

IMPACTS OF TECHNOLOGIES ON PHYSICAL PROPERTIES OF AGRONOMIC MATERIALS

H.J. Hellebrand

Institute of Agricultural Engineering Bornim (ATB), Potsdam, Germany, E-mail: jhelle@atb.uni-potsdam.de

Abstract. Different ways in which agricultural and other technologies can impact the physical properties of agronomic materials are discussed. Direct and indirect effects of these technologies are shown. The necessity of further research especially on the genetic engineering is proposed.

Key words: agronomic materials, technologies, physical properties

INTERACTION OF TECHNOLOGIES AND PROPERTIES

A certain technology is always designed as a sum of procedures for transforming materials into materials with new or changed properties. Usually the input materials are called raw materials and the output gives products, which might be the input for the next technology or the products are consumed. All technologies are based upon three categories: materials, energy and information. Due to the applications of technologies the entropy of the whole system increases, but technologies might be considered to be entropy separators. This means that there are subsystems, where the entropy will be reduced by the work performed and in parallel entropy is increased in other subsystems (including export of entropy). The change in entropy is the physical background that we can define directions of flowing and changing, as indicated by arrows in Fig.1. Entropy as a

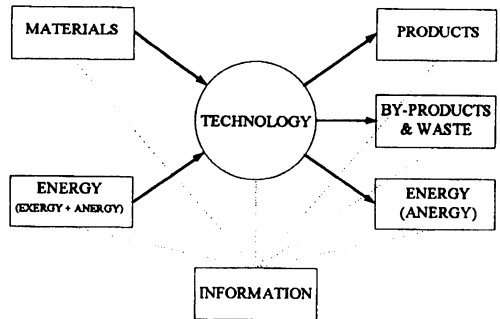


Fig. 1. Scheme of the categories from material to products.

thermodynamically function of state does not belong to physical properties, but it can be utilised for the evaluation of environment related aspects of technologies. Environmentally friendly technologies will contribute to the total increase of entropy on a small scale only. If it is possible to evaluate technologies numerically in terms of variation in entropy, then the optimum will be get by minimising the total increase [12,13].

Since technologies are developed to modify some selected properties of the materials in a definite way, there is an impact of technologies on the properties of the material processed. On

Table 1. Survey of few relevant technologies, properties, and materials. Marked lines indicate as example the impacts of drying on properties of grains

Type of technology		Physical property		Agronomic material
		Basic	Composed	
Agriculture and Horticulture	Soil cultivation	Mass Volume Density Shape Surface Viscoelasticity Stiffness Strength ... Colour Colour distribution Spectral absorption Dielectricity Permeability ... Heat capacity Moisture Sorption ...		Soil
	Planting			Roots
	Sowing			Fruits
	Fertilising			Grains
	Weed treatment			Plants
	Spraying			...
	Harvesting			
	Drying			
	Cleaning			
	Sorting			
	Storage			
	...			
Animal keeping	Milking			Manure
	Feeding			Fertilizer

	Breeding			Biocides
Science and Engineering	Aeration			...
	Heating			
	Air conditioning			Ripeness
	Controlling			Smell
	Physical engineering			Flavour
	Chemical engineering			Turgor
	Genetic engineering			Composition...
	...			

the other hand, technologies must be designed in an appropriate way to handle the materials concerned. For this reason we have to speak of interaction between technologies and properties of materials. To go deeper into the details one must specify technologies, materials and properties. When considering technologies and properties we find a tremendous number of possible combinations (Table 1).

Physical and other effects are used for designing of technologies. The properties of the materials, its dependencies and variables, and its relation to the structure of the material should be known in order to influence the change of the material as desired. Such a way the impacts of technologies on the materials processed and products gained might be controlled.

IMPACT OF DRYING ON MECHANICAL PROPERTIES OF GRAINS

It is a well-known effect that the water content of plant materials determines the mechanical properties of the material. The

turgor pressure of cells is one of the reasons. Tissue strength changes with turgor. The turgor pressure is controlled by cell walls and osmotic water transport in connection with ion concentration inside and outside of cell walls. The water molecules inside the cells are free movable (free water). The mechanical properties of plant tissues depend on the mobility and net structure of long chain molecules. Water is adsorbed at surfaces of fibre molecules (bound water). This water stabilises the spatial structure of molecules by hydrogen bonds. If this water is removed, the fibre structure will change. Two effects are possible in principle. When water is removed then crystalline parts may grow resulting in an increase of stiffness. This loss of mobility of the molecules against each other is observed in so-called frame or stroma molecules like cellulose and sclero-proteins. The other extreme is a complete change in spatial structure of the molecules leading to increased mobility of chain molecules like lipids (loss in stability of cell structures). The uptake of water

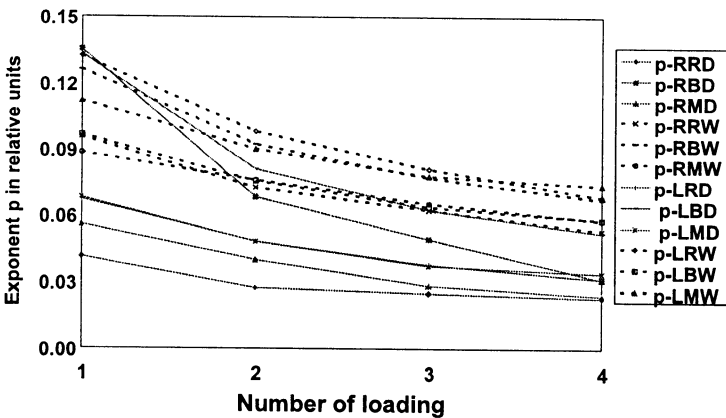
molecules by wetting of dried tissues does not result in restructuring of the original molecules. Once the structure is lost it can not be regained. Therefore the study of mechanical properties of dried and re-wetted substances will give different results compared with non dried products, although the moisture content might be identical. Measurements by Proton-NMR [9] a) and EPR-marker technique [9] b) indicate different water bond distributions for natural products and dried/re-wetted samples.

As a consequence for designing the drying process, in which mechanical properties should be controlled, the water content of the material must drop continuously without zones or intervals with moisture uptake by the material.

The effect of moisture uptake on mechanical properties of rice and corn kernels (fissuring) has been reported in several papers (e.g., [7,11]). The evaluation of relaxation curves by several models [4] serves as an example for changing of mechanical properties due to drying and wetting. To demonstrate these changes, few results of the curve fitting by the model:

$$F(t) = F_0 / (1 + t/T_p)^p \quad (1)$$

shall be discussed. The difference between wetted and dried samples is clearly visible by repeated loading (Fig. 2). There is a correlation of the relaxation parameters to the moisture state (Table 2, Fig. 3).



with the abbreviations:
 First symbol: type of model (p: Power Function)
 Second symbol: type of sample (R: rice Ricco, L: rice Lemont, C: Corn, P: Popcorn)
 Third symbol: processing (R: rough, B: brown, M: milled)
 Fourth symbol: moisture state (E: oven dried 5 h at 105°C, D: sun dried, W: saturation moisture after 72 h at 100% humidity, F: sun dried samples exposed for 1 h 100% humidity, G: oven dried samples exposed for 1 h 100% humidity)

Fig. 2. Change of parameter p in dependence on number of loading and on water state of single rice kernels (mean values of 14 kernels).

Table 2. Parameters T_p and p in dependence on moisture state (mean of the evaluation of 1st loading using the model (1) with F_0 initial load)

Water state	E	D	W	F	G
Parameter T_p					
Rough rice	0.32±.17	0.12±.08	1.76±.56	0.49±.16	1.00±.50
Brown rice	0.30±.02	0.18±.13	1.04±.44	0.90±.58	0.48±.19
Milled rice	0.34±.11	0.55±.29	0.64±.31	1.33±.53	1.44±.43
Corn	0.55±.32	0.65±.33	1.13±.13		
Parameter p					
Rough rice	0.053±.005	0.063±.010	0.107±.018	0.090±.027	0.118±.004
Brown rice	0.059±.009	0.102±.022	0.111±.014	0.142±.010	0.177±.046
Milled rice	0.028±.003	0.062±.005	0.109±.019	0.135±.007	0.137±.026
Corn	0.032±.002	0.038±.011	0.089±.043		

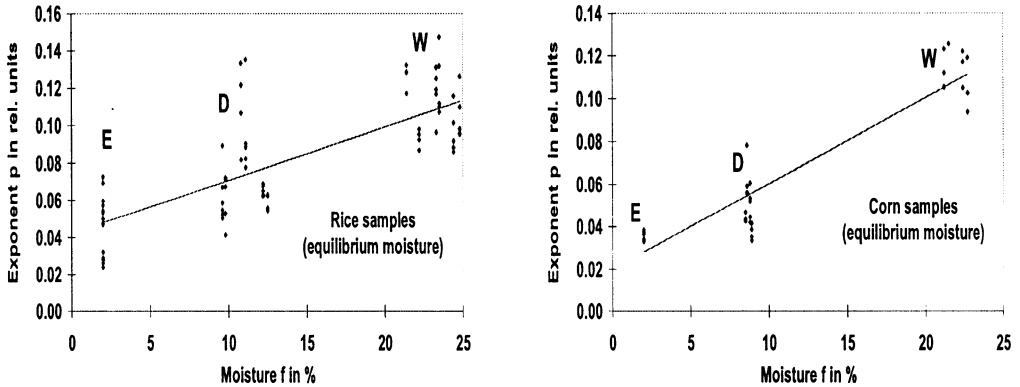


Fig. 3. Dependence of relaxation parameter p on moisture state (first loading; E - oven dried kernels, D - sun dried kernels, W - wetted kernels).

IMPACT OF FERTILISING ON COLOUR OF PLANTS AND PLANT PRODUCTS

The colour of plants depends on several factors. What we see is the reflected (remitted) light from the plant surface with a light active thickness of a few wave-lengths (about 2 .. 3 μm). The absorption is determined by the density of colour active molecules like chlorophyll or carotene in the surface cells. The availability of plant nutrients in the soil influences the development of these molecules. Although the chlorophyll density and activity depend on the supply with all necessary ingredients, usually nitrogen is the limiting factor in agriculture. If this is known, the colour evaluation of plants might be used for control of nitrogen fertilising (Fig. 4).

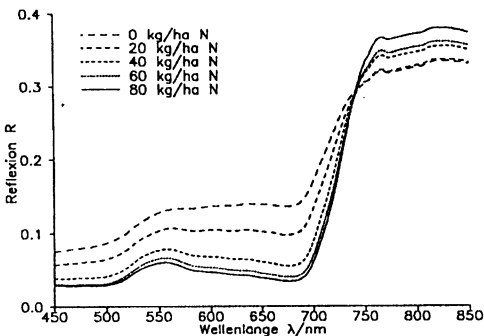


Fig. 4. Typical spectra of reflected sun light from rye with different levels of fertilising [10].

Different fertiliser level in the soil can affect the element concentrations in plants and plant products. In general, one differentiates structural and functional elements. Nitrogen, phosphorus and sulphur are considered as structural elements, since they are essential for proteins and other biomolecules. Chlorine and potassium are said to be pure functional elements. Other elements like magnesium and calcium can be found in both configurations. Only in case of functional elements a correlation between soil content and concentration in the plants should be observed [1].

There is an indirect way of influencing the uptake of elements. The fertiliser level of the structural elements N and P enables some plants to control the uptake of other elements like Ca, Fe, K, Mg, and Zn [5]. The content of metal ions is one factor for oxidation and changes in colour of cut products. The colour of fried products depends on several factors. Temperature and duration of frying are essential on the one side. On the other side the sugar content of potatoes and the content of amino acids are also responsible for the fry colour [2,3,6].

CONCLUSIONS

There are different ways, in which agricultural and other technologies can impact the physical properties of agronomic materials. In discussing this broad field it is possible to distinguish technologies by their aim and way of action. We find indirect effects such as

influence of fertilisers on colour of plants and plant products. The actual knowledge on these indirect or unexpected effects is rather poor at present. There are direct effects when considering technologies as drying. Then the change in physical properties is expected and intended due to alteration of the composition and structure of the material. The connection between technological parameters and modification of properties is usually a function based on correlation. More research is necessary on the interaction of technology in conjunction the supplemental fields of structure and properties of agronomic materials. A third, now vary rapidly growing technology is genetic engineering. This technology is quite different from the examples mentioned here, since the acting principles of this direction are based on biomolecules. It acts selective as a rule. Usually genetic engineering is not utilised to alter physical properties, but this is not excluded, if properties as colour, mass, volume or shape are considered. This field of research will considerably affect the future agriculture.

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