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these species, measured both in vivo and in vitro, ranged from 6.05 to 7.03 pg per 4C nucleus. No marked change in DNA value was noted in cells with high chromosome numbers, thereby confirming their origin through fragmentation of chromosomes. In callus cells, the DNA amount was higher than in normal cells, indicating fragmentation and duplication of individual chromosomes.

2033 SHAILA P; ARATI, AK; BALASUBRAMANYA, RH. 1988. **Bioenriched cottonseed hulls as cattle feed**. *Newsletter, AICOSCA*, 7-9.

2034 TALWAR, MANJUBALA; RASHID, A. 1989. **Somatic embryo formation from unemerged inflorescences and immature embryos of a graminaceous crop *Echinochloa***. *Annals of Bot.*, 64: 2, 195-199.

Formation of somatic embryos of *E. frumentacea* was dependent on the concentrations of specific auxins and mineral nutrients in the culture medium. On N6 medium with a low concentration of 2,4-D somatic embryos were obtained from both immature inflorescences and embryos. Direct differentiation of somatic embryos occurred more frequently in embryos than in inflorescences. On MS medium with different concentrations of 2,4-D compact callus-like masses appeared which regenerated plantlets on auxin-free medium. At higher concentrations of 2,4-D and also on N6 medium compact tissues (morphogenic calluses) made up of thallus-like structures were formed.

2035 TRIPATHI, SN; PATIL, BD. 1984. **Interspecific cross between *Atylosia albicans* and *Atylosia scarabaeoides***. *Current Science*, 53: 14, 755-757; 4 ref.

The single F1 plant obtained from the cross *A. albicans* X *A. scarabaeoides* was semifertile and intermediate between the parents in most characters. It had 10II + 2I at metaphase I and pollen stainability of 53.7%. Some of the F2 plants were fertile, pollen stainability ranging from 30.85% to 93.26%, and varied in the number of univalents at metaphase I. The F2 plants varied considerably in habit.

2036 TYAGI, AK; BHARAL, S; RASHID, A; MAHESHWARI, N. 1985. **Plant regeneration from tissue cultures initiated from immature inflorescences of a grass, *Echinochloa colonum (L.) Link***. *Plant Cell Reports*, 4: 3, 115-117; 30 ref.

Organized structures developed on a white and compact callus initiated from small segments of immature inflorescences of *E. colonum* cultured on MS medium supplemented with 5.0 mg 2,4-D/l and 10% coconut milk. These developed into plantlets upon subculture on to MS medium containing 0 or 0.2 mg 2,4-D/l. The overall success in regenerating plants was about 50%, and 76% of regenerated plantlets grew well on transfer to soil; 11 plants produced seeds.

2037 YABUNO, T. 1985. **A cytogenetical study on a new hexaploid annual species of the genus *Echinochloa* from Sri Lanka**. *Cytologia*, 50: 4, 907-912.

Strain 77-10 (2n = 6x = 54), collected from a rice field at Peradeniya, Sri Lanka, resembles *E. crus-galli* but is distinguished by its convex, coriaceous and lustrous lemma and variegated upper glumes. These characteristics were transmitted as dominant in crosses of 77-10 with the hexaploids *E. colona* and *E. crusgalli* and the tetraploid *E. oryzicola*. On the basis of cytological data from these hybrids, it is suggested that (1) 77-10 should be regarded as a novel species of *Echinochloa* and (2) the 3 hexaploids are distantly related, probably having one genome in common.

AGRICULTURAL WASTES

2038 ARAUJO, A; D'SOUZA, J. 1986. **Enzymatic saccharification of pretreated rice straw and biomass production**. *Biotechnology and Bioengineering*, 28: 10, 1503-1509; 35 ref.

Comparative saccharification of pretreated rice straw using cellulase enzyme produced by *Aspergillus terreus ATCC 52430* and its mutant str. UNGI-40 was studied. The effects of enzyme and substrate concn on the saccharification rate at 24 and 48 h were studied. A higher sugar concn at lower enzyme concn was obtained with the mutant str. The hydrolysate supported the growth of *Candida utilis* and *Saccharomyces cerevisiae ATCC 52431*. A biomass with protein content of 48% was obtained.

2039 BAJPAI, P; SHARMA, A; RAGHURAM, N; BAJPAI, PK. 1989. **Whole cell immobilization for high stability in ethanol production**. *Journal of Microbial Biotechnology*, 4: 2, 87-92; 7 ref.

The main disadvantage of Ca alginate as an immobilization matrix is its disruption via Ca2+ solubilization by certain ions (e.g. Mg2+, K+ and phosphates) and Ca-chelating agents (notably EDTA). A technique is described for hardening and stabilizing such a system for ethanol production. Cells for immobilization were obtained by growing *Saccharomyces cerevisiae* SC 20-2, isolated from sugarcane juice, in a medium containing 50 g [raw?] cane sugar/litre and nutrient salts; they were resuspended in NaCl/Na alginate solution, which

was then extruded as droplets into 4% CaCl2 to give beads of size 1.5-2 mm. Various organic and inorganic chemicals were tested for hardening the beads with no loss of activity; the aim was achieved using a cheap inorganic compound [identity not stated], followed by a physical treatment which halved the volume of the beads. In continuous or batch conversion of medium based on 20% cane sugar, the beads gave ethanol concentration ≈90 g/litre for 15 days but began to soften. Beads lost no cells or activity when re-treated and regenerated in medium containing 50 g cane sugar, 3 g yeast extract, 3 g malt extract and 5 g peptone/litre. The interval before softening was extended to 30 days by including CaCl2 at 6 g/litre in the fermentation medium; slight cell leakage from beads began after the third regeneration, but the condition of the beads was still quite good after 6 months. In batch operation, average ethanol concentration in fermented liquor was 90.5 g/litre, with substrate utilization 95%; in continuous operation, these values were 85.9 g/litre and 92.5%. A slightly stronger treatment was needed to harden beads for use in 18% molasses medium; the ethanol concentration reached 70 g/litre (84.4% utilization) throughout 6 months' operation with monthly regenerations.

2040 BALASUBRAMANYA, RH; SHAIKH, AJ; SUNDARAM, V. 1987. **Biodegradation of bagasse for various end uses**. *Bharatiya Sugar*, p. 25-29.

2041 BALASUBRAMANYA, RH; BHATAWDEKAR, SP. 1980. **Semisolid microbial fermentation of rice and wheat straw for protein enrichment and increased digestibility**. *Indian J. Agri. Sci.* 50: 965-970.

2042 BHASIN, SD; KAPUR, JP. 1988. **Effluent disposal in medium sized molasses based distilleries**. *Dechema Biotechnology Conferences: No. 2*. (Weinheim, VCH Verlagsgesellschaft mbH: p. 353-363.

Tabulated compositions show that Indian sugarcane molasses has poorer fermentability than Brazilian, owing to high contents of heavy metals and other inhibitors of fermentation. Hence Indian distillery effluent (vinasse + fermenter sludge + wash water) is less biodegradable and more highly polluted. Possible treatments for this effluent are indicated, none being cheap but effective. Evaporation + incineration is capital-intensive and is only economic with efficient heat recovery. More suitable in India is anaerobic biodegradation in either lagoons or closed digesters (typically decreasing B.O.D. and C.O.D. by about 90% to 5000-10000 mg/litre), followed by aerobic treatment to B.O.D. and C.O.D. values of about 100 mg/litre. Lagooning is cheaper and less sensitive to fluctuations, but requires retention on a large area for up to 100 days and does not yield collectable biogas. Closed digestion has been adopted by large distilleries, both new and old. Types of process available are listed and characteristics of digesters marketed by different companies are compared. The aerobic stage is usually performed in open lagoons with surface aerators; attached-growth alternatives are noted. Capital costs and other economic factors are briefly discussed.

2043 CHAKRAVERTY, A. 1989. **Biotechnology and other alternative technologies for utilisation of biomass/agricultural wastes**. New Delhi: Oxford & IBH Publishing, 249 p.

This book comprises sections on: biomass; thermal and thermochemical conversion of biomass and other solid wastes; biochemical conversion of biomass and other solid wastes (including anaerobic digestion and alcoholic fermentation); and chemical conversion of biomass.

2044 DEY, S; MAITI, TK; SREEMANY, M; GHOSH, TB; BHATTACHARYYA, BC. 1992. **Characterisation of white-rotted and brown-rotted rice straw by X-ray photoelectron spectroscopy**. *Holzforschung*, 46: 385.

2045 DILLON, GS; GREWAL, SK; AJIT SINGH; KALRA, MS. 1988. **Production of sugars from rice straw**. *Acta Microbiologica Polonica*, 37: 2, 167-173; 19 ref.

Trichoderma reesei [T. longibrachiatum] QM 9414 a highly cellulolytic fungus was cultivated on rice straw to produce cellulase enzyme by solid state fermentation. The crude extract of the fermented medium showed CMCase 14.96 IU/ml, FPA 5.64 IU/ml, CSA 0.049 IU/ml and cellobiase 0.98 IU/ml activity after 7 d incubation at 28°C. Crude cellulase enzyme was used to saccharify rice straw. The opt. saccharification (49%) was achieved when 9% delignified rice straw hydrolysed with culture filtrate at 50°C, pH 5.0 after 48 h incubation was used. Saccharified hydrolysate containing 7.68% reducing sugars was fermented by *Saccharomyces cerevisiae* to produce 2.89% (v/v) alcohol after 36 h at 27°C.

2046 JAIN, VK; MISHRA, VK. 1989. **Kinetics of growth and continuous ethanol production by immobilized growing yeast cells**. *Journal of Microbial Biotechnology*, 4: 2, 103-109; 12 ref.

Saccharomyces cerevisiae 3287(NCIM) cells, immobilized in beads of Ca alginate gel, showed no significant change in kinetics of batch growth on 2% sucrose

medium when mildly agitated by shaking at 50 r.p.m.; inclusion of CaCl2 at 2 g/litre minimized cell leakage and increased cell yield. When medium containing 110 g sucrose/litre was passed at different rates through a packed bed reactor holding 70 ml gel containing 5.8% w/v cells, ethanol yield on sucrose remained in the range 43-45%. With increase of dilution rate from 0.1 to 1.3 h-1, hourly ethanol productivity increased from 5.0 to 28.6 g/litre while sucrose conversion decreased from 98.3 to 46.4%. With ethanol concentration 40.7 g/litre in the exit stream, the conversion was 86.5% and the hourly productivity 16.3 g/litre (or 53.8 g/litre if based on the volume of liquid only). The maintenance coefficient (expressing the energy requirement for immobilized growth) was 0.08 g g-1h-1, compared with 0.15 for Zymomonas mobilis in kappa-carrageenan.

2047 PEIRIS, PS; SILVA, I. 1987. **Hydrolysis of rice straw to fermentable sugars by trichoderma enzymes**. *MIRCEN Journal*, 3: 57-65.

2048 PODDER, AK. 1992. **Biofertiliser production of BINA (mimeo)**. Bangladesh Institute of Nuclear Agriculture, Mymensingh.

2049 RAJORE, A; KOTHARI, RM; GARG, RP. 1992. **Optimal anaerobic digestion of high BOD waste with an acclimatised seed culture combination**. *International J. Environ. Pollution*, 1: 51-64.

2050 SASTRY, KSM; SINGH, P; RAO, MVVS; SUBRAHMANYAM, CVS. 1988. **Possibility of utilising industrial residues in gibberellic acid fermentation**. *Indian Journal of Experimental Botany*, 26: 11, 851-853; 6 ref.

Glucose is one of the commonly used C sources for the production of gibberellic acid, using *Gibberella fujikuroi* submerged fermentation. Various residues such as milk whey, hydrol, liquid glucose and molasses which form some of the rich sources of carbon and minerals were used to substitute the commercial glucose in seed as well as in production medium separately or in combinations. Milk whey supplemented with magnesium provided good results. Cultures grown in the medium with hydrol as a C source both in seed and production media produced 602 mg/litre GA on 8th day of fermentation. Molasses did not show promise.

2051 SHARMA, RK; YADAV, KR; KOTHARI, RM. 1994. **Innovative recycling of vegetable proteins waste for the increased crop productivity**. *Technovation*, 14: 31-36.

2052 THANIKACHALAM, A; PANGARAJAN, M. 1987. **Scaling up of the yield of single cell protein in bacterial fermentation of rice straw**. *Madras Agricultural Journal*, 74: 8-9, 405-406; 5 ref.

Increasing the strength of the culture medium (Berg's) increased protein and biomass yield of *Cellulomonas sp.* using alkali pretreated rice straw.

2053 WISE, DL. 1989. **International Biosystems Volume III.** Boca Raton, FL: CRC Press, 246 p.

This volume comprises 12 contributions on: the treatment and utilization of alcohol stillage; high solids digestion of MSW to produce methane; low capital cost fuel gas production from combined organic residues; energy recovery from manure through aerobic and anaerobic digestion; bioenergy recovery and potentials in India; ethanol production from lignocellulosic wastes; aerobic microbial treatment of sewage from industrial animal production; anaerobic digestion of C4 grasses for production of methane and organic acids; anaerobic treatment and integral utilization of swine manure; field crops as renewable sources of convertible energy for methanogenic fermentation; the development of the anaerobic fixed-bed reactor and its application to the treatment of agricultural and industrial wastes; and impact of genetic engineering in pollution control (enhanced biological destruction of environmental xenobiotics).

2054 YADAV, JS. 1988. **SSF of wheat straw with alcaliphilic *Coprinus***. *Biotechnology and Bioengineering*, 31: 5, 414-417; 14 ref.

The solid-substrate fermentation (SSF) of wheat straw using the white-rot fungus *Coprinus* to enhance the nutritive value of the straw as an animal feed was investigated. Constraints on SSF processing of straw experienced in farm (non-sterile) conditions have included the growth of contaminating fungi and a low specific growth rate and substrate utilization. *Coprinus* proved capable of growing under a selective range of pH and temp. and of upgrading straw through preferential delignification and protein enrichment under varying cultural conditions.

2055 ZAFAR, SI; QAISERA-SHEERAZ; NAHEED-ABDULLAH. 1989. **Degradation of the lignocellulosic component on wheat straw - *Coriolus versicolor* solid state fermentation under nitrogen-starved conditions**. *Biological Wastes*, 27: 1, 67-70; 10 ref.

Data are tabulated on the degradation of the lignocellulosic compounds by *C. versicolor*. Over a 35 d period the cellulose content fell from 42.3% in the control to

38% and the lignin content from 12.4 to 7.2%. Of the 42% lignin degraded in this period, 36.3% was degraded in the first 14 d. The results indicated that *C. versicolor* is slightly more efficient than Ganoderma applanatum and *Pleurotus ostreatus* in relation to organic matter loss.

BIOGAS

2056 AMARAKONE, SP; SIVAYOGASUNDERAM, SK. **Biogas production from cellulosic material**. Industrial Microbiology Section, Ceylon Inst. of Scientific and Industrial Research, 363, Bauddhaloka Mawatha, Colombo 7, Sri Lanka.

2057 BALASUBRAMANUYA, RH; KHANDEPARKAR, VG; SANDARAM, V. 1986. **Production of biogas and biomanure from the testile processing residue, willow-dust by dry anaerobic fermentation**. *Agri. Wastes*, 16: 295-302.

2058 BALASUBRAMANYA, RH; GANGER, HU; KHANDEPARKAR, VG; SUNDARAM, V. 1986. **Production of biogas and biomanure from willow-dust by dry anaerobic fermentation on a pilot plant**. *National Seminar on microbial Ecology*. Tamil Nadu Agricultural University, Dept. of Agril. Microbiology, Coimbatore, Tamil Nadu, India.

2059 BALASUBRAMANYA, RH; GANGAR, H U; KHANDEPARKAR, VG; SUNDARAM, V. 1990. **Production of biogas and biomanure form willow-dust, a textile mill processing residue.** *Encyclopedia of Environmental Control Technology, Vol. 4*/edited by PN Cheremisinoff. Texas: Gulf Publishing, p. 389-409.

2060 BALASUBRAMANYA, RH; KHANDEPARKAR, VG; BETRABET, SM; SUNDARAM, V. 1981. **Production of biogas from willow dust by a bathch fermentation process**. *J. Textile, Assn.* 42: 145-149.

2061 BALASUBRAMANYA, RH; KHANDEPARKAR, VG; SUDARAM, V. 1982. **Utilisation of willow-dust through anaerobic digestion for production of biogas and biomanure**. *Engineering Design*, 11: 31-33.

2062 BALASUBRAMANYS, RH; GANGAR, HU; KHANDEPARKAR, VG. 1994. **Biogas from solid cellulosic wastes by solid state fermentation**. *35th Annual Conference of the Association of Microbiologists of India*, p. 9-12.

2063 BALASUBRAMANYA, RH; KHANDEPARKAR, VG; SUDARAM, V. 1983. **Biogas from willow-dust by dry fermentation**. *Indian Society Cotton Improvement*. 8: 93-94.

2064 GADRE, RV. 1989. **Removal of hydrogen sulfide from biogas by chemoautotrophic fixed-film bioreactor**. *Biotechnology and Bioengineering*, 34: 3, 410-414; 39 ref.

The development of a fixed-film bioreactor for the removal of hydrogen sulfide from biogas using chemoautotrophic bacteria is described. A 50 ml- capacity glass reactor packed with porcelain rings was used. A high volumetric efficiency of H2S removal was achieved, and this could be further increased by improving the packings to increase the available surface area. The recovery of elemental sulfur as a valuable by-product was feasible. The proliferation of heterotrophs was not expected to be a problem, since the autotrophic environment would prevent any major proliferation.

2065 GUNASEELAN, VN. 1988. **Anaerobic digestion of *Gliricidia* leaves for biogas and organic manure**. *Biomass*, 17: 1, 1-11; 11 ref.

Gliricidia maculata [*G. sepium*] is a tree grown in India for green leaf manuring. The digestibility of *Gliricidia* leaves for biogas production was determined in 3.0 litre batch digesters at room temp. (32±3°C). Results indicated a gas yield of 165-180 ml CH4 g-1 volatile solids added and a VS reduction of 37-39%. Determination of the N,P and K content of the digester influent and effluent slurries showed anaerobically digested slurry of *Gliricidia* leaves to be better in quality than the fresh *Gliricidia* leaves as organic manure.

2066 GUPTA, RA; RAI, SN; TIWARI, GN. 1988. **An improved solar assisted biogas plant (fixed dome type): a transient analysis**. *Energy Conversion and Management*, 28: 1, 53-57.

A transient analytical study of a fixed dome type biogas plant incorporating a water heater for higher biogas production, particularly for winter conditions in India, is presented. Further improvements in performance by using insulation on the walls and the base of the digester are investigated. An explicit expression for the slurry temp. as a function of time (depending upon various parameters) is developed.

2067 KALIA, AK. 1988. **Development and evaluation of a fixed dome plug flow anaerobic digester**. *Biomass*, 16: 4, 225-235; 11 ref.

A 3 m3 fixed dome plug flow anaerobic digester was