
| | BISI 2 | POP | BISI 2 fermented | BISI 2 fermented |
| 50 | 4.81 | 3.77 | 4.36 | 3.71 |
| 60 | 4.83 | 3.85 | 4.70 | 4.08 |
| 70 | 5.16 | 4.46 | 4.83 | 4.50725 |
| 80 | 4.97836 | 4.42524 | 4.44947 | 4.48267 |

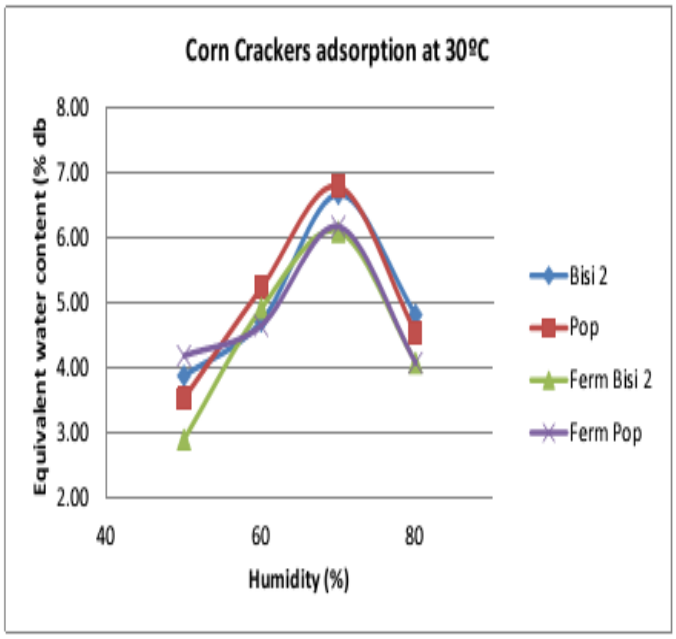


Figure 3. Corn crackers adsorption at 30ºC

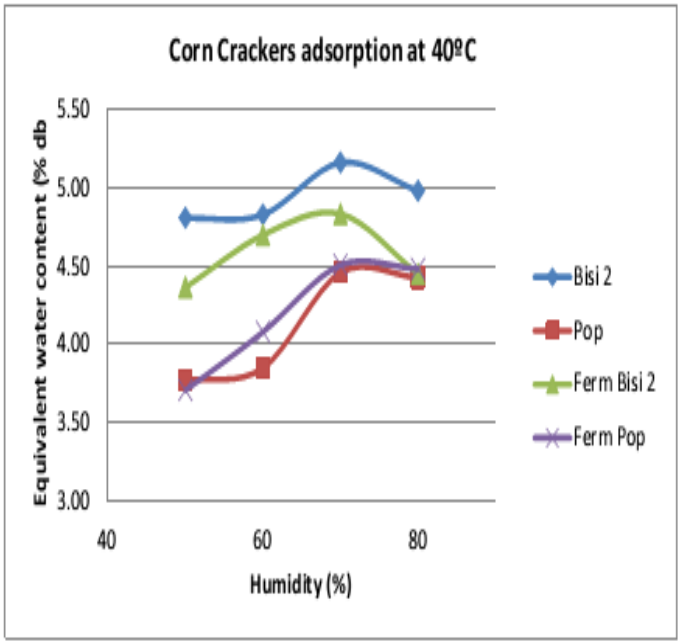


Figure 4. Corn crackers adsorption at 40ºC

## CONCLUSION

Fermentation process in all observed corn types could increase the nutrient content of corn flour. The same was true form isothermic sorption which indicated type II isothermic sorption (sigmiod) in all observed corn types, fermented or non-fermented, flour or crackers. According to the volume of absorbed water during storage, it was observed that fermentation treatment influenced corn flour either at 30°C or 40°C, particularly at humidity of <60%. Whereas, the fermentation treatment for corn cracker indicates positive influence at 30°C in all corn types. And at storage temperature of 40°C, fermentation treatment had influence only on BISI 2 variety.

## REFERENCES

[1]. Lamsal, B.P., P. Pathirapong, and S. Rakshit, *Microbial growth and modification of corn distillers dried grains with solubles during fermentation.* Industrial Crops and Products, 2012. **37**(1): p. 553-559.

[2]. Liu, C.-z. and X.-y. Cheng, *Improved hydrogen production via thermophilic fermentation of corn stover by microwave-assisted acid pretreatment.* International Journal of Hydrogen Energy, 2010. **35**(17): p. 8945-8952.

[3]. Mohiedeen, I.E., et al., *Effect of fermentation and cooking on protein quality of maize (Zea mays L.) cultivars.* International Journal of Food Science & Technology, 2010. **45**(6): p. 1284-1290.

[4]. Mjoun, K., K.F. Kalscheur, and A.D. Garcia, *Fermentation characteristics and aerobic stability of wet corn distillers grains with solubles ensiled in combination with whole plant corn.* Journal of the Science of Food and Agriculture, 2011. **91**(7): p. 1336-1340.

[5]. Oke, M.O. and I.F. Bolarinwa, *Effect of Fermentation on Physicochemical Properties and Oxalate Content of Cocoyam (Colocasia esculenta) Flour.* ISRN Agronomy, 2012. **2012**: p. 4.

[6]. Yao, L., et al., *Effects of fermentation substrate conditions on corn–soy co-fermentation for fuel ethanol production.* Bioresource Technology, 2012. **120**(0): p. 140-148.

[7]. Cui, L., D.-j. Li, and C.-q. Liu, *Effect of fermentation on the nutritive value of maize.* International Journal of Food Science & Technology, 2012. **47**(4): p. 755-760.

[8]. Cova, A., et al., *The effect of hydrophobic modifications on the adsorption isotherms of cassava starch.* Carbohydrate Polymers, 2010. **81**(3): p. 660-667.

[9]. Chisté, R.C., et al., *Sorption isotherms of tapioca flour.* International Journal of Food Science & Technology, 2012. **47**(4): p. 870-874.

[10]. Moreira, R., et al., *Water adsorption and desorption isotherms of chestnut and wheat flours.* Industrial Crops and Products, 2010. **32**(3): p. 252-257.

[11]. Sopade, P.A., et al., *MOISTURE-SORPTION ISOTHERMS OF IRISH AND SWEET POTATOES.* Journal of Food Process Engineering, 2010. **33**(3): p. 385-397.

[12]. Bolade, M., *Effect of Flour Production Methods on Yield, Physicochemical Properties of Maize Flour and Rheological Characteristics of Maize-Based*

*Non-Fermented Food Dumpling.* African Journal of Food Science 2009. **3**(10): p. 288-298.

[13]. Amankwah, E.A., J. Barimah. R. Acheampong, L.O. Addai & C.O. Nnaji, *Effect of fermentation and Malting on the Viscosity of Maize-Soyabean Weaning Blends.* Pakistan Journal of Nutrition, 2009. **8**(10): p. 1671-1675.

[14]. Amankwah, E.A., J. Barimah, A.K.M. Nuamah, J.H. Oldham & C.O. Nnaji, *Formulation of Weaning Food from Fermented Maize, Rice, Soybean and Fishmeal.* Pakistan Journal of Nutrition, 2009. **8**(11): p. 1747-1752.

[15]. ABD EL-KHALEK, E. and G.P.J. JANSSENS, *Effect of extrusion processing on starch gelatinisation and performance in poultry.* World's Poultry Science Journal, 2010. **66**(01): p. 53-64.

[16]. Huang, M. and S. Zhang, *Starch degradation and nutrition value improvement in corn grits by solid state fermentation technique with Coriolus versicolor.* Brazilian Journal of Microbiology, 2011. **42**: p. 1343-1348.

[17]. Alsaffar, A.A., *Effect of food processing on the resistant starch content of cereals and cereal products – a review.* International Journal of Food Science & Technology, 2011. **46**(3): p. 455-462.

[18]. Chan, H.-T., R. Bhat, and A.A. Karim, *Effects of sodium dodecyl sulphate and sonication treatment on physicochemical properties of starch.* Food Chemistry, 2010. **120**(3): p. 703-709.

[19]. Clementson, C.L. and K.E. Ileleji, *Particle heterogeneity of corn distillers dried grains with solubles (DDGS).* Bioresource Technology, 2012. **107**(0): p. 213-221.

[20]. Cornejo-Villegas, M.A., et al., *Study of the physicochemical and pasting properties of instant corn flour added with calcium and fibers from nopal powder.* Journal of Food Engineering, 2010. **96**(3): p. 401-409.

[21]. Hoffman, P.C., et al., *A query for effective mean particle size in dry and high-moisture corns.* Journal of Dairy Science, 2012. **95**(6): p. 3467-3477.

[22]. Sokrab, A.M., I.A. Mohamed Ahmed, and E.E. Babiker, *Effect of malting and fermentation on antinutrients, and total and extractable minerals of high and low phytate corn genotypes.* International Journal of Food Science & Technology, 2012. **47**(5): p. 1037-1043.