International Journal of Agriculture and Food Science Technology.
ISSN 2249-3050, Volume 4, Number 4 (2013), pp. 347-352

http://www.ripublication.com/ ijafst.htm

Study of Absorption behaviour, Functional and Pasting Properties of Pearl Millet Soaking under Different Chemical Stresses

M.S. Sibian*, D.C. Saxena and C.S. Riar

Deptt. Of Food Engineering & Technology, SLIET, Longowal.

Abstract

The soaking kinetics, physical, functional and Pasting characteristics of Pearl millet treated under different (NaOH-0.1%, $NaHCO_3$-0.5%, $MgCl_2$-0.5%, Control-Distilled water) chemical stresses during soaking were studied. Peleg's constants (K_1 & K_2) were used to study the effect of soaking under different chemicals on kinetics of soaking. The variation in values of Peleg's constant shows that K_1 & K_2 are not only temperature dependent but also depends on the type of solution used for soaking. Lower value of Peleg's constant signifies the high initial absorption rate and absorption capacity. Water binding capacity, Oil binding capacity ranges from 296.77±0.14 and 223.40±0.16 and 217.12±0.03 to 292.12±0.65 (%). Beside that hydration capacity, hydration index and other seed properties also varied significantly during soaking under different chemical stresses. Flour prepared from soaked grains shows the variation in the pasting properties as well, which ranges from 77.45 to 83.2 for pasting temperature, 447 to 1561 for final viscosity and 289 to 677 for Set Back viscosity.

Keywords: Peleg's constant, pasting properties, soaking, physical properties.

1. Introduction

Soaking of seeds is necessary before germination of seed, which by hydrating the reserve food material of seed initiates the metabolic activity responsible for growth of seedling. During soaking, the various soaking properties differ due to the distribution of seed reserves among seed differs and type of seeds to variety of seeds. Thus seeds exhibit different hydration rates and other hydration properties depending upon the size of pore, hygroscopic properties of seed reserve material, concentration gradient, elasticity of seed coat and its permeability. Thus understanding soaking studies is of practical importance as it affects the further processing of seed (**Turhan et. al., 2002**). Scientist had studied the effect of different temperature for soaking of grains but the data on soaking under different chemical stresses is still deficient. Soaking solutions affects the soaking kinetics i.e. absorption rate as well as physical and functional properties, which might be due to alteration of cell wall properties as a result of ionic interactions during soaking under chemical stresses.

2. Materials and Methods

2.1 Raw material:

Pearl millet was used as experimental material. The initial moisture content of grains was 9.93%. Seed grains were divided into four categories. Salt concentrations were optimized by soaking seeds under different solute concentrations and germination tests.

2.2 Water absorption procedure:

Salt solutions were prepared using standard grade lab chemicals and each solution's minimal concentration that would not affect germination was determined. Distilled water was taken as control. Four set of pre-weighed seed grains sample were taken in duplicates and were soaked in respective solutions (NaOH-0.1%; $NaHCO_3$-0.5%; $MgCl_2$-0.5%; Distilled water-control) at 40 ±2°C in water bath. About 5-10g of seeds was soaked in 250 ml of solution. 40°C is optimal temperature which facilitates water uptake and does not affect germination rate. The hydrated seeds were blotted free of excess surface moisture with tissue paper and then weight was determined. Change in weight gives the amount of water uptake at that specific time (initial moisture (Dry basis) + water uptake), (**Jideani et. al., 2009**). The moisture content on dry basis was used for the calculation of Peleg constants K_1 & K_2 using Equation as given by Peleg, 1988:

$$Mt = Mo \pm \frac{t}{K_1+K_2.t} \quad (1)$$

Where: Mt=moisture content at known time (t) (%dry basis); Mo=initial moisture content (%dry basis); t= soaking time; K_1= Peleg's Rate Constant (h%-1); K_2= Peleg's Capacity constant (%-1);

2.3 Effect of Soaking on physical properties of Grains:

The physico-chemical tests like hydration capacity (ml/seed) and swelling index were determined by the methods used by other workers **(Williams et al., 1983)**. All the tests were carried out in triplicates:

$$Density = \frac{weight\ of\ material}{volume\ of\ material} \quad (2)$$

$$Hydration\ Capacity = \frac{100\ seed\ weight\ after\ soaking - 100\ dry\ seed\ weight}{100} \quad (3)$$

$$Hydration\ Index = \frac{Hydration\ capacity(100\ seed)}{100\ dry\ seed\ weight} \times 100. \quad (4)$$

$$Swelling\ Capacity\ per\ seed = \frac{100\ seed\ volume(\ soaked) - 100\ seed\ volume\ (dry)}{100} \quad (5)$$

$$Swelling\ Index = \frac{Swelling\ Capacity\ (100\ seed)}{100\ seed\ weight\ (dry\ seed)} \quad (6)$$

2.4 Functional properties and Pasting properties of soaked grain's flour:
Water absorption capacity of bean flours was measured by the centrifugation method of **Kaur and Singh (2006)**. For the determination of oil absorption, the method of **Lin, Humbert, and Sosulski (1974)** was used. The water and oil absorption capacities were expressed as percentage on a dry-weight basis. Pasting properties of Pearl millet flour gels prepared from seeds soaked under different chemical stresses were evaluated using Rapid Visco Analyzer (RVA, Tecmaster, Perten, Australia).

3. Results & Discussion

3.1 Physical Properties of Seed:

Physical characteristics of seeds evaluated for different treatments of pearl millet were seed weight, seed volume, seed density, hydration capacity, hydration index, swelling capacity and swelling index. The results for the physical characteristics are as shown in **Table1**.

Table 1: Effect of soaking on seed physical properties for different treatments.

Treatment	Density(dry seed)	Density (soaked)	Hydration Capacity/ Seed	Hydration Index	Swelling Capacity/ Seed	Swelling Index
NaOH (0.1%)	0.525±0.003[b]	0.500±0.006[b]	0.003±0.00[a]	0.949±0.007[c]	0.007±0.00[a]	1.164±0.003[a]
NaHCO3 (0.5%)	0.591±0.005[a]	0.551±0.005[a]	0.003±0.00[a]	1.082±0.004[a]	0.005±0.00[bc]	1.154±0.01[b]
MgCl2 (0.5%)	0.420±0.001[d]	0.394±0.004[d]	0.002±0.00[b]	0.821±0.026[b]	0.006±0.00[ab]	0.921±0.003[ab]
Distilled water	0.456±0.001[c]	0.421±0.002[c]	0.002±0.00[b]	0.749±0.007[d]	0.006±0.00[ac]	0.856±0.01[ab]

The results are average of triplicates ±S.D. and Averages followed by the same letters in the same column are not significantly different from the test of Duncan at a level of 5% of significance.

Hydration capacity of seeds ranged from 0.00234 to 0.003, the lowest was observed for $MgCl_2$ soaked seeds and higher for NaOH and $NaHCO_3$, whereas hydration index was reported lower for distilled water and higher for $NaHCO_3$ soaked seeds . Swelling capacity and swelling index ranges from 0.0055 to 0.007 and 0.857 to 1.167 respectively and observed highest for NaOH and lower for Distilled water soaked seeds in both cases. Density of grains decreased during soaking, with lowest decrease range was found in $MgCl_2$ soaked seeds.

4. Effect of soaking solutions on absorption rate and Peleg's Constants:

Peleg's constants (K_1 & K_2) were used to describe the effect of different soaking solutions on the kinetics and soaking studies. K_1 is known as Peleg's rate constant and signifies the mass transfer rate and is related to water absorption rate as lower the value of K_1 higher is the initial absorption rate. K_1 was observed lower for distilled water soaked millets, and higher for grains soaked under different chemical stresses, this could be attributed to the accumulation of solids leached out of the grains during soaking. The possible reason for solid leaching might be the ionic molecules of Na^+-OH^-, Na^+-HCO_3^- and Mg^+-Cl_2^- , which dissociates in solution and facilitates the inner molecule to leach out, but during the course of time inner large molecules start accumulating on the inner wall or pores of grains. Rate of water absorption during soaking in different solutions is as shown in Figure 1.

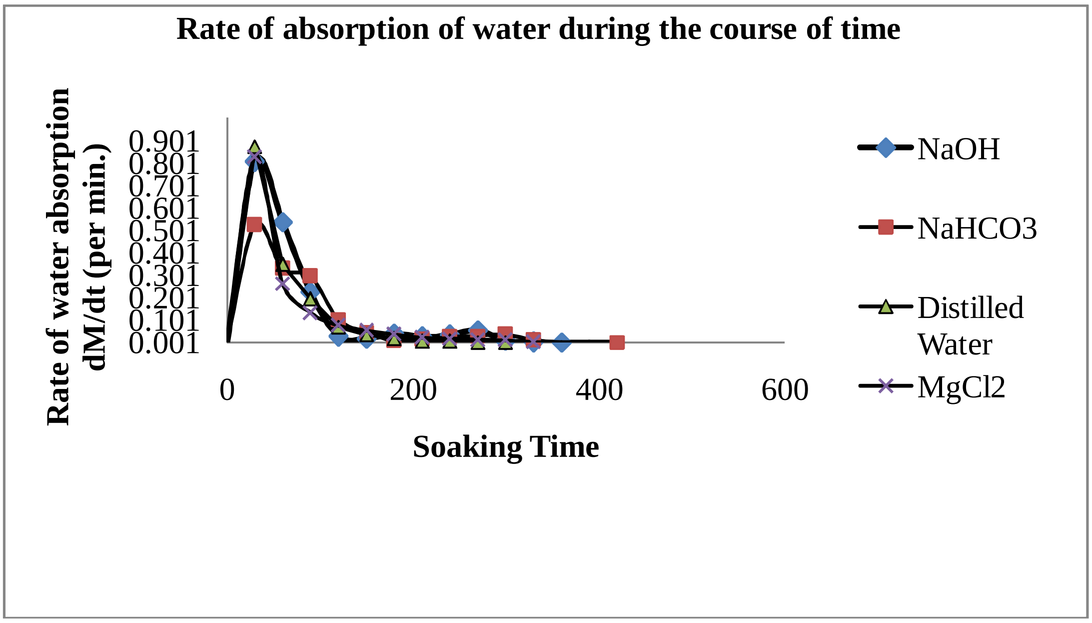

Figure 1: Rate of Water Absorption (dM/dt) for millets soaking in different soaking solutions.

K2 is the Peleg's capacity constant and signifies the extent of water absorption. It is related to maximum water absorption capacity as lower the value of K2, higher is the water absorption capacity (**Turhan et al., 2002**). Value of K_2 also depends on the type of wall material and exhibit mixed behavior, if soluble solid is considered in calculations of moisture contents (**Sayar et al., 2001**). The solid loss is considerable high during soaking in different solution and very little during soaking in distilled water.

Table 2: Effect of different soaking chemicals on the Peleg's constants (K_1 & K_2).

Treatment	K_1	K_2	r^2
NaOH (0.1%)	0.013168	0.006038	0.990353
Distilled Water	0.010240	0.009423	0.991553
$NaHCO_3$ (0.5%)	0.018026	0.005742	0.98046
$MgCl_2$ (0.5%)	0.016227	0.007829	0.998672

5. Functional and Pasting Properties of Flour of millets soaked in different solutions:

Functional characteristics like water binding capacity, oil binding capacity and swelling capacity of millet flour was studied. Oil binding capacity ranges from 217.12±0.03 to 292.12±0.65 (%), with highest value was observed in NaOH and lowest in $MgCl_2$ treated grain's flour. Water binding capacity on dry basis was observed higher in $NaHCO_3$ (296.77±0.14) and lower in case of $MgCl_2$ (223.40±0.16). Swelling power of the flour ranges from 1.6833±0.09 for NaOH to 2.7033±0.18 for $MgCl_2$ and for $NaHCO_3$ and Distilled water is 1.74±0.10 and 2.39±.04 respectively. Solubility ranges from 4.34± 0.07 for $NaHCO_3$ to 12.53± 0.13 for Distilled water, whereas for $MgCl_2$ and NaOH solubility is 9.40±0.05and 8.23±0.02. Both solubility and swelling index shows mixed behavior as compared to control which is 11.41±0.06 and 2.45±0.22 respectively. Pasting Properties of soaked grain's flour is as shown in **Table 3**.

Table 3: Pasting properties of pearl millet soaked in different solutions.

Treatments	Peak viscosity	Trough	Breakdown	Final Viscosity	Setback	Peak time	Pasting temperature
NaOH (0.1%)	1076	158	918	447	289	4.93	83.2
$NaHCO_3$ (0.5%)	1286	920	366	1561	641	5.33	84.85
$MgCl_2$ (0.5%)	1071	566	505	1243	677	5.07	82.3
Distilled Water	914	552	362	911	359	5.07	82.3
Unsoaked	975	658	317	1310	652	5	77.45

Pasting properties of flour of different soaked grains were observed to exhibit different pasting characteristics and differs significantly. Pasting properties and Viscosity behavior of flour is the characteristic of starch and reflects its properties like swelling and ability to absorb water **(Sandhu et al., 2007)**. The ranges observed were 914 to 1286cP for peak viscosity, 158 to 920cP for trough viscosity, 317 to 918cP for break down, 447 to 1561cP for final viscosity, 289 to 677cP for setback and 77.45 to 83.2 °C for pasting temperature. Peak time was observed higher for $NaHCO_3$ while lowest for NaOH.

6. Conclusion:

Soaking solutions besides affecting the soaking kinetics and behavior of grains, also affects the functional and pasting behavior of flour. Peleg's rate constant K_1 and capacity constant K_2, are not only temperature dependent but also depend on the type of solution used for soaking at specific temperature. This clearly shows the effect of different chemical stresses on the absorption behaviour and effect of these chemical on the inner molecules like starch of seed grains, which alters the pasting and other functional characteristics of soaked grains.

References

[1] K S Sandhu, N Singh and N S Malhi (2007), Some properties of corn grains and their flours I: Physicochemical, functional and chapatti making properties of flours. Food Chemistry, **101**, pp. 938–946.

[2] M J Y Lin, E S Humbert and F W Sosulski (1974), Certain functional properties of sunflower meal products, Journal of Food Science, **39**, pp. 368–370.

[3] M Kaur and N Singh (2006), Relationships between selected properties of seeds, flours, and starches from different chickpea cultivars, International Journal of Food Properties, **9**, pp. 597–608.

[4] M Turhan, S Sayar and S Gunaskeran (2002), Application of Peleg model to study water absorption in chickpea during soaking, journal of Food Engineering, **53**, pp. 153-159.

[5] P C Williams, H Nakul and K B Singh (1983), Relationship between cooking time and some physical characteristics in kidney bean (*Cicer arietinum L*), Journal of the Science of Food and Agriculture, **34**, pp. 492-496.

[6] S, Sayar, M., Turhan, S Gunasekaran (2001), Analysis of chickpea soaking by simultaneous water transfer and water–starch reaction, Journal of Food Engineering, 50, pp. 91–98.

[7] V A Jideani and S M Mpotokwana (2009), Modelling of Water absorption of *Botswana bambara* varities using Peleg's equation, journal of Food Engineering, **92**, pp. 182-188.