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STUDIES ON PHYSICAL AND CHEMICAL CHARACTERISTICS AND UTILIZATION OF MAIZE *(ZEA MAYS)*) STEMS

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Studies on the physico-chemical characteristics of maize stems have been carried out. The average weight of whole and clean stems were 56.94 and 30.38 g. and the average value for length were 2.25 and 1.94 meter respectively. Average number of nodes per stem was 12, and weight per meter was 21.4 g. Density of ground stems was 0.102 and compressability of about 74.6% under a pressure of 135 kg/cm^2.

The average value of ash content, solvent soluble matter, holocellulose, α-cellulose, α-hydrolysis, β-hydrolysis and acid purification were 2.90, 2.01, 79.86, 61.0, 8.37, 11.62 , and 5.0% respectively. Chemical characteristics have been compared with other crop residues and vegetable raw materials. In view of the physico-chemical characteristics the utilization of maize stems has also been discussed.

Key words : Maize stems, Physico chemical characteristics.

Introduction

Maize *(Zea mays)* commonly known as sweet corn is one of the major food crops in most countries of the world including Pakistan. Maize stems are by-product of the maize crop and are available in huge quantities, about 505 to 513 thousand tons per annum in the country as crop residue [24].

In recent years increasing interest in the recycling of Industrial and Municipal waste and utilization of agricultural waste and crop residue has been developed [1-11]. This has two important considerations:(1) to regenerate the materials and energy resources and (2) to eliminate the hazard environmental pollution.

In view of the above fact and availability of maize stems, it was proposed to under take a study of its physical and chemical characteristics to obtain preliminary information in order to find out further economic use of this crop residue.

Materials and Methods

Materials . Random maize stem samples were collected from Peshawar and Charsadda in the harvesting season i.e. August-September. Dried in the shade and cleaned from leaves, peels of cobs, tassels and other adhering matter. Physical measurements were carried out on the whole and the cleaned stems. Wherease density, compressability and chemicals studies were carried out on the ground maize stems.

Method. Physical characteristics studied:

(i) Lenght and weight of whole and cleaned stems, number of nodes and diameter.

(ii) Microscopic structure:- cross sections of stems from the bottom, middle and apical portions.

(iii) Density of ground maize stems was determined from the weight of the ground stems which completely filled the die with depth 8.0 cm and diameter 8.0 cm.

(iv)Compressability: This was determined with a pneumatic press and a die. The depth and internal diameter of the die were 8.0 cm each. The die was filled with the ground material (as for determining the density) and then the plunger was placed on the top of the die and the assembly was placed in the press. Pressure was gradually applied reaching a maximum of 135 kg/cm^2. Reduction in volume at each stage was recorded by measuring the distance of plunger moved down in the cylinder of the die. Compressability was calculated by recording the change in volume at various pressure.

$$\text{Compressability} = \frac{\text{Change in volume} \times 100}{\text{Initial volume}}$$

Chemical characterization determined:(i) Ash content (ii) Alcohol - benzen soluble matter (iii) Holocellulose (iv) α-Cellulose (v) α-Hydrolysis (vi) β-Hydrolysis (vii)Acid purification. 10 Determinations were carried out for each.

Pre-treatment. All the samples for chemical studies were grounded (40- mesh) and a sub sample was oven dried for moisture content.

(i) Ash content. Weighed sample of ground maize stems was subjected to 600° for 3 hr in a laboratory furnace [12].

(ii) Alcohol-benzene soluble matter was determined as per TAPPI Test T6m-50 [13].

(iii) Holocellulose was determined by the chlorite method of jayme as adopted by Sen Gupta *et .al.* [14-15].

(iv)α*- Cellulose-by the chlorite method in conjuction with the method adopted by Chatterjee [16].

(v) α-Hydrolysis as per Chatterjee method [17].

(iv) β-Hydrolysis as per TAPPI Test T4 m-59 [18,19].

(vii) Acid purification as per method of Chatterjee [20].

(viii) Utilization: Samples of insulation sheets (size 30x30x5 cm) were made by mixing the ground maize stems with waste paper pulp in three different proportions ; 25:75 50:50 and 75:25 in wooden mold. Waste paper pulp was

prepared by soaking waste papers in water for 24 hr and then breaking them into the pulp in a mixer-blander. A wooden mold consisting of three components - a rectangular frame, a detachable base and a top plate was used. A manually operated screw press was employed. Samples were dried in the laboratory oven.

Results and Discussion

The results of various physical and chemical characteristics have been given in Table 1-3 wherease a comparison of chemical characteristics of maize stems with other crop residues and vegetable raw materials, i.e. wheat straw, rice straw, bagasse, kenaf, kahi, pine needles and ak has been given in Table 4.

Maize stems are roughly cylindrical, somewhat straight sticks which are divided into segments by the nodes at intervals. Since the stems are slightly eliptical in cross section, accurate measurement of diameter presents some difficulty and so the values of diameter are approximate only. Cross section of the stem shows a small semi-circular grove which runs longitudinally along the internode. Length of internode is shorter near the root and gradually increases towards the apex. Diameter follows the reverse, i.e. stems are thicker near the root and thinner near the apex, the change is gradual. Cross section of stem examined under a microscope shows an inner spongy cellular pith and the outer stiff layer which does not yield fibres. The pith is composed of soft, thin-walled, irregularly shaped parenchymatous cells of the inner stock tissue.

Comparison of chemical characteristics of maize stems with wheat straw, rice straw, sugar can bagasse, pine needles, kenaf, kahi and ak shows that maize stems contain less mineral matter in the form of ash than wheat straw and rice straw, but it is close to that of kahi and pine needles, and is higher than that of kenaf, ak and bagasse. The comparison of chemical

TABLE 1. PHYSICAL CHARACTERISTICS OF MAIZE STEMS.

S. No.	Weight of whole stem (gm)	Weight of clean stem (gm)	Lenght of whole stem (meters)	Lenght of clean stem (meters)	No. of node per stem	Weight per running meter	Density of ground maize stems
1.	85.52	51.09	2.31	2.02	10.0	23.9	0.104
2.	54.32	29.27	2.19	1.92	12.0	16.7	0.098
3.	51.42	32.18	2.32	1.87	11.0	21.4	0.102
4.	47.20	20.45	2.20	1.94	12.0	26.1	0.101
5.	33.45	17.47	2.08	1.73	9.0	21.6	0.103
6.	38.87	19.55	2.41	1.84	15.0	19.3	0.105
7.	83.17	45.97	2.17	1.95	12.0	22.4	0.102
8.	53.55	25.72	2.24	2.07	10.0	17.9	0.104
9.	48.77	24.43	2.22	1.95	13.0	20.5	0.102
10.	73.20	37.70	2.45	2.12	14.0	24.3	0.101
Mean	56.94	30.38	2.25	1.94	12.0	21.41	0.102
S.D.	16.91	10.82	0.11	0.11	1.78	2.78	0.002
S.E.	5.94	3.61	0.04	0.04	0.59	0.93	0.001

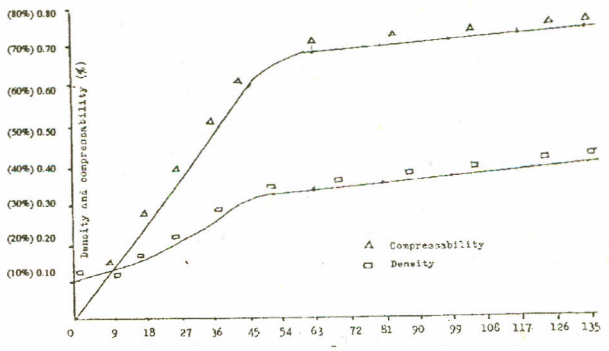
S.D. = Standard deviation, S.E. = Standard error.

TABLE 2. CHEMICAL CHARACTERISTICS OF MAIZE STEMS.

S.No.	Ash content %	Alocohol-benzene soluble meter %	Holocellulose %	α-Cellulose %	α-Hydrolysis %	β-Hydrolysis %	Acid purification %
1.	2.6	1.9	82.4	61.1	8.7	11.8	5.2
2.	2.5	2.1	78.3	60.5	8.0	12.0	4.7
3.	3.4	1.8	79.8	61.7	8.3	11.6	4.9
4.	2.8	1.9	78.7	60.4	7.9	12.2	5.3
5.	2.4	1.7	80.6	60.8	8.1	11.1	4.8
6.	2.9	2.3	81.0	59.9	8.4	11.9	4.1
7.	3.2	1.8	80.2	61.3	8.6	10.9	5.4
8.	2.7	2.0	79.7	62.2	8.2	12.3	5.0
9.	2.8	2.5	78.8	60.6	9.0	11.0	4.7
10.	3.7	2.1	79.1	62.2	8.5	11.4	5.6
Mean	2.90	2.01	79.86	61.0	8.37	11.62	5.0
S.D.	0.39	0.23	1.18	0.74	0.32	0.48	0.41
S.E.	0.13	0.08	0.39	0.25	0.11	0.16	0.14

TABLE 3. DENSITY AND COMPRESSABILITY OF GROUND MAIZE STEMS UNDER VARIOUS PRESSURES.

Pressure	Volume	Density	Compress-ability %	Weight of ground maize steam filling die (gm)
0.0	402.3	0.102	0.0	41.034
9.0	352.0	0.116	12.5	40.832
18.0	301.0	0.138	25.0	41.538
27.0	253.0	0.164	37.1	41.492
36.0	201.0	0.206	50.1	41.406
45.0	153.7	0.269	61.7	41.345
54.0	125.0	0.328	68.6	41.328
63.0	125.0	0.330	68.9	41.415
72.0	–	–	–	–
81.0	122.0	0.331	68.9	41.375
90.0	–	–	–	–
99.0	116.0	0.358	71.0	41.528
108.0	–	–	–	–
117.0	110.0	0.376	72.4	41.376
126.0	–	–	–	–
135.0	102.0	0.404	74.6	41.208
Mean	-	-	-	41.323g



Pressure kg/cm^2

Fig.1. Graph of density and compressability of ground maize stems against pressure.

and it was found that the 50:50 pulp to nmaterial ratio gave a better product in terms of strength (Table 5). The lower pulp ratio gave a poorly bonded product, while a high pulp containing sample gave a more compact and dense product with less porosity and hence reduced insulation. Samples of various

TABLE 4. COMPARISON OF THE CHEMICAL CHARACTERISTICS OF MAIZE STEMS WITH OTHER CROP RESIDUES.

S.No.	Material crop residue	Ash content %	Alcohol-benzene soluble matter %	Holocellulose %	α-Cellulose %	α-Hydrolysis %	β-Hydro lysis %	Acid puri fication %	Lignin	Pentosans %	Moisture %
1.	Maize stems	2.9	2.01	79.86	61.07	8.37	11.62	5.0	-	-	7.2
2.	Wheat straw	7.5	–	58.8	43.2	–	–	3.9	16.9	19.2	10.0
3.	Rice straw	9.5	7.2	53.1	48.8	–	–	4.7	31.0	20.0	7.8
4.	Sugar can bagasse	1.7	0.9	63.4	35.1	–	–	2.4	21.0	23.1	6.8
5.	Pine needles	3.3	11.5	60.5	31.5	8.4	10.2	3.3	25.6	10.2	10.3
6.	Kenaf	2.0	1.3	86.3	58.7	10.2	13.1	2.3	10.7	9.4	9.8
7.	Kahi	2.5	8.9	59.7	35.4	8.8	11.0	3.1	17.0	24.4	14.2
8.	AK	1.7	1.4	90.0	62.3	7.8	11.4	4.3	5.3	7.1	8.3

α = Greek alpha, β = Greek beta

characteristics of maize stems with those of the said materials shows good resemblance as appraised by the chemical assay. The value of acid purification of maize stems is the highest among the materials under consideration. Most of these materials have been used in pulp and paper manufacture, or at least have been put to trial for this purpose.

The study of physical characteristics of maize stems indicates low density and high compressability (Fig. 1), and the chemical data shows that the stems contain a high proportion of holocellulose (about 80%) which represents the cellulose in the crude form. Maize stems lack bast fibre structure so their use in pulp and paper manufacture is not indicative of practical application. The ground maize stems, if however, blended with suitable binding materials, can be used in making inexpensive insulating and packing materials. It was in this direction that trials were carried out for their utilization. Density and strength of the insulation sheets prepared were compared

TABLE 5. WEIGHT, DENSITY AND STRENGTH OF THE SAMPLES OF INSULATION SHEETS.

Sample No.	Size (cm)	Ratio material to pulp	Weight	Density	Strength
1.	30x30x5	25:75	2140g	0.453	High, binding good.
2.	30x30x5	50:50	1857g	0.412	Medium, binding good.
3.	30x30x5	75:25	1476g	0.328	Low binding good.

degree of compactness, density, porosity and insulation can be prepared as desired by taking appropriate amounts of pulp and material mixture and the pressure used in molding.

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