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# The effect of soaking time on water absorption and solid losses of whole and dehulled soybeans

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**SUMMARY.** Dehulled entire soybean cotyledons are required for the preparation of many interesting products. Removing hulls had a dramatic effect on the rate of water uptake during soaking. Maximum uptake was reached in only 3 hr compared to the 12 hr needed by whole beans. This saves time and reduces microbial growth during soaking. The amount of water absorbed by beans, with and without hulls, was similar once corrected for solid losses and surface water. Removal of fibrous shells during dehulling increased both the protein and oil contents by 2 %. Dehulled beans steadily lost solids during soaking. Losses were 8.6 % compared to 0.7 % for whole beans when maximum uptakes were first reached. Ways of avoiding or reducing these losses are discussed.

**RESUMEN. Efecto del tiempo de remojo en la absorción de agua y pérdida de sólidos en soya entera y descascarada.** Los cotiledones enteros de soya descascarada son requeridos para la preparación de muchos productos interesantes. La remoción de la cáscara tiene un efecto marcado en la tasa de absorción de agua durante el remojo. La máxima absorción de agua fue alcanzada en solamente 3 hr en comparación con 12 hr requeridas por las semillas enteras. Esto ahorra tiempo y reduce el crecimiento microbiano durante el remojo. La cantidad de agua absorbida por las semillas, con y sin cáscara, fue similar una vez corregida por la pérdida de sólidos y agua superficial. La remoción de la cáscara fibrosa durante el descascarado ocasionó que se incrementara el contenido de proteína y aceite en 2 %. Los frijoles descascarados perdieron sólidos a una tasa constante durante el remojo. Las pérdidas estimadas, cuando se alcanzó la máxima absorción de agua, fueron de 8.6 % en comparación con 0.7 % para los frijoles con cáscara. Se discuten las alternativas para reducir o impedir estas pérdidas

## INTRODUCTION

High contents of protein and calories, together with a relatively low cost, have led to considerable interest in the direct use of soybeans in human diets as a partial solution to protein-calorie malnutrition. However, in spite of a considerable marketing effort, they are still rarely used in most countries. Reasons for this are the lack of familiarity with their flavor and the way soybeans should be cooked and used. Their long cooking time is seen as a major problem that is best solved by using a pressure cooker, a common item in many homes in which *Phaseolus* beans are a staple. However, there has been some trouble with the hulls separation from the beans and rising up on a foam to block the escape valve (1). While this can be solved with small amounts of cooking oil and a sieve on the cooking surface, the use of entire splits obtained by careful dehulling is an attractive alternative that we are now pursuing. It offers several other advantages such as the familiarity of the split beans to lentil and dahl eaters (2). Dehulling also removes the unpleasantly bitter hypocotyls and is essential for the preparation of a number of interesting options like tempeh and certain fried snacks, which have been well accepted and are now being commercialized in Brazil (3). Furthermore, split beans can be expected to have higher protein and calorie contents following the removal of the fribrous hulls. Removing the hulls will also reduce contamination due to dirt, microbes and pesticide residues.

A preliminary soaking is a common step in the preparation of whole soybeans for direct consumption or for processing into products such as tempeh. It shortens the cooking time and is also said to improve the texture and appearance of cooked beans (4). Less power is required to disintegrate soaked beans when making products such as soymilk and tofu.

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As the seed coat is the principal barrier controlling the absorption of water, damaging it is said to increase the rate of uptake dramatically (5). Costa and Arkcoll (6) found that dehulled soybeans needed only a 90 min soaking to become soft enough to mill easily when making soymilk. Whole soybeans are known to take much longer to absorb water. However, they loose smaller amounts of solids during soaking. These losses have been shown to increase from 0.75% after 4hr to 5% after 24hr (7) and to increase from 5% to 10.4% when the soaking temperature was raised from 20 to 37°C (4). One would expect split beans to lose even more solids. The objetive of this study was to examine the effect of dehulling on solid losses and to clarify its effect on soaking time.

## MATERIAL AND METHODS

Seed quality soybeans (var. Williams 82) were purchased from the Illinois Foundation Seed Inc. nine months after harvest. They were cleaned by passing through a series of sieves to remove foreign matter, splits, broken beans and loose hulls. Immature and damaged beans were removed by hand and small beans were removed with a 6.4 mm sieve to reduce the effect of size on dehulling efficiency.

Industrial dehulling for oil extraction is carried out with rollers but this unfortunately breaks the cotyledons into several pieces. A more delicate separation, leading to the recovery of a high proportion of entire cotyledons, was achieved by using the equipment and process developed by the University of Illinois (8-9). Beans with 9.7% H2) content were initially heated in thin layers on trays for 20 min at 99°C in a forced air oven. This plasticized the cotyledons, thus avoiding their rupture during dehulling and improving their separation from the brittle, rigid, dried out hulls. The dehuller consisted of a narrowing passageway between a moving roller and an adjustable concave plate. Hulls and fine particles were subsequently sucked off with an aspirator and broken bits and hypocotyls removed by sieves.

Weight gain during soaking was determined using the method of Uebersax and Bedford (10) in which 10 g of beans (3 replicates) in metal baskets were immersed in 100 ml beakers containing 50 ml of deionized water at room temperature (22°C). The baskets were removed at 30 min intervals and then drained for 2 min at an inclination of 30° prior to weighing. Baskets were tared initially after immersion and a similar draining. Solid losses during soaking were obtained by evaporating the soaking water to constant weight in a vaccum oven set at 60°C. True water uptakes were calculated with correction for these solid losses at the time when maximum weight gains were first reached and after 14 hr. Absorbed water was calculated by a further correction for surface water measured by the weight change following careful drying with a cloth.

The volume of both dry and wet beans was determined by water displacement in a 50 ml cylinder, and their composition obtained using AOAC methods (11), with moisture measured in a vaccum oven at 60°C, fiber by acid detergent extraction, oil in a Goldfish apparatus and protein with a factor of 6.25 times Kejeldahl nitrogen.

## RESULTS AND DISCUSSION

The apparent water uptake measured by weight increase with immersion time for whole and dehulled soybeans is shown in Fig. 1 and the rate of uptake in Fig. 2. There was no obvious initial lag and water was absorbed very rapidly by both samples. Whole beans absorbed water at a lower rate which slowed down faster than that of the dehulled beans. It seems that soybeans are significantly different from other beans in the lack of an initial lag, presumably due to differences in composition (12). Whole beans were fully hydrated after 12 hr while dehulled beans reached this point in 3 hr, thus confirming the importance of hulls as barriers to water absorption. Uptake rates are also known to be affected by variety (5), temperature, age, density, seed size and soak water composition (13).

There was an abrupt change in the uptake by the dehulled beans once the maximum point was reached, followed by an apparent slow loss of water. In fact, this is due to the loss of solids with time as shown in Table 1. When these losses are used to correct the apparent water uptake values, the true uptake is in fact slightly greater in the dehulled (142.2%) than in the whole beans (136.7%). This is substantiated by the moisture content, that of the hydrated split beans being 3% more than the value for whole beans. Opposite and false conclusions could be obtained from the values uncorrected for solid losses shown in Fig. 1, in which the greater weight gain suggests that the uptake by whole beans is apparently greater. The extra water in the dehulled beans is easily explained by the larger amount of water on their surface, the area of which is considerably increased by splitting. This surface water is not easy to measure as it is readily dislodged or blotted of to differing degrees; this may help to explain some of the differences beween the results of various authors who take it into account or ignore it. It represents about 4 and 9% of the total water uptake for whole and dehulled beans respectively, and can be subtracted to give the water that was in fact absorbed rather than just taken up (Table 1). If this second correction is made, the amounts of water absorbed are very similar, although quite difficult to measure accurately. Since water uptake and absorption are affected also by age (13), variety (5) and presumably by seed size, these factors can be expected to affect the proportion of hulls and surface water.

FIG. 1
Effect of soaking time on water uptake by whole and dehulled soybeans

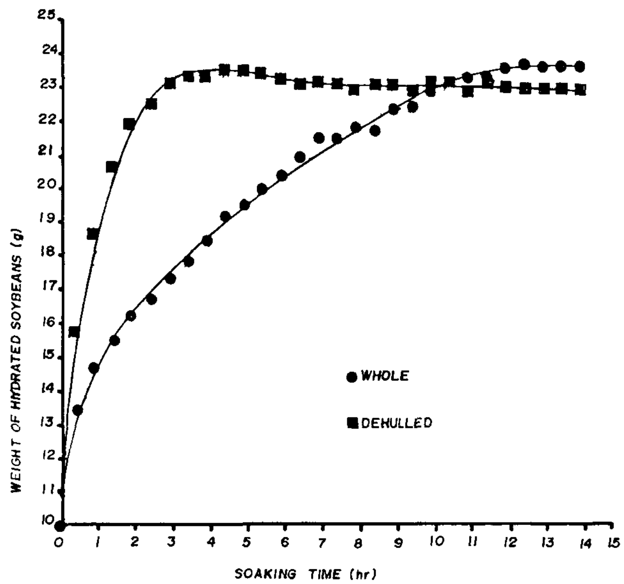


FIG. 2
Effect of soaking time on rate of water uptake by whole and dehulled soybeans.

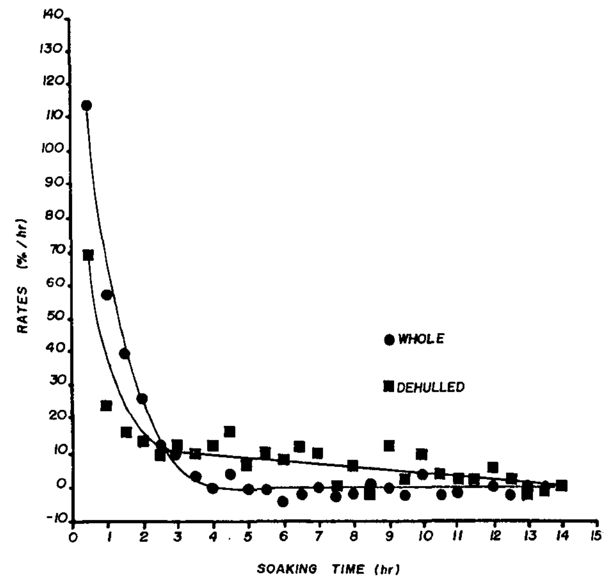


TABLE 1
EFFECT OF SOAKING ON WATER ABSORPTION, SOLID LOSSES AND SEED VOLUME OF WHOLE AND DEHULLED SOYBEANS[a].

| | Water Absorption (hr) | Moisture % | Weight Gain % | Solid Losses % | Water Absorption[b] % | Water Superficial % | Water Absorbed[c] % | Volume (ml) |
|---|---|---|---|---|---|---|---|---|
| Whole | — | 9.7 | — | — | — | — | — | 8 |
| | 12 | 62.0 | 136.0 | 0.7 | 136.7 | 4.5 | 132.2 | 22 |
| | 14 | 62.1 | 136.0 | 0.7 | 136.7 | 4.4 | 132.3 | 22 |
| Dehulled | — | 6.8 | — | — | — | — | — | 8 |
| | 3 | 63.3 | 130.0 | 8.6 | 138.6 | 9.5 | 129.1 | 20 |
| | 14 | 65.1 | 129.0 | 13.2 | 142.2 | 9.1 | 133.1 | 20 |

a Initial weight was 10g.
b Corrected solid losses
c Corrected superficial water

Losses of solids were considerably greater in the dehulled beans (13.2 %) than in whole beans (0.7%) after 14 hr. This could be due to the slight damage suffered by the testa during dehulling; the testa forms a barrier against loss of soluble and insoluble matter (Table 2). As the losses increase with time of soaking, especially in the dehulled beans, it is clear that the shorter the time, the smaller the losses. It may pay to soak for less time than is needed for maximum uptake, and certainly not soak beyond this point at which losses have already reached 8.6 %. Prolonged soaking is less important in the whole beans although our results (0.7 % loss of solids) are lower than the 3 % found by Wang et al (4). Differences due to variety, surface dirt, age, volume and composition of soak water may be involved. A small difference in the volume of whole (22 ml) compared to dehulled (20 ml) beans is partly explained by the water held between the testa and cotyledons and the greater loss of solids in the dehulled beans.

TABLE 2
CHEMICAL COMPOSITION OF WHOLE AND DEHULLED SOYBEANS[a]

| Soybean | Crude Protein[b] | Ether Extract | Ash | Crude Fiber | NFE[c] |
|---|---|---|---|---|---|
| | | | % | | |
| Whole | 40.5 | 22.1 | 5.6 | 6.6 | 25.2 |
| Dehulled | 42.3 | 24.2 | 5.5 | 3.8 | 24.2 |

a Values are expressed on dry matter basis
b Nitrogen x 6.25
c Nitrogen free extract. Calculated by difference.

Decreasing the soaking time by using dehulled beans has two major advantages: industrial processing is speeded up and microbial growth and contamination are reduced. Soaking losses of about 10% solids in the dehulled beans must be added to the costs of dehulling and the losses of at least an extra 15% of hulls, hypocotyls and undehulled beans that this involves (9). Although losses of this order are usually prohibitive, especially in the industry, they may be tolerable when one considers their composition. The hull is rich in fiber so its removal increases the protein and oil contents of the dehulled beans by about 2 % (Table 2). Hypocotyl removal is desired because they impart a bitter flavor. Soaking losses were principally of carbohydrate which included a good portion of undesirable flatulence producing oligosaccharides (4,7). Alternatively, these losses can be reduced by not using excess soaking water or by finding other uses for, or reincorporating, unhulled beans, chips, hulls, hypocotyls and soluble components in some products. For example, solids can be used in animal rations and solubles added back to soups and milks. Thus, the need to dehull, and assessing its advantages and disadvantages, will depend on the product being made. The effect on costs, cooking time, flavor, nutritional value and storage, the subjects of future papers, must also be considered.

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