Utilisation of Agro-Industrial Solid Wastes for high added value products by recycling Bio-technologies

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Hellenic Agricultural Organization DEMETER

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on Sustainable Solid Waste Management,
Tinos island, Greece

The waste world in one place

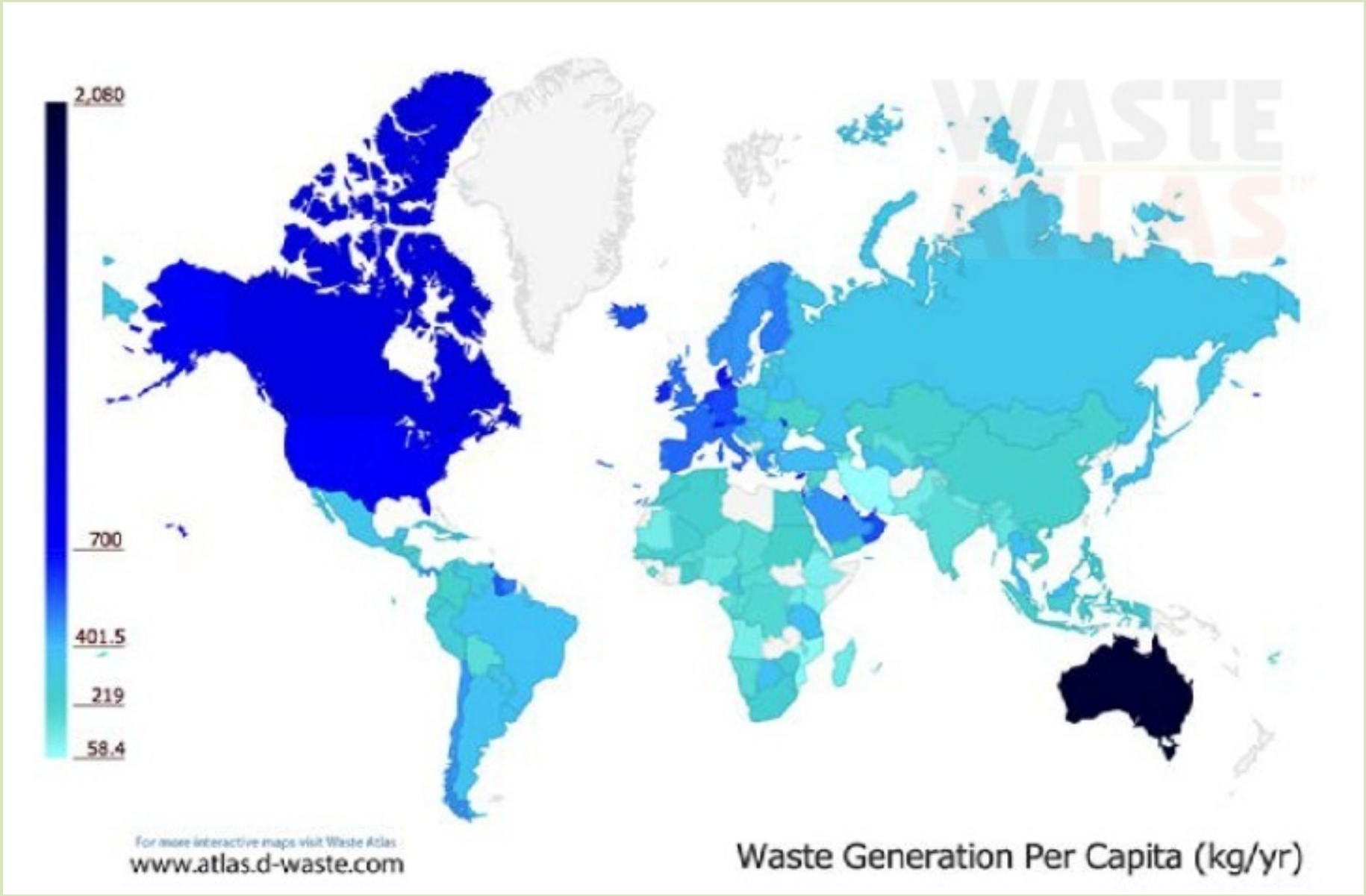
Global waste generation

1.9 billion tons
equal to
25% of the shipments
traded in 2011

Metals	3.48 %
Paper Cardboard	16.26 %
Plastic	10.47 %
Glass	3.78 %
Organic matter	45.34 %
Other	20.66 %

Global Generation Per capita

One generates annually waste equal to **3-4 times** his weight


2,080
700
401.5
219
58.4
For more interactive maps visit Waste Atlas
www.atlas.d-waste.com
Waste Generation Per Capita (kg/yr)


49
10
1
0
WASTE ATLAS
For more interactive maps visit Waste Atlas
www.atlas.d-waste.com
Recycling Rate (%)

SOLID WASTE AND ITS MANAGEMENT

It is defined as:

“Non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes that contain complex and sometimes hazardous substances”

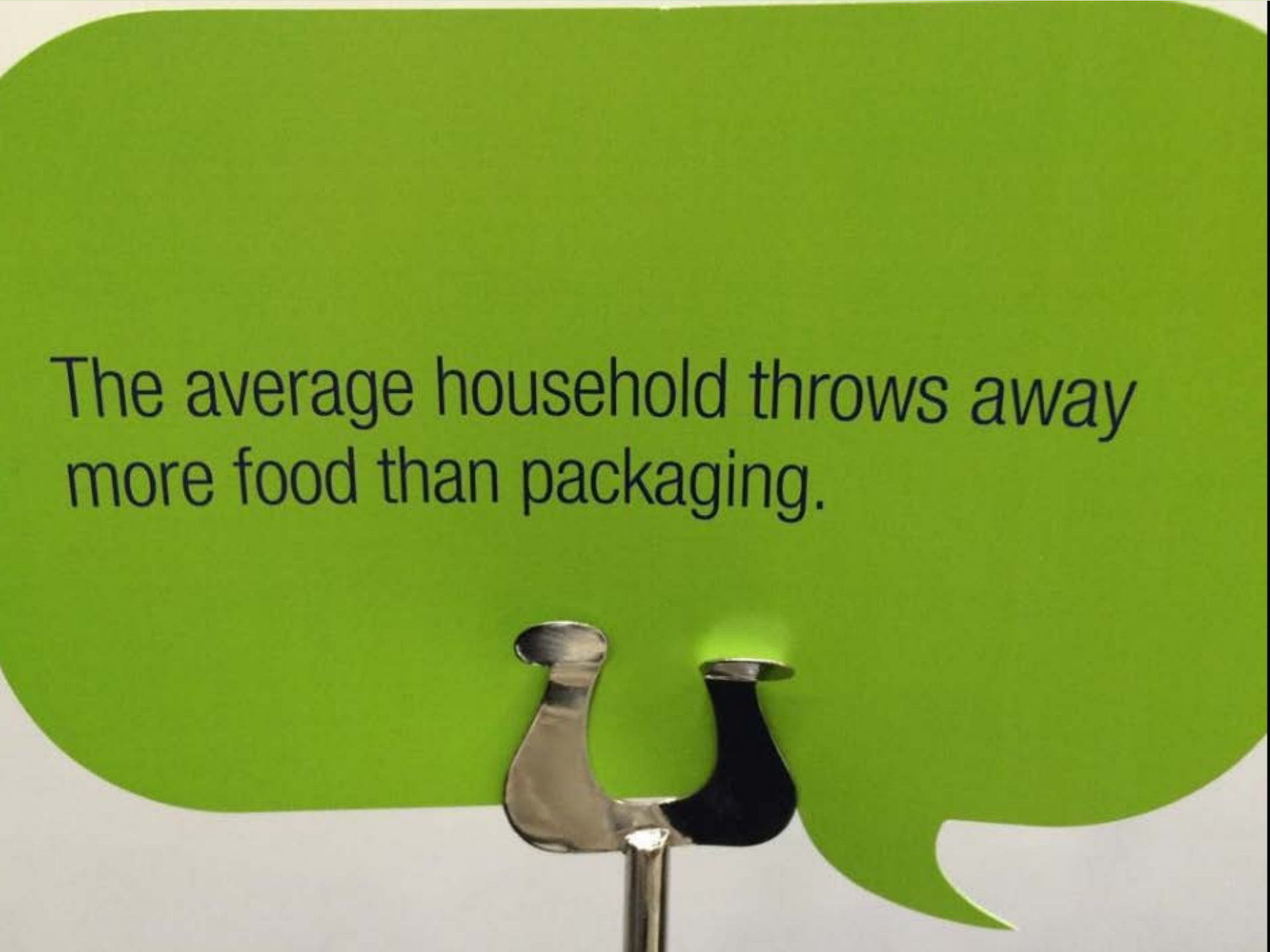
Source of Solid Wastes

- Mining waste consist mainly of rock and soil overburden from mining operations – an earth moving project
- Agricultural wastes are typically organic residuals – biodegradable and recyclable
- Industrial wastes are widely varied – have the potential of being hazardous
- Municipal solid wastes (MSW) vary greatly in quantity and composition
- We will focus on the management of Agricultural wastes

The global issue of food waste

- Worldwide about one-third of all food produced – equivalent to 1.3 billion tonnes – gets lost or wasted in the food production and consumption systems, source: FAO


NOW
1/5
1/3
OF THE FOOD
WE BUY
WE THROW
AWAY!


The average household throws away more food than packaging.

COMPOSTING

- Composting, often described as nature's way of recycling, is the biological process of breaking up of organic waste such as food waste, manure, leaves, grass trimmings, paper, worms, and coffee grounds, etc., into an extremely useful humus-like substance by various micro-organisms including bacteria, fungi and actinomycetes in the presence of oxygen.

"MESSIEURS, C'EST LES MICROBES QUE AURONT LE DERNIER MOT"

LOUIS PASTEUR

MASS DOUBLING TIMES - TABLE III

Organism	Time for One Mass Doubling
Bacteria and yeast	10-120 Min
Mold and algae	2-6 h
Grass and some plants	1-2 wk
Chickens	2-4 wk
Pigs	4-6 wk
Cattle	1-2 mo
People	0.2 - 0.5 yr

TABLE 3

EFFICIENCY OF PROTEIN PRODUCTION OF SEVERAL PROTEIN SOURCES IN 24 HOURS (5)

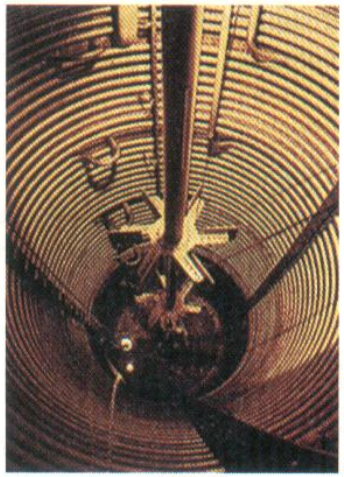
Organism (1,000 lbs)	Amount of Protein
Bullock	0.9 lb
Soybeans	82.0 lbs
Yeast	50 tons

ADVANTAGE OF SCP OVER CONVENTIONAL PROTEIN

1. PRODUCTIVITY
2. INDEPENDENT OF LAND AND CLIMATE
3. CONTROLABILITY
4. LESS POLLUTION

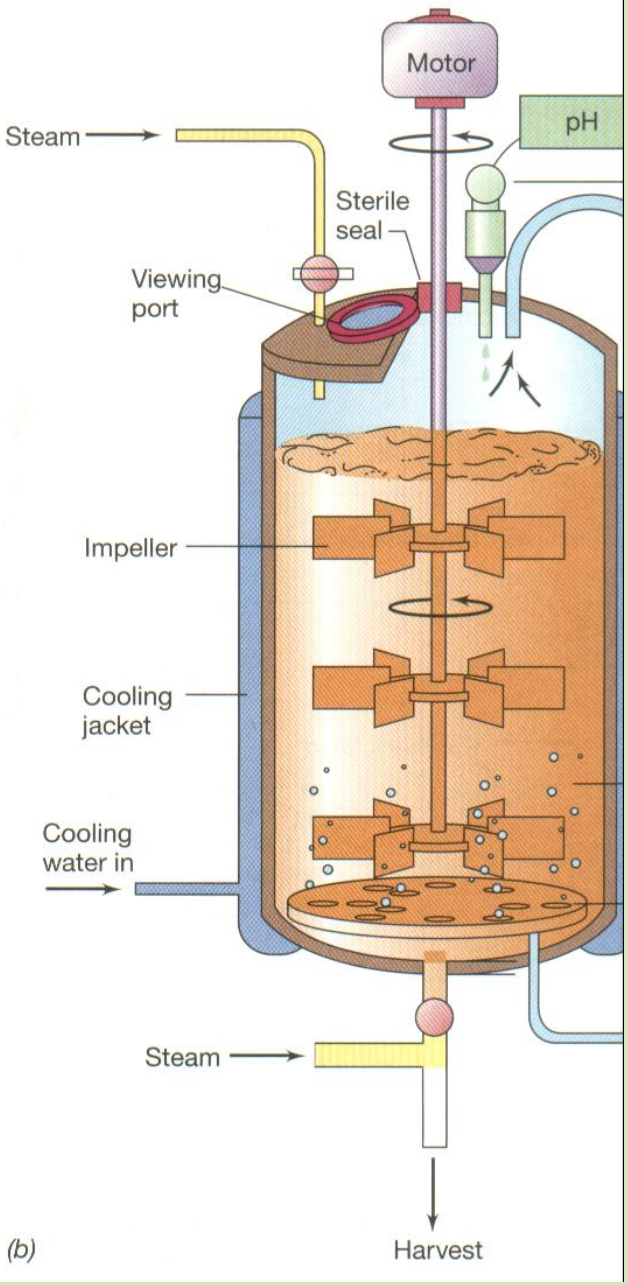
Queue Systems, Inc.

(a)

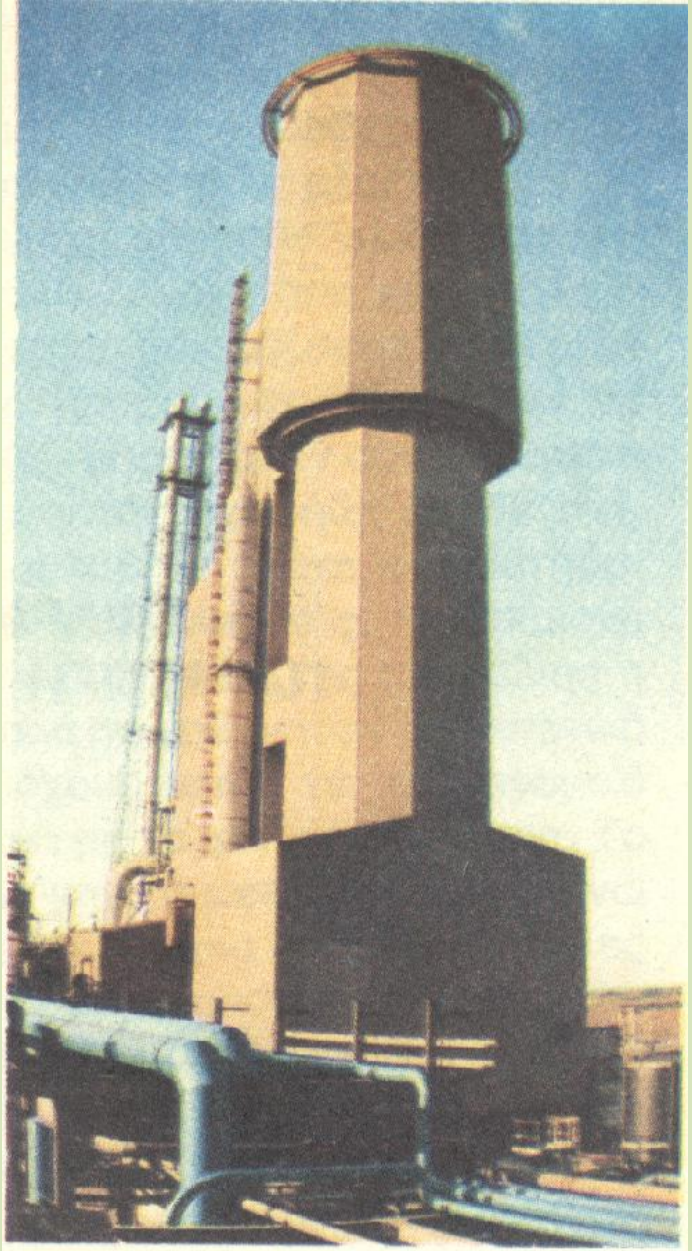


Novo Industri

(c)



(b)



Εικ. 15.1.β: Βιοαντιδραστήρας παραγωγής μονοκυτταρικής πρωτεΐνης από βακτήρια.

SCP as Meat Substitute

- Protein……50%
- Fat……13%
- Fiber……25%
- Minerals……great spectrum
- Vitamins……Full B complex
- Nucleic Acids ……..< 15%

Fig. 7.11 Mycoprotein before processing. Left "beef", right "chicken".

Fig. 7.12 First trial meals with "refined" mycoprotein.

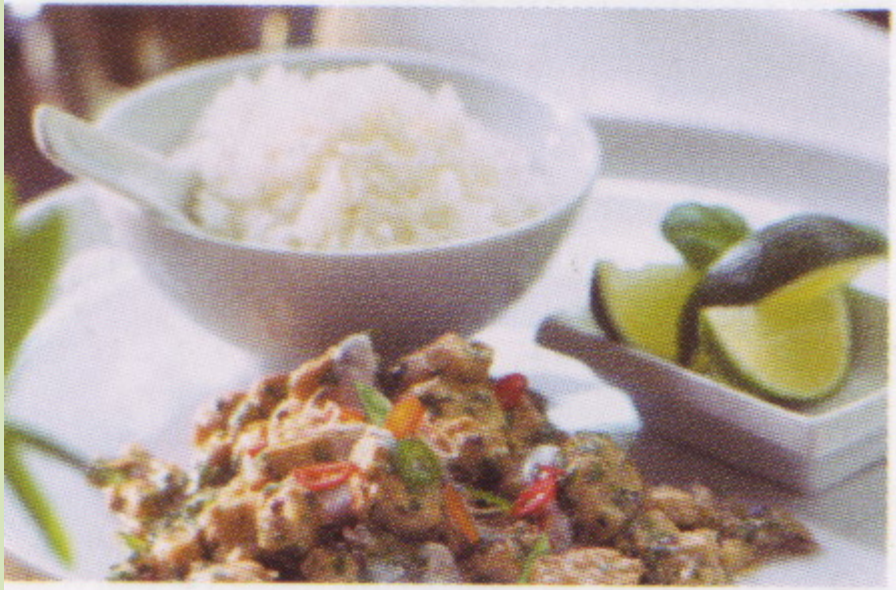


Fig. 7.13 *Quorn* products made of *Fusarium*: meatballs and sausages without meat.

SUGAR PRODUCTION BY-PRODUCTS

- **Molasses**

(cane & sugar beet)

  - Animal feed
  - C source in Fermentation
  - Citric acid, L-Lysine, L-glutamate

- **Bagasse**

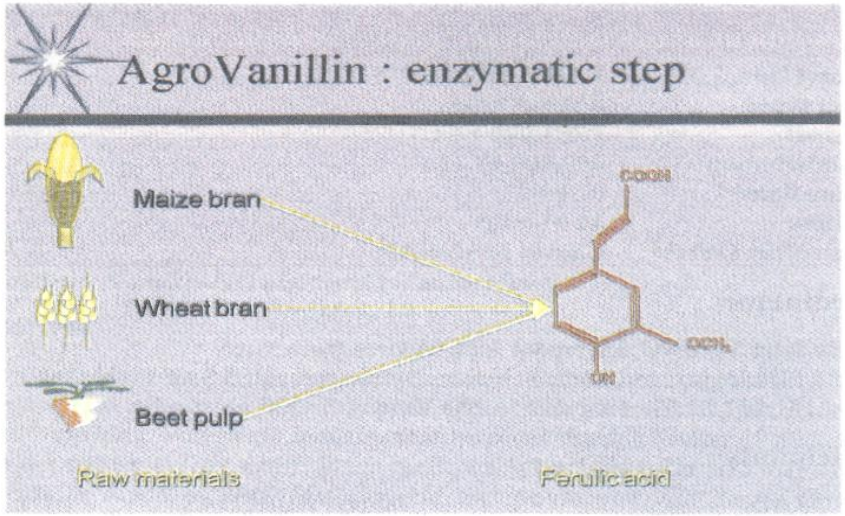
  - Fuel (pentosans) → furfurals

- **Beet pulp**

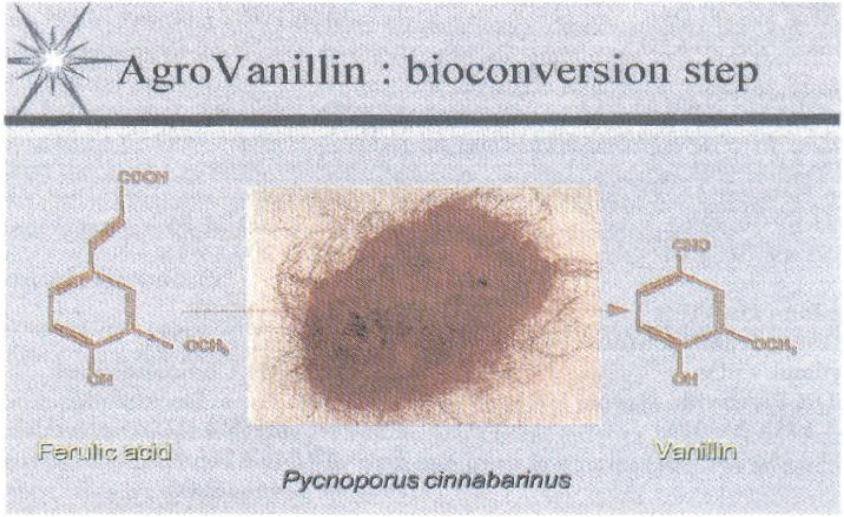
  - Animal feed
  - Ferulic acid → vanillin
  - Arabinan

- **Biomass**

  - Ethanol
  - Acetic acid (Ca, Mg, Acetate)
  - n-Butanol
  - Acetone, Glycerol, Citric acid, Polylactate (PLA)



FAIR2-CT95-1099: Enzymatic step in the production of natural vanillin from agricultural by-products



FAIR2-CT95-1099: Bioconversion step in the production of natural vanillin from agricultural by-products

Bioresource Technology **47** (1994) 97–101

FERMENTABILITY OF SUGAR BEET PULP AND ITS ACCEPTABILITY IN MICE

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(Received 2 May 1993; revised version received 29 May 1993; accepted 1 June 1993)

Table 1. Chemical compositions (% dry matter) of unfermented and fermented sugar-beet pulp (USBP and FSBP)

	USBP	FSBP
Moisture	7·00 ± 0·20	7·01 ± 0·20
Crude protein (N × 6·25)	9·60 ± 0·20	19·50 ± 0·30
Fat[a]	1·60 ± 0·30	2·30 ± 0·10
Crude fiber[b]	23·35 ± 0·20	18·04 ± 0·20
Cellulose[c]	24·80 ± 0·40	18·40 ± 0·10
Hemicellulose[c]	27·90 ± 0·30	12·90 ± 0·30
Lignin[c]	2·60 ± 0·20	3·50 ± 0·30
Ash[c]	3·50 ± 0·20	3·24 ± 0·30

[a]Soxhlet, in AOAC (1984).
[b]Weede, in AOAC (1984).
[c]Van-Soest (1970).

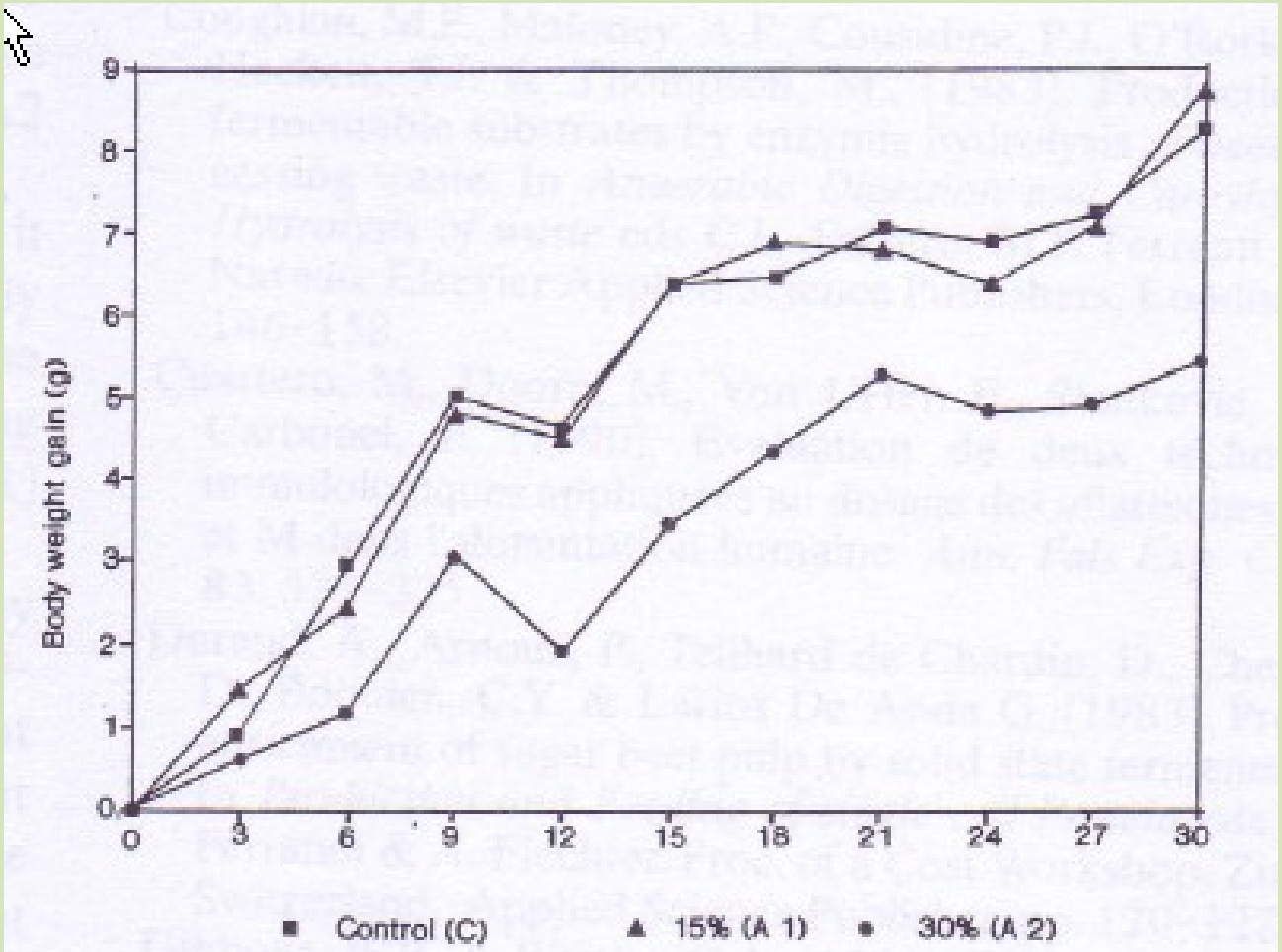

Fig. 2. Body weight gain of SWR mice on diets containing 15% and 30% fermented sugar-beet pulp plus control. ■, Diet C (control); ▲, diet A1 (15%); ●, diet A2 (30%).

ELSEVIER

Small Ruminant Research 27 (1998) 55–61

Small Ruminant Research

Protein enhancement of sugar beet pulp by fermentation and estimation of protein degradability in the rumen of sheep

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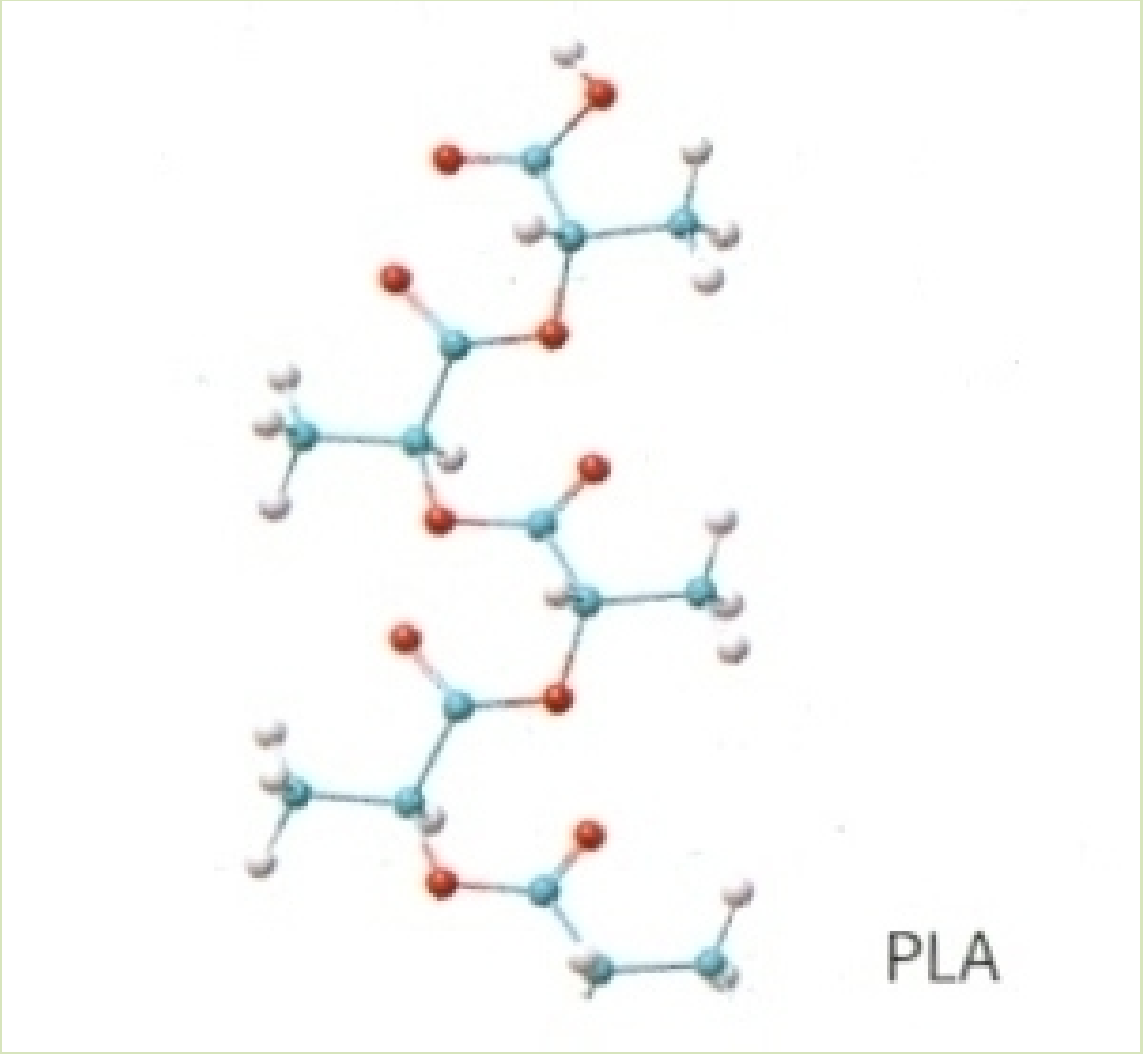
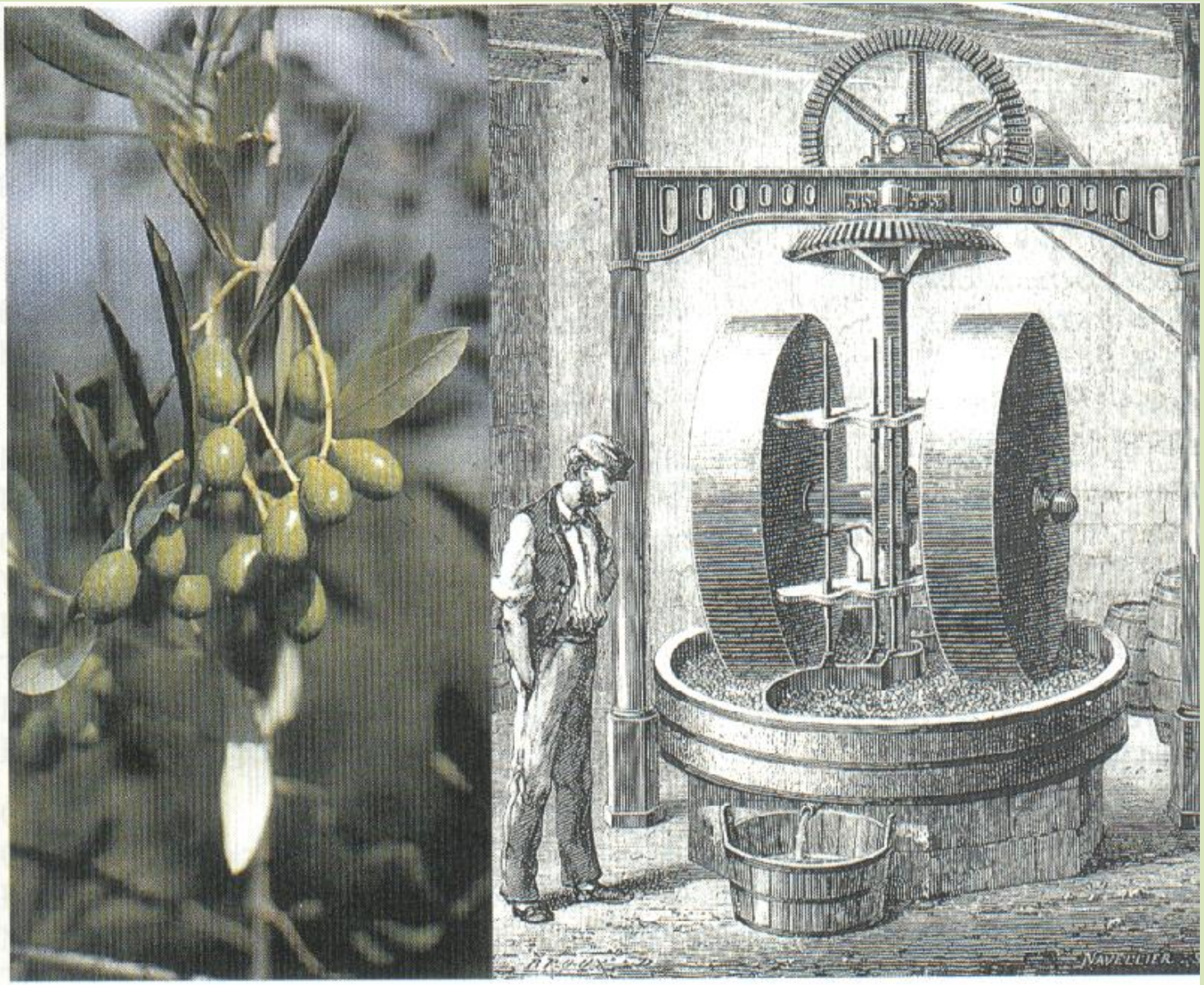
Accepted 14 January 1997



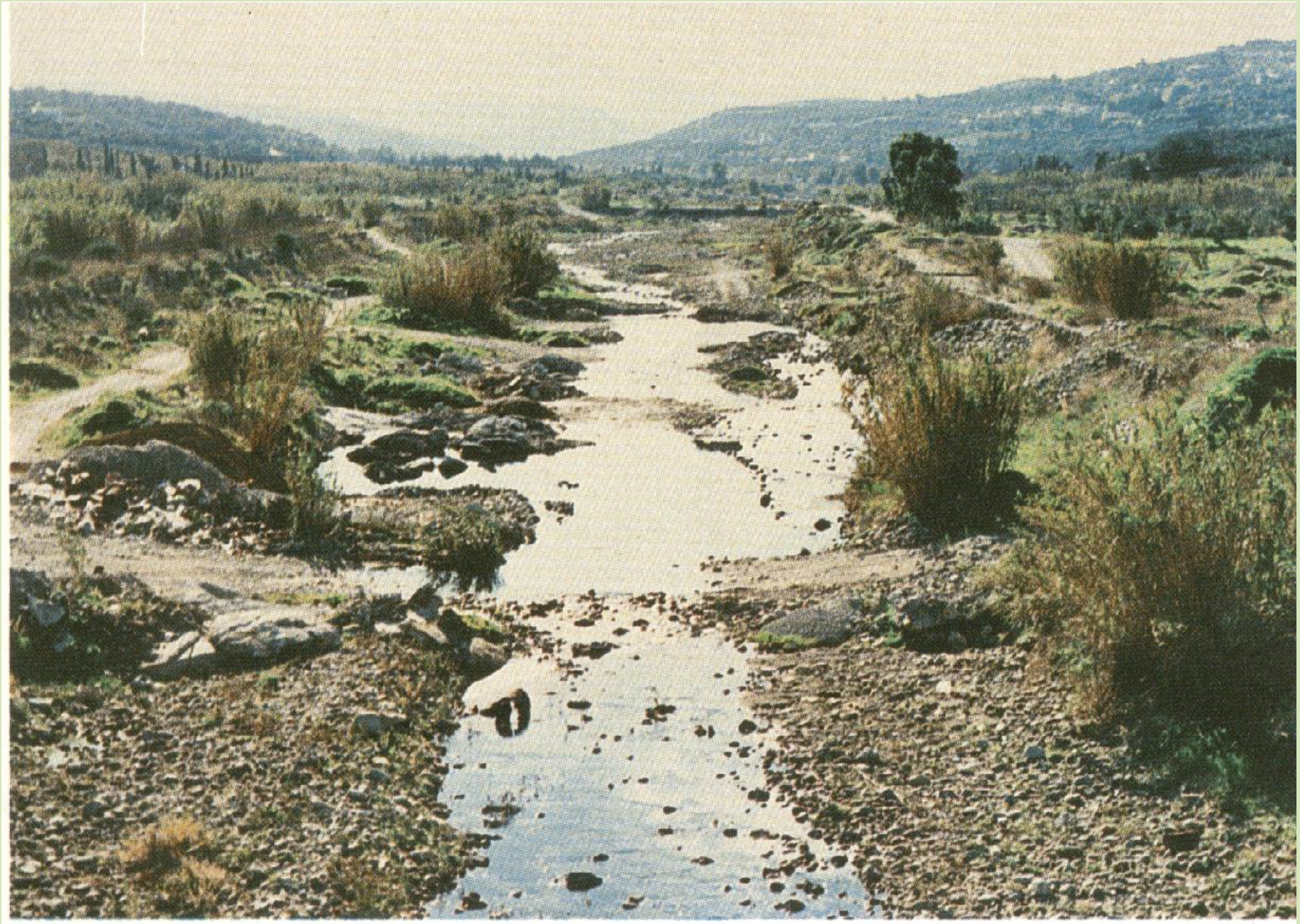
PLA


PLASTARCH
プラスターチ


DVDディスク
(試作品)
日本ビクター株式会社
原料：トウモロコシ



FAIR4-CT96-3039: Olives (left) and a traditional olive oil mill (right)




1

HUMO OLEA

HUMO OLEA

ΟΡΓΑΝΟ - ΧΟΥΜΙΚΟ ΕΔΑΦΟΒΕΛΤΙΩΤΙΚΟ

Προϊόν κατάλληλο για κηπευτικά, ελιές, αμπέλια, εσπεριδοειδή, οπωροφόρα, γκαζόν, ανθοκομικά και μεταφυτεύσεις

100% ΑΠΟ ΠΑΡΑΠΡΟΪΟΝΤΑ ΕΛΙΑΣ

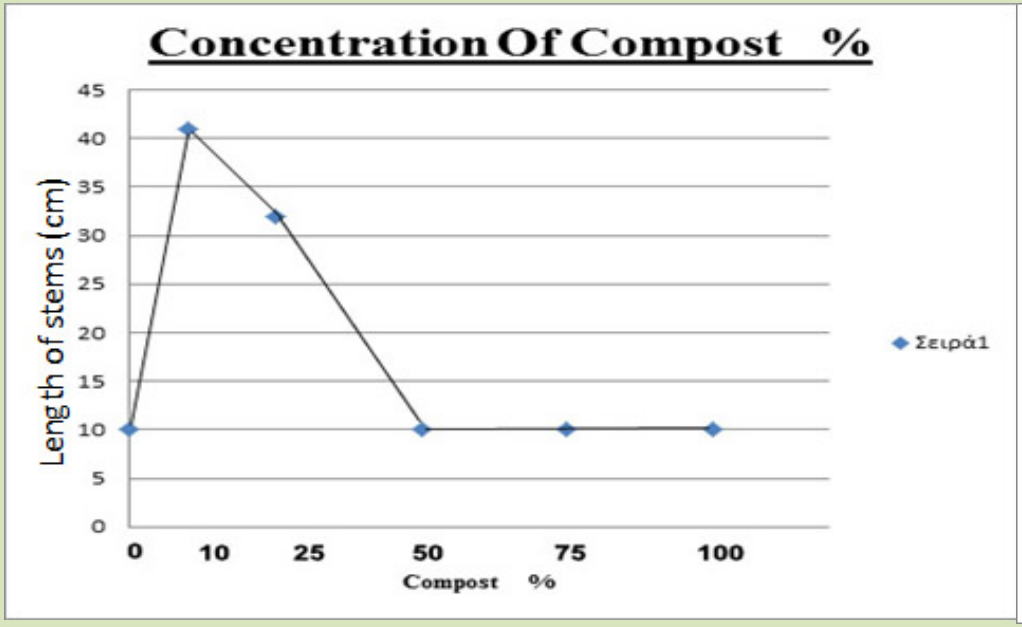
Προερχόμενο αποκλειστικά από παραπροϊόντα επεξεργασίας ελαιοκάρπου (ελαιόφυλλα,ελαιοπυρήνα, φυτικά υγρά ελιάς)

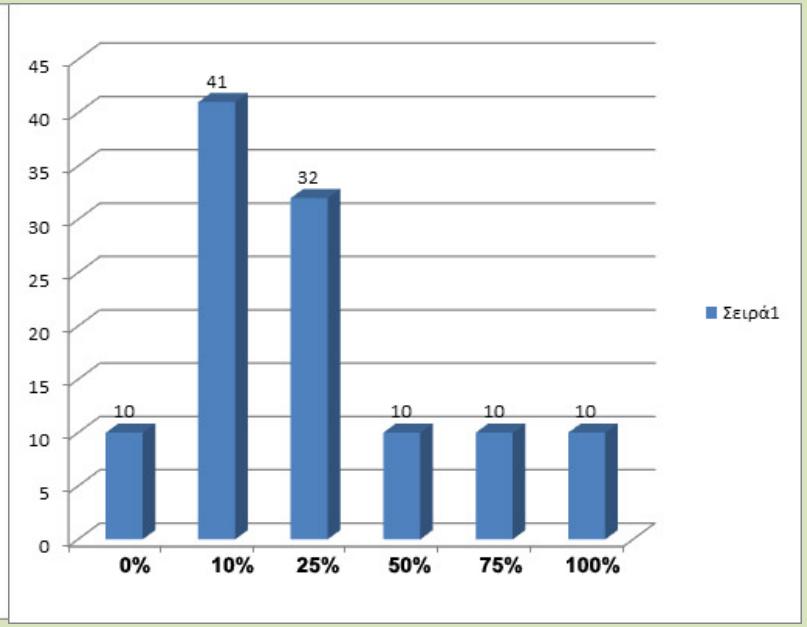
ΙΔΑΝΙΚΟ ΓΙΑ ΒΙΟΛΟΓΙΚΕΣ ΚΑΛΛΙΕΡΓΕΙΕΣ

Προϊόν σύμφωνο με τους κανονισμούς 2092/91, 2381/94, 834/07 της ΕΕ για τη βιολογική γεωργία

1st Year

0%	10%	25%	50%	75%	100%


Concentration Of Compost %
Length of stems (cm)
45
40
35
30
25
20
15
10
5
0
0
10
25
50
75
100
Compost %
Σειρά1

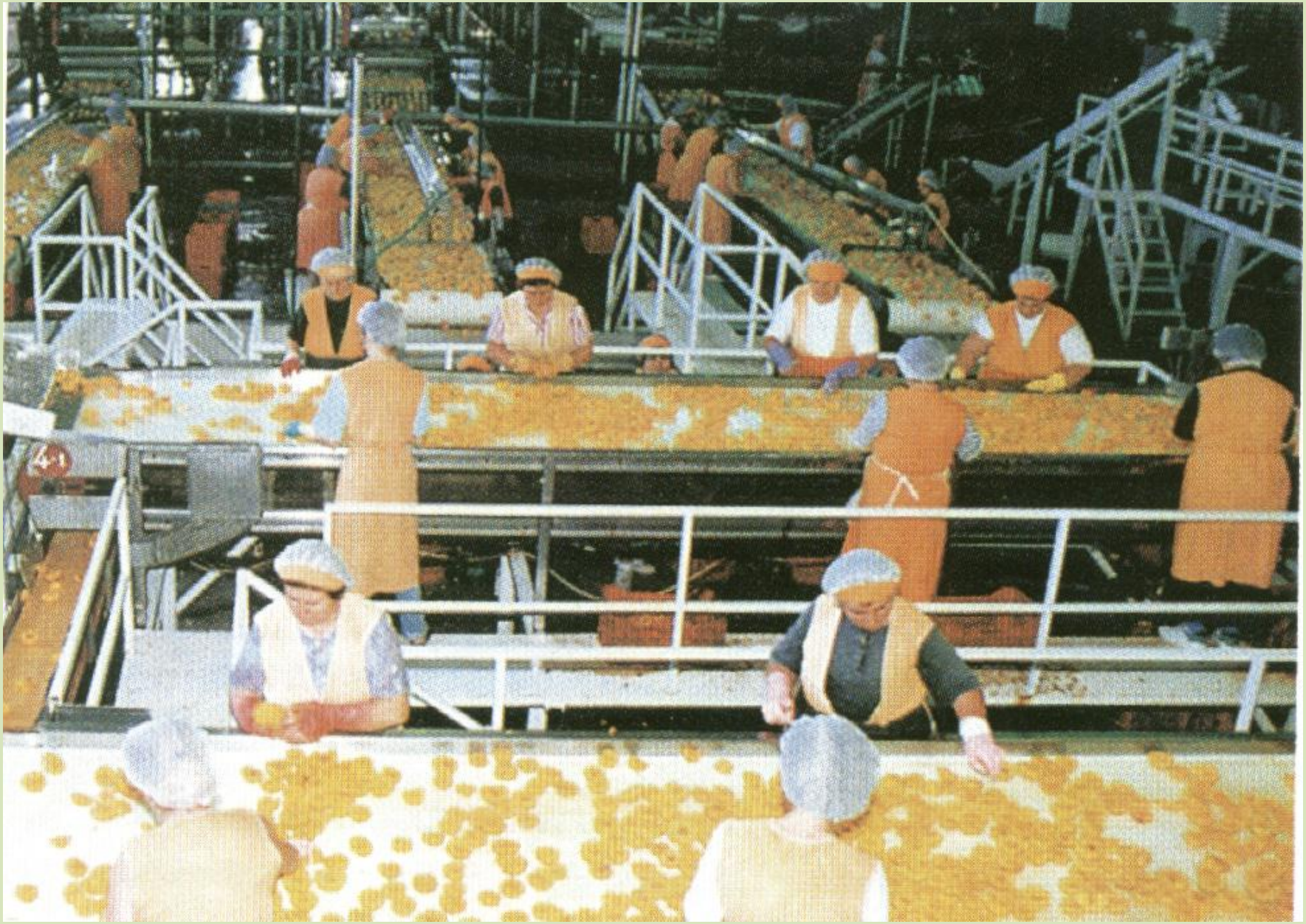

45
40
35
30
25
20
15
10
5
0
41
32
10
10
10
10
0%
10%
25%
50%
75%
100%
Σειρά1

3rd Year

0%	10%	25%	50%	75%	100%

4th Year

0%	10%	25%	50%	75%



CITRUS FRUITS BY-PRODUCTS

- Peels & Rugs → Pectin
  Cattle feed (dried)
  Essential oils
- Pulp → Animal Feed (SSF)
- Seeds → Citrus flavonoids
- Citrus molasses → Fermentation products
- Colourings → Natural clouding agents

Table 1: Chemical composition* % of dry matter (DM) of unfermented (CP) and fermented citrus pulp (FECP) with the fungi *T. reesei* and *T. viride* in solid-state fermentation (SSF) on bioclimatic chamber for 7 days of culture.

Component %DM	CP	FECP
Dry matter	90.4± 0.28	91.0± 0.25
Crude Protein (Cr.Prot): Nx6.25	6.78 ± 0.26	21.90 ± 0.15
Fat	3.01 ± 0.23	1.34 ± 0.18
Crude Fibre (CF)	14.75 ± 1.08	12.19 ± 0.40
NDF	36.54±1.55	24,35± 0.85
ADF	30.98 ± 0.29	23.80 ± 0.80
Cellulose	24.34 ± 1.26	17.50± 0.90
Hemicelluloses	5.56 ± 0.29	0.54 ± 0.10
Lignin	6.26 ± 1.48	5.95± 0.10
Ash	0.38 ± 0.26	0.45± 0.50

Table 5. Dry matter (DM) and crude protein (Cr.Prot.) degradability of concentrate Feeds of rations' nutrient of sheep.

Nutrient	Concentrate			SEM[1]	Level of Significance (p-level)
	A	B	C		
Dry matter	81.7[a]	84.9[b]	86.6[c]	0.31	***
Crude protein	92.7[a]	94.2[b]	95.2[c]	0.22	***

***; P<0.001

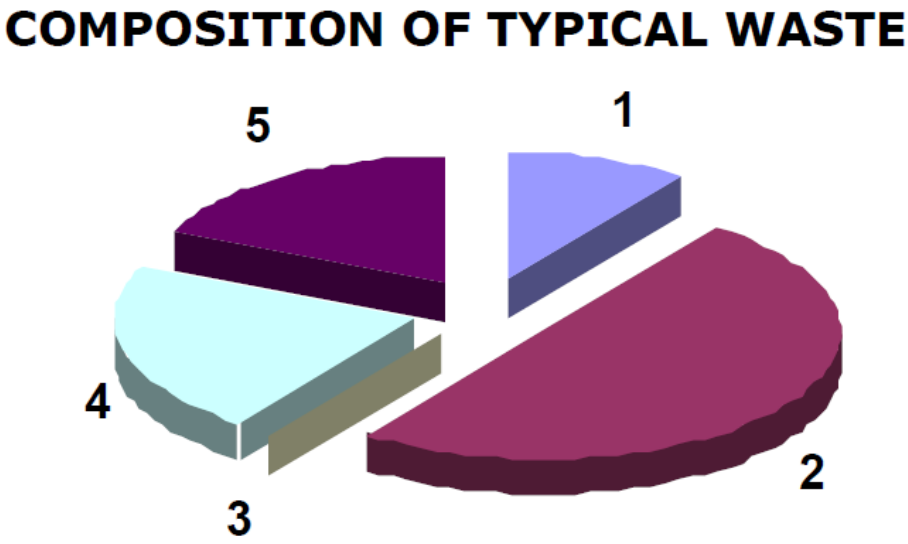
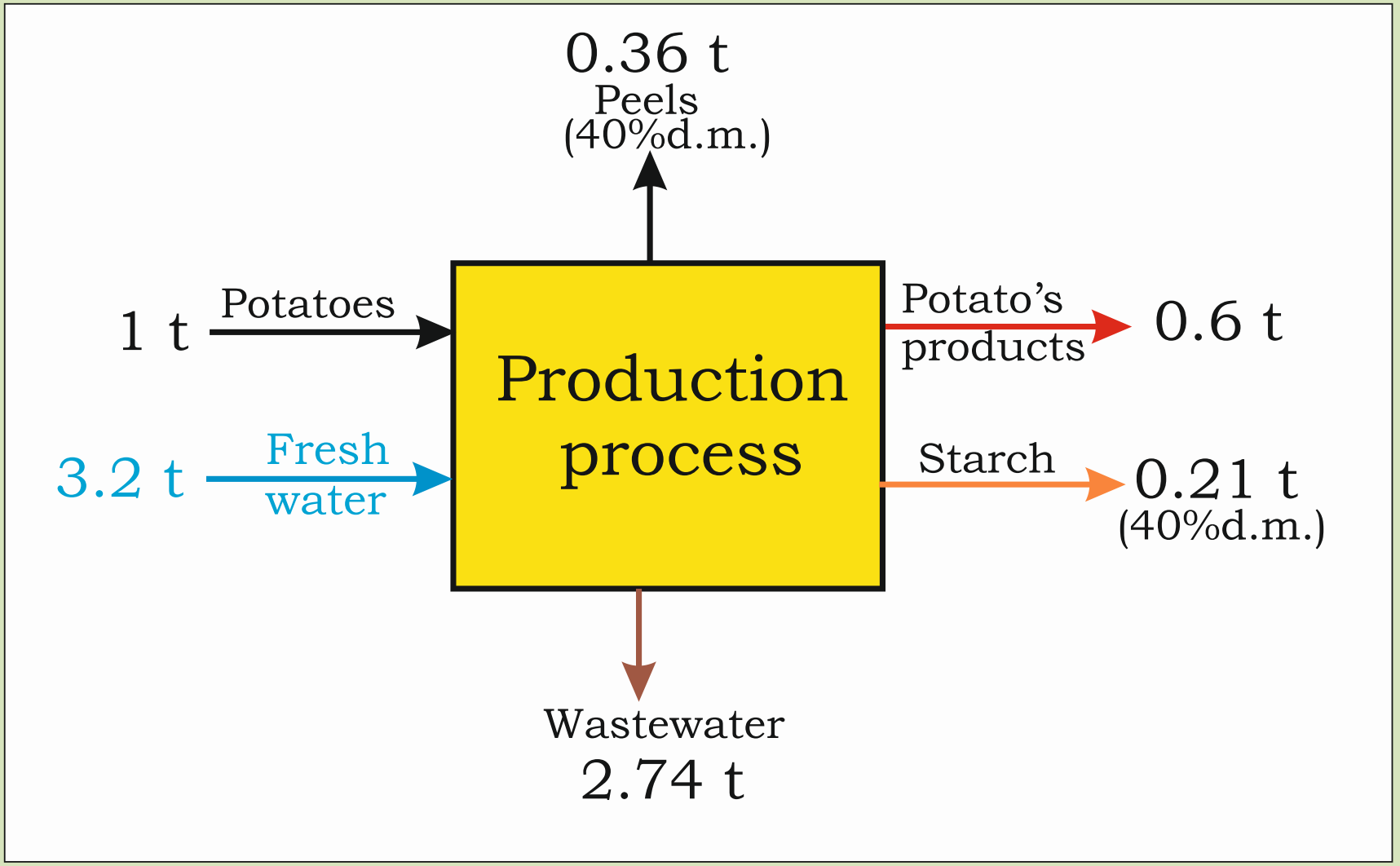


Figure 3: 1. fats: 10%; 2. fibers – polysaccharides 50%; 3. Lycopene and β-carotene 0,3%; 4. water 22%; 5. proteins 18%

Walker's Crisps


0.36 t
Peels
(40%d.m.)
1 t
Potatoes
Production process
Potato's products
0.6 t
3.2 t
Fresh water
Starch
0.21 t
(40%d.m.)
Wastewater
2.74 t

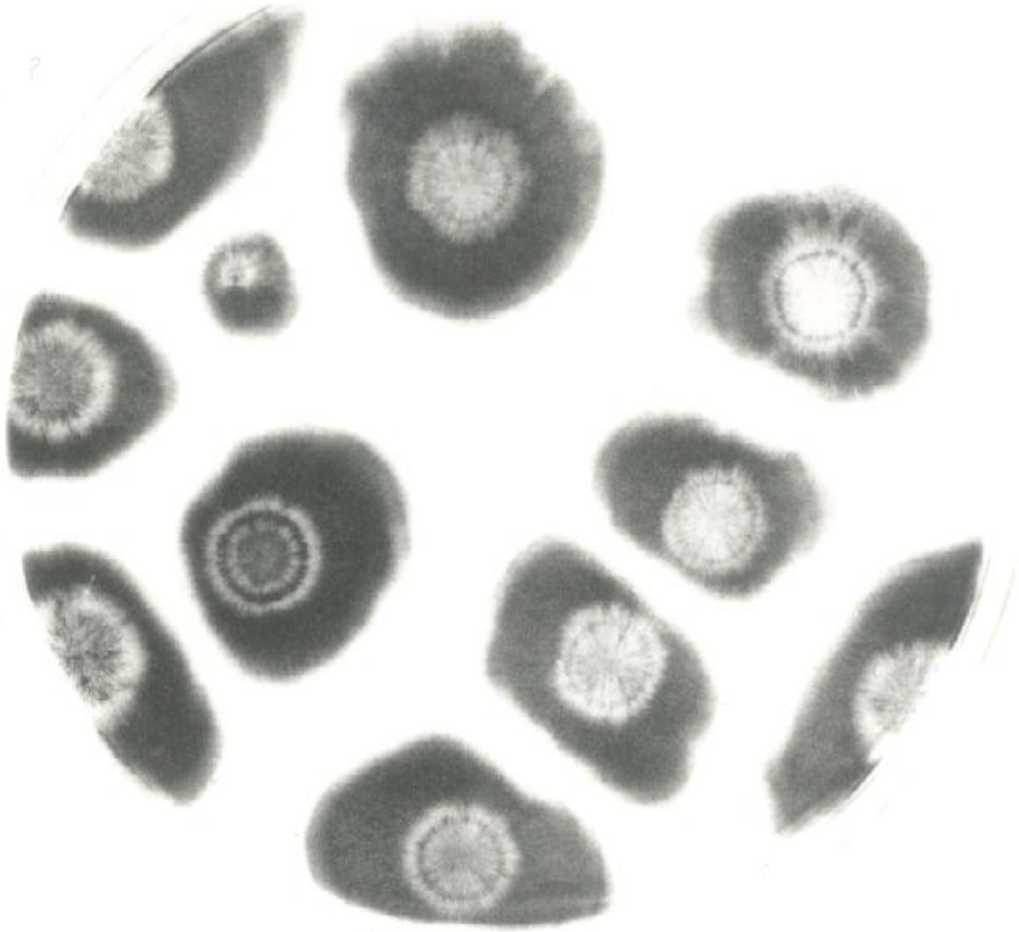
POTATO INDUSTRY WASTES

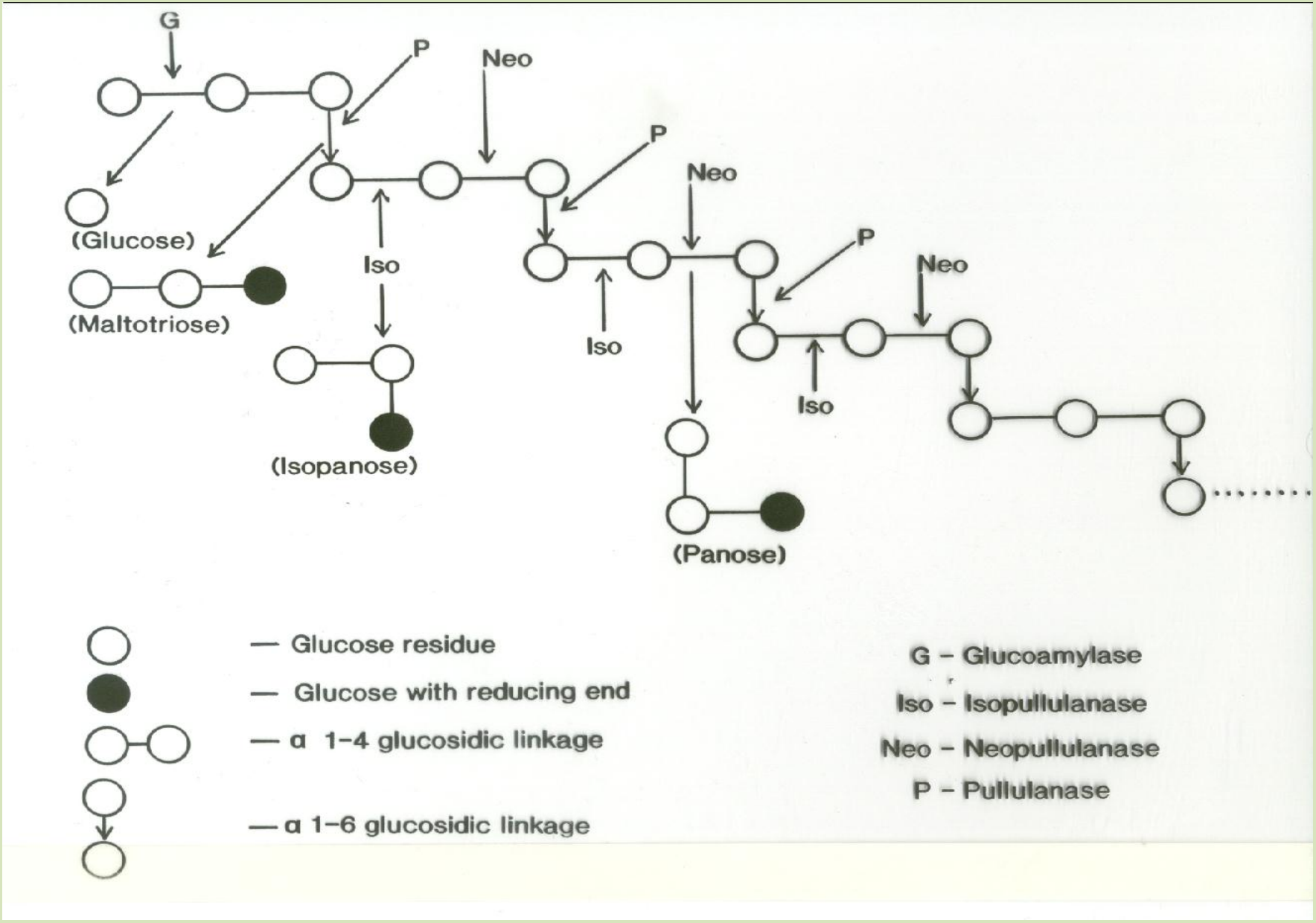
PEELS (15-40%)

a) Animal Feed
b) Ethanol
c) Compost
d) Energy (Pyrolysis)
e) Biogas
f) Antioxidants
g) Solanin

STARCH

a) Food grade starch
b) High value compounds by fermentation (e.g. Pullulan)



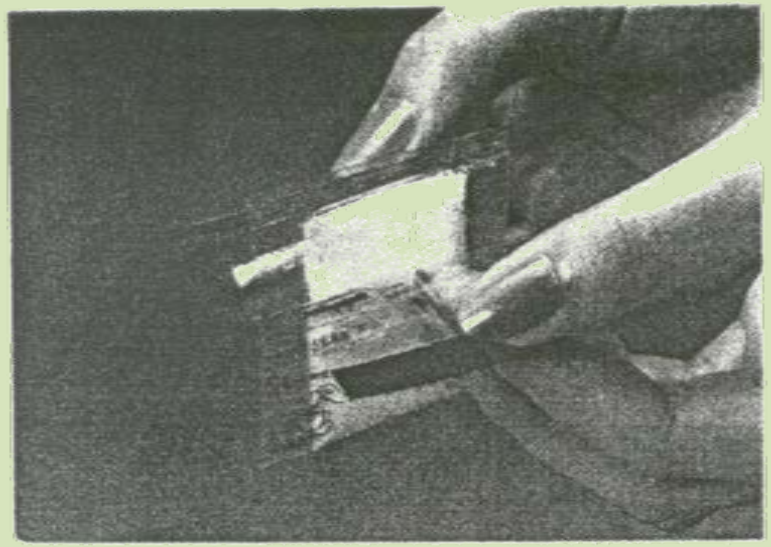

G
P
Neo
P
Neo
P
Neo
Iso
Iso
Iso
(Glucose)
(Maltotriose)
(Isopanose)
(Panose)
— Glucose residue
— Glucose with reducing end
— α 1–4 glucosidic linkage
— α 1–6 glucosidic linkage
G – Glucoamylase
Iso – Isopullulanase
Neo – Neopullulanase
P – Pullulanase


MOU-STAR
PULULAN
HAYASHIBARA
GROUP

2. Character–printed Pullulan film

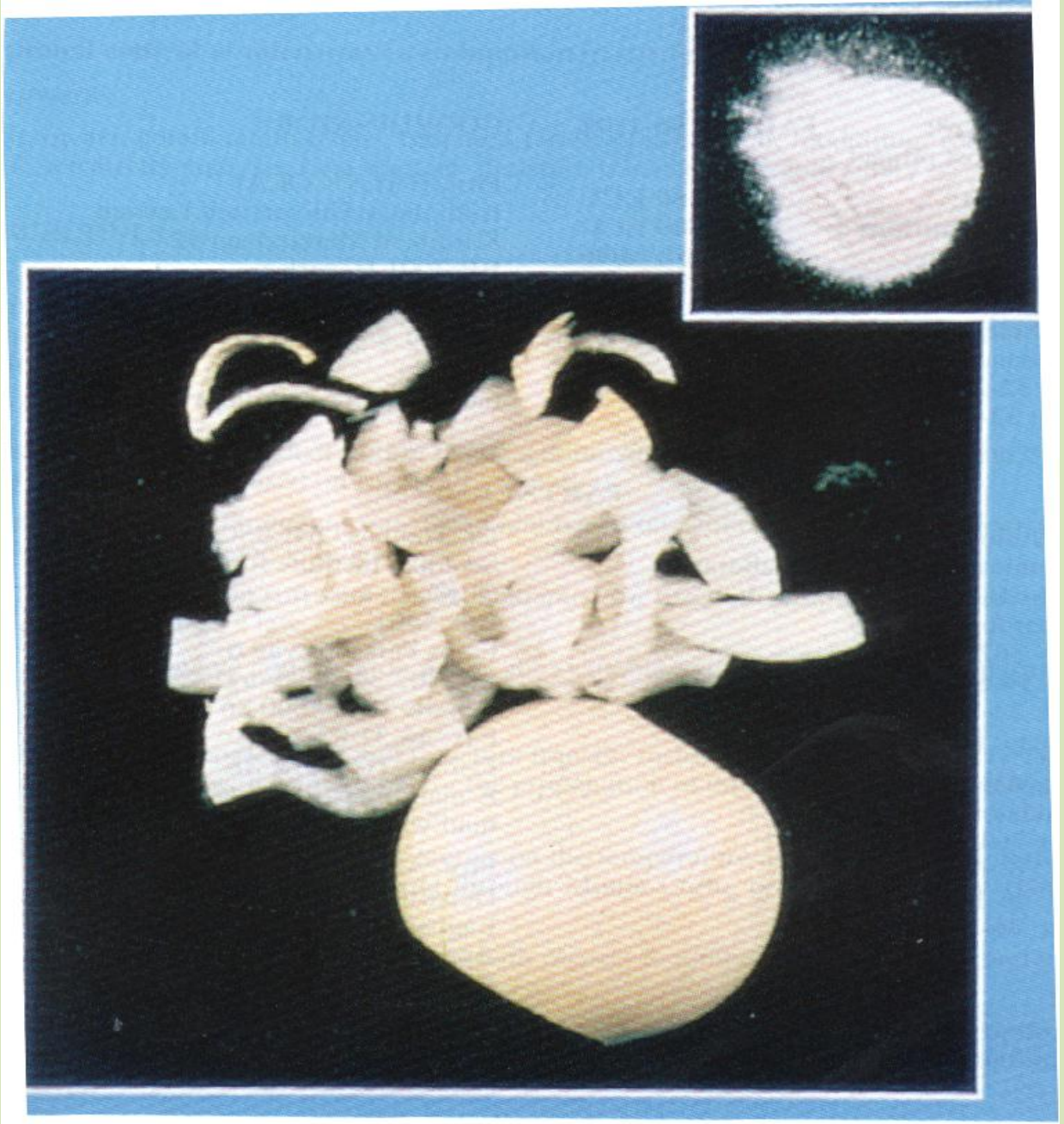
3. Same as above 2, character–printed Pullulan film is inserted in a fancy candy

8. Seasoning (pepper) incorporated Pullulan film is used to wrap the ham



11. Table sugar wrapped with edible Pullulan film

FAIR-CT96-1020. Harmonization of safety criteria of minimally processed foods

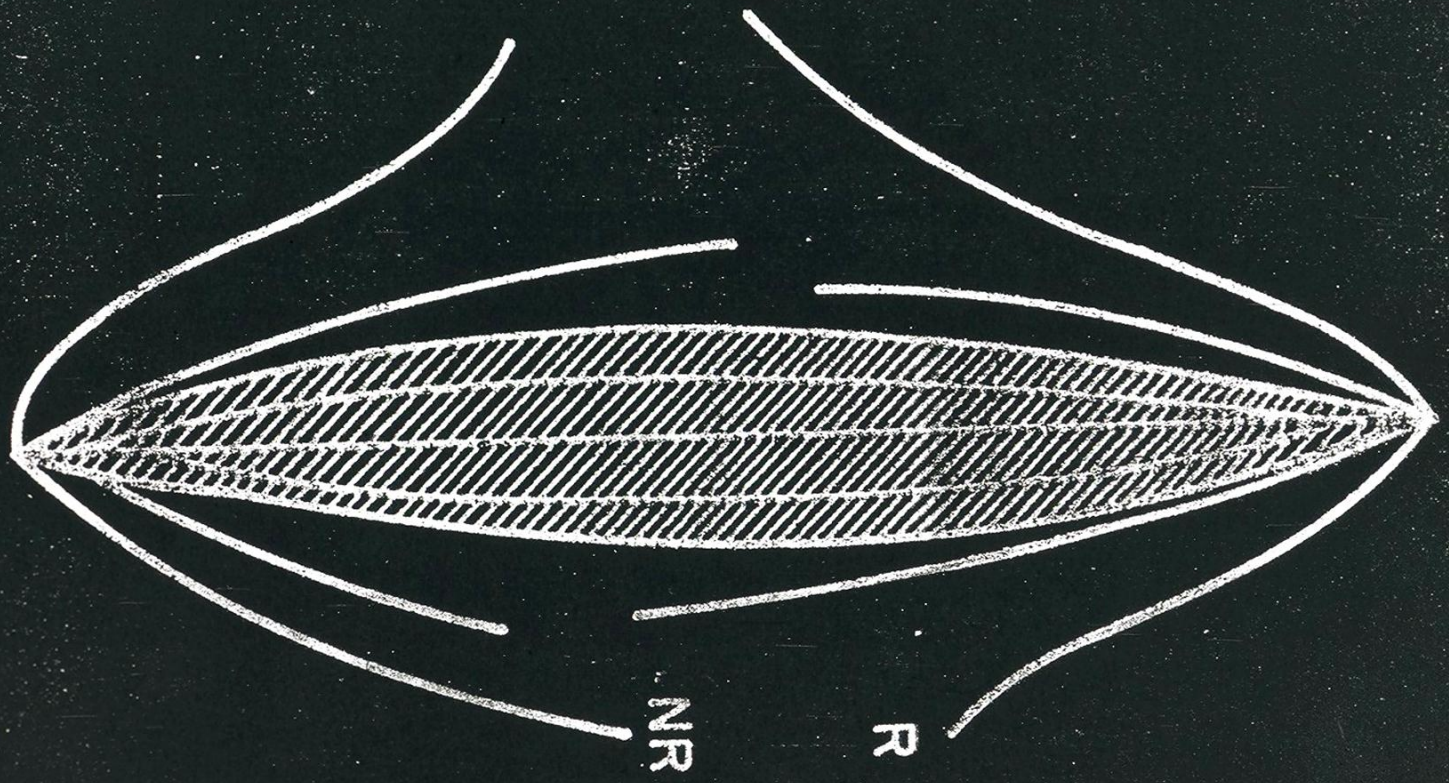


AIR-CT96-1184. Conversion of environmentally-unfriendly onion waste into food
gredients.

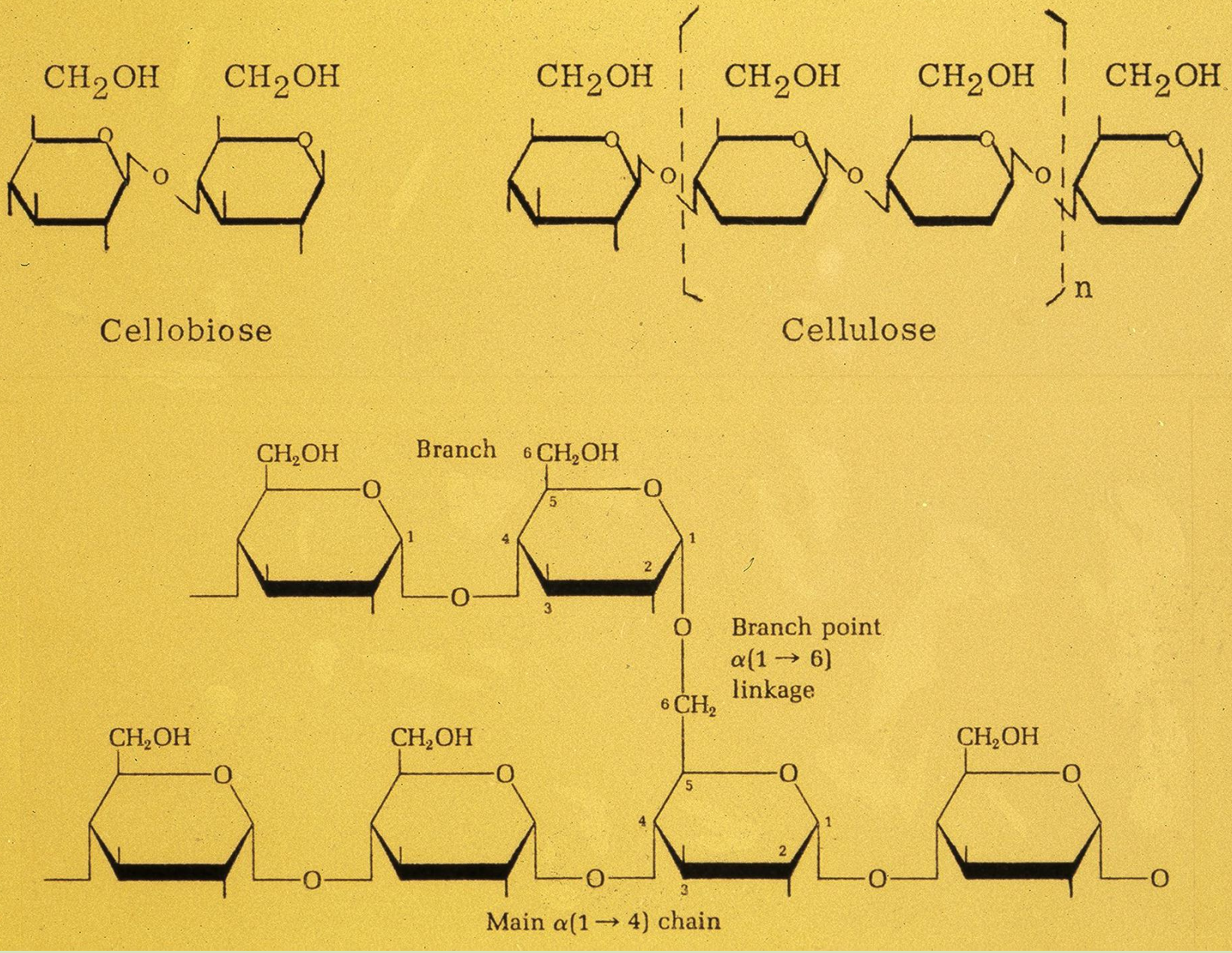
FRUCTOOLIGOSACCHARIDES

- **What is a Fructooligosaccharide?**
- A fructooligosaccharide (also written fructo-oligosaccharide) is a carbohydrate, which is made out of a short chain of fructose molecules. It is also classed as an oligosaccharide; *oligo* meaning few and *saccharide*, sugar. Fructooligosaccharides are also sometimes called oligofructose. Often the term is abbreviated to the letters FOS.
- Together with inulin fiber, fructooligosaccharides are probably most recognized for their prebiotic qualities

CELLULOSE STRUCTURE SHOWING CRYSTALLINE AND AMORPHOUS COMPONENTS



Διάγραμμα 3


CH2OH
CH2OH
O
Cellobiose
CH2OH
CH2OH
CH2OH
CH2OH
O
O
O
n
Cellulose
CH2OH
Branch
6 CH2OH
O
1
4
5
1
2
3
O
Branch point
α(1 → 6)
linkage
6 CH2
CH2OH
CH2OH
CH2OH
O
O
O
O
O
O
O
O
5
4
1
2
3
Main α(1 → 4) chain

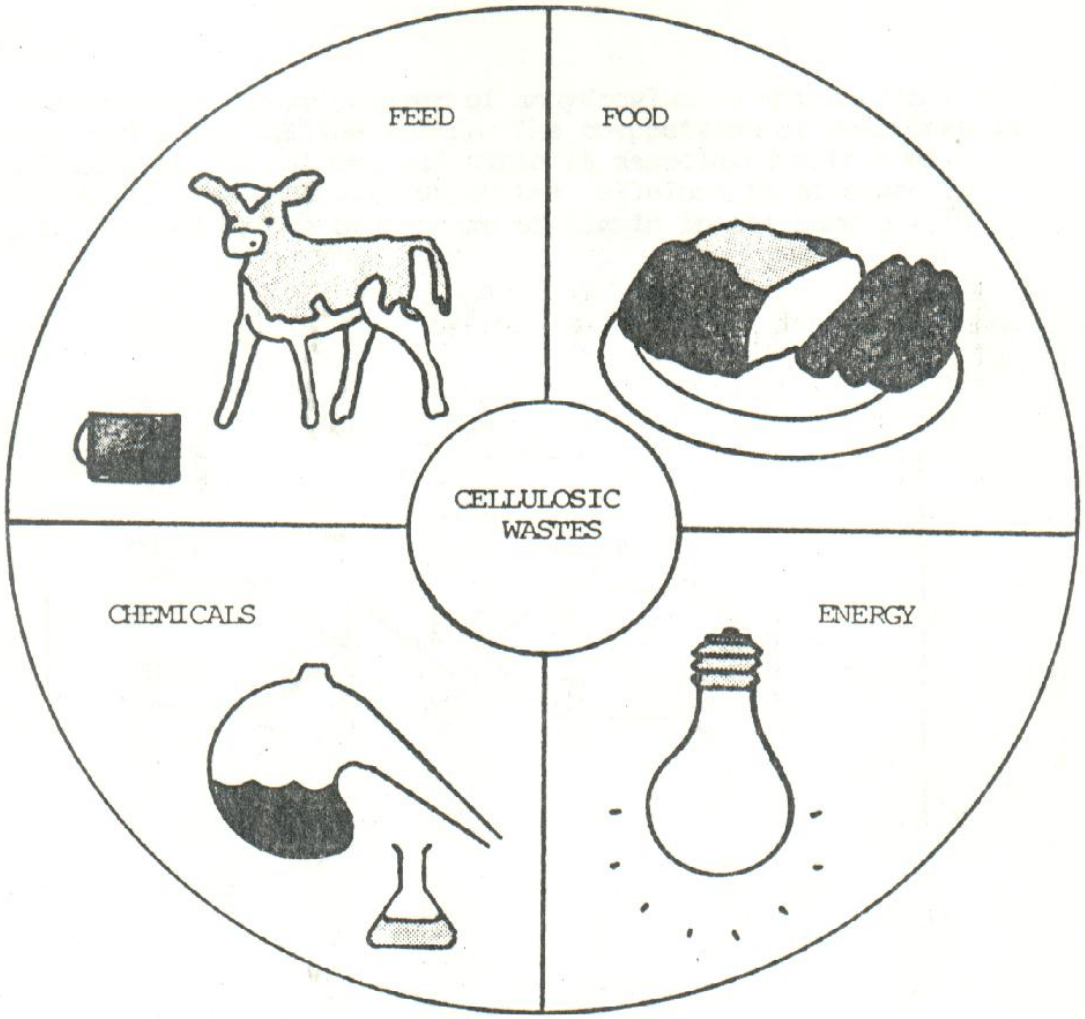


Figure 5. Alternative Products from Salvage of Cellulosic Wastes

STRAW UTILIZATION (method)

1. Direct Uses:
   Fuel, Mulch, Fertilizer, Soil Conditioner, etc.

2. Mechanical Conversion:
   Densification, Pulping, Defibrizing, Cubing, Pelleting,

3. Chemical Conversion:
   Sugar, Alcohol, Furfural, Xylitol, etc.

4. Biological Conversion:
   Ensiling, Composting, SCP, Enzymes, Fermented feed.

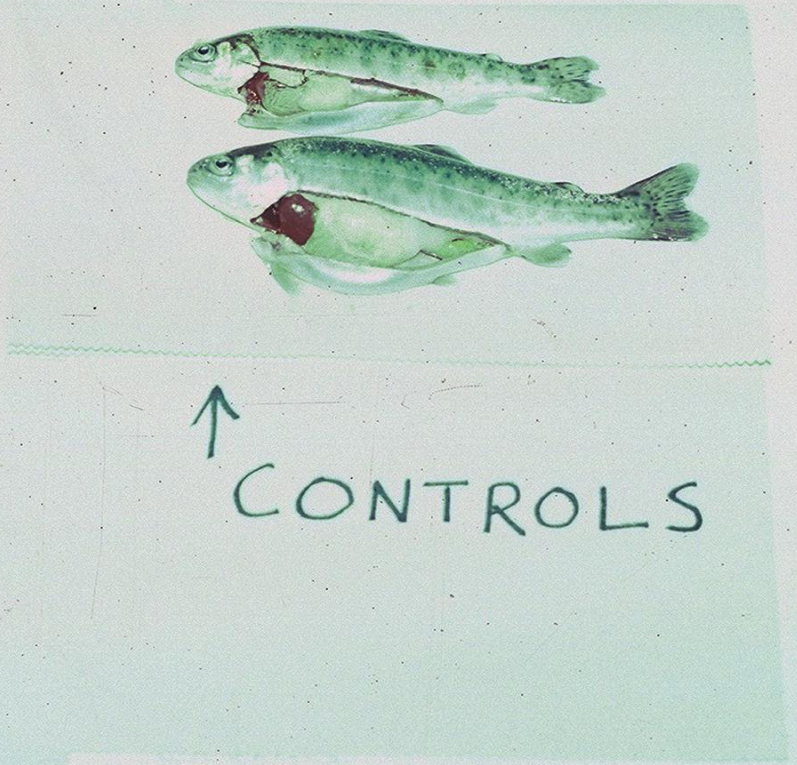
SHORTCOMINGS OF STRAW AS ANIMAL FEED

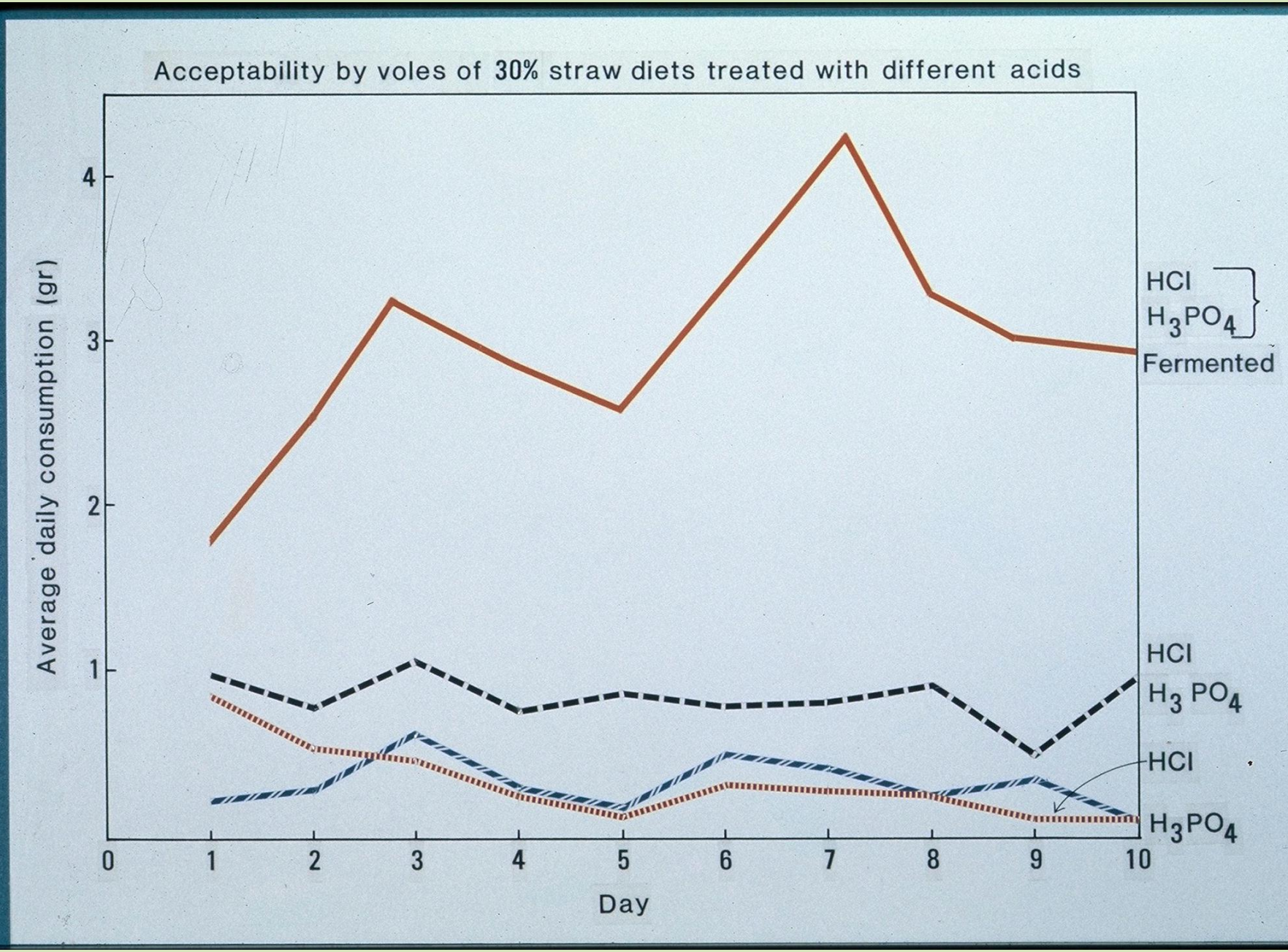
1. DIGESTIBILITY
2. PROTEIN
3. PALATABILITY
4. BULKINESS

Table 12. Protein content of straw treated various ways.

Treatment	Protein (mg)	(% dry weight)
Plain straw	2.54	3.3
HCl/H_3PO_4 treated and fermented	4.60	6.1
HCl/H_3PO_4 treated and ammoniated	2.62	3.5
HCl/H_3PO_4 treated, not ammoniated	1.24	1.7


D4


CONTROLS


Acceptability by voles of 30% straw diets treated with different acids
Average daily consumption (gr)
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
Day
HCl
H3PO4
Fermented
HCl
H3 PO4
HCl
H3PO4


SILVER SHIELD
SILVER SHIELD

ΔΙΑΤΡΟΦΑΡΜΑΚΕΥΤΙΚΑ

NUTRACEUTICALS,

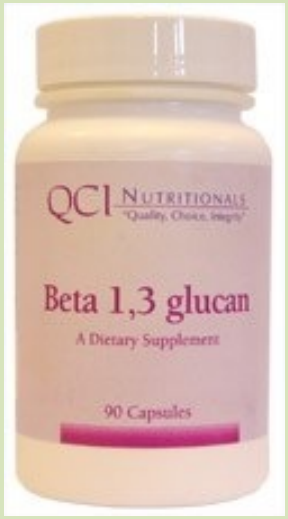
Functional Foods

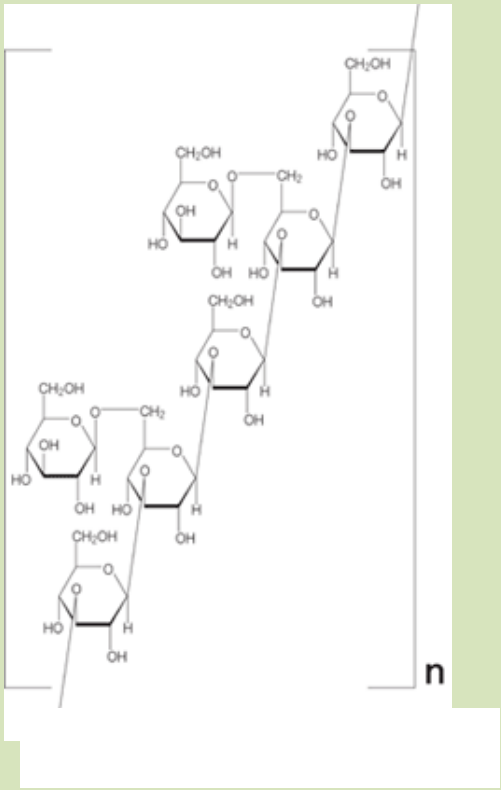
Fig. 1 Three mushrooms from which the antitumour polysaccharide agents have been developed in Japan and China. A: Krestin (PSK) from *Trametes versicolor* (mycelium); B: Lentinan from *Lentinus edodes* (fruit body); and C. Schizophyllan from *Schizophyllum commune* (medium product) (Mizuno, 1999).

Fig. 10 ***Trametes versicolor*** **growing naturally on fallen timber**


祝您康復
生產日期(批號)950803
萊福集團
批准文號：滬衛藥准字(1994)
第2491號-162
純天然野生雲芝精製
Krestin Capsules
雲芝多糖
膠囊
0.37g×40粒
上海萊福製藥有限公司
[主要成份] 雲芝多糖
[功能與主治] 免疫調節藥，用于慢性活動性肝炎及腫瘤的輔助治療。
[用法與用量] 口服，一次2粒，一日2～3次。
[規　　格] 每粒裝0.37g，每瓶裝40粒。
[貯　　藏] 密封，乾燥陰涼處保存。
上海市農科院食用菌研究所研製
上海萊福製藥有限公司生產
地址：上海浦東新區川北公路4883號
郵編：201203　電話：8570864
Action and Indications: This drug is an immunomodulator It is indicated for chronic infectious hepatitis and cancers as an adjuvant treatment to radiotherapy and chemotherapy.
Dosage and Administration: 2 capsules each time.,
2 or 3 times daily orally.
Packing: 0.37g in a capsule. 40 capsules in a bottle.
Storage: Keep in a tightly closed container store in a cool and dry place.
Researched by Institute of Edible Fungi, Shanghai Academy of Agricultural Sciences.
Produced by Shanghai Life Pharmaceuticals Ltd.
Grifolus ver

IV Fungal beta glucans: lentinans





Lentinan-an extract of the shiitake Mushroom is approved as an anti-cancer drug in Japan

Shiitake

The Healing Mushroom

Fig. 2a *Lentinus edodes* growing naturally on fallen timber

LENTINAN

Lentinan-an extract of the shiitake Mushroom is approved as an anti-cancer drug in Japan

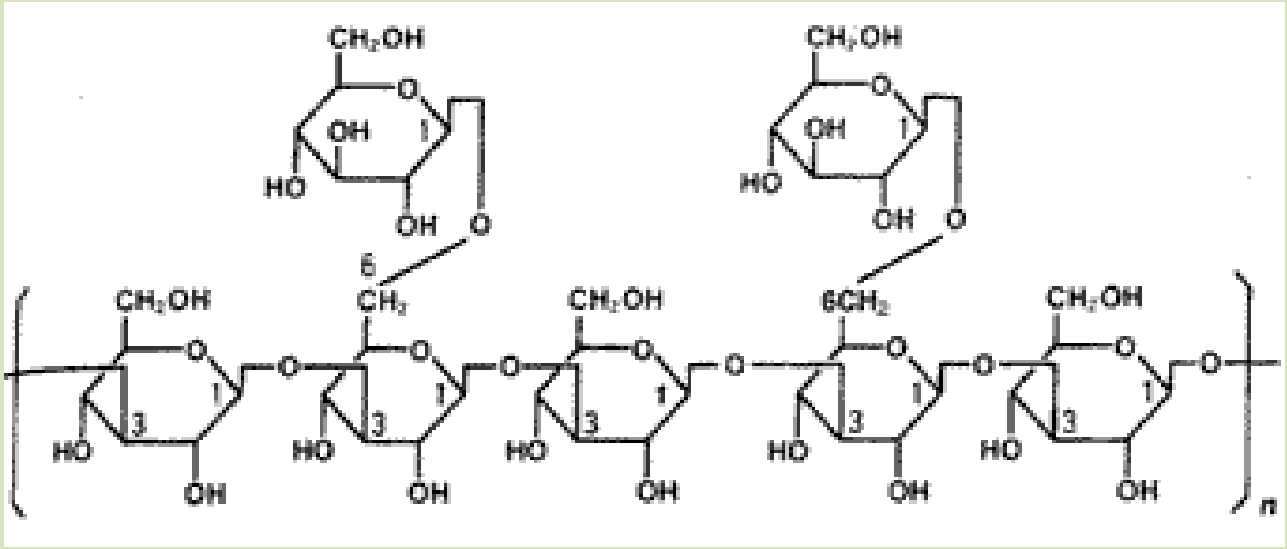
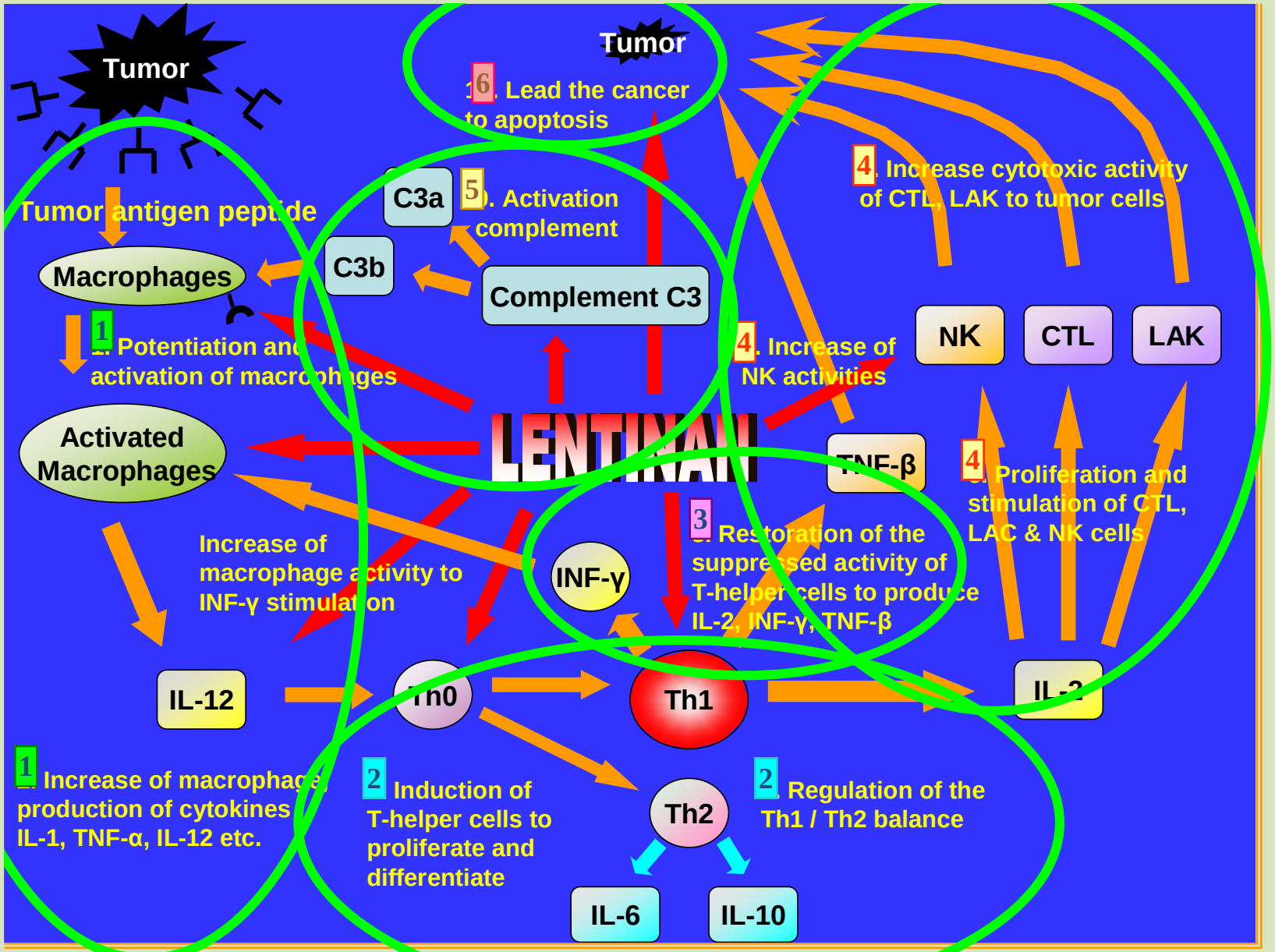
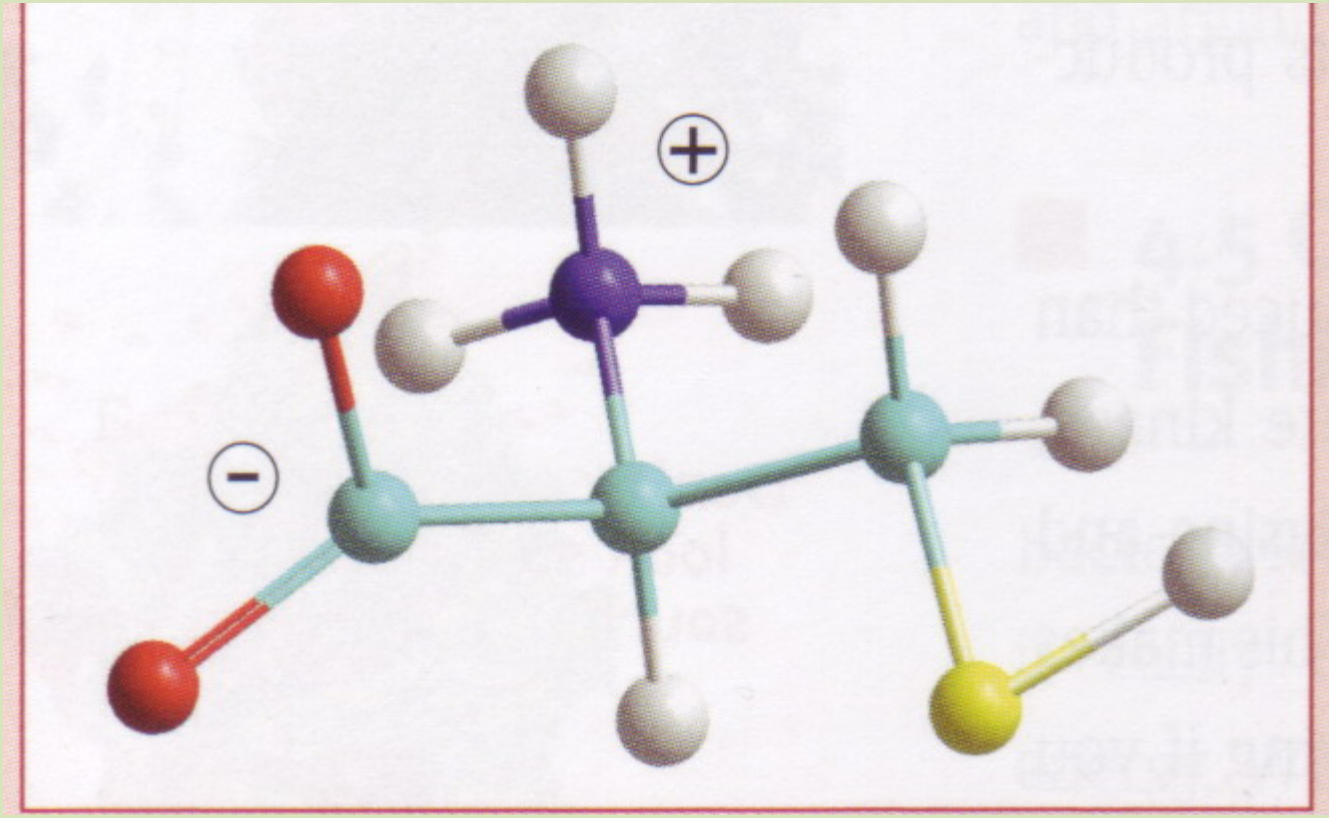


Figure 1: Primary Structure: (1 → 6): (1 → 3)-ß-D-glucan[3]

ANTITUMOR ACTIVITY OF LENTINAN






THANK YOU