BACKYARD OR HOME COMPOSTING OF BIODEGRADABLE POLYMER PACKAGING

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1. ABSTRACT

The aerobic degradability of different types of biologically degradable polymer (BDP) packaging in two selected home composting systems was investigated during a test period of 12 months. Tested items were starch based films, copolyester coated starch trays and poly lactic acid (PLA) cups. The results of two experimental test series are presented here: indoor pilot-scale experiments under optimised environmental conditions and outdoor pilot-scale trials under the conditions of European climate. Tested BDP items degraded well with the exception of (PLA) products. Mass based degradation rates of starch based materials were detected between 67 and 97% in indoor trials after 12 months of processing. The type of composting system showed only slight variations in the degradation velocity and final degradation values were detected in the same range. Generally no significant differences of the degradation behaviour between in- and outdoor composting trials and the different systems were detected.

KEYWORDS: biodegradable polymer packing, backyard and home composting

2. INTRODUCTION

Biologically degradable polymers (BDP) have been developed in the last few years to be ready for practical utilization as a result of intensive sponsorship, scientific and commercial research efforts. The application of biodegradable materials for packaging purposes was and is considered to be the most practical area for their use (Tänzer 2000, Witt et al. 1998). Biologically degradable polymers based on renewable resources are considered in the German Packaging Ordinance (VerpackV 1998), in the Biowaste Composting Ordinance (BioAbfV 1998) and it is possible to carry out a biodegradability test according to a DIN standard (DIN V 54 900 1998) to determine their compostability. Product certification is carried out for Germany by the DIN CERTCO, a subsidiary of the German Institute for Standardisation (DIN). Product certification for BDP items is accepted mutually by the respective organisation in different countries (BPS, OK Compost etc.). It is possible to approve the collection of biologically degradable packaging via the municipal organic waste collection as a dual system according to the German Packaging Ordinance (VerpackV 1998). Biodegradable items scheduled for use as substitutes for conventional plastic packaging have been introduced to the market in Europe and other continents. Most of them are blends, containing a certain percentage of mineral oil based biodegradable polymers. Marketable packing products are bags, trays and dishes for fruits, vegetables, bread, cakes, pastries and meat products as well as containers for dairy products, bin liners and compostable foodware/catering articles. Examples are shown in Fig 1 and 2. All certified, i.e. tested biodegradable packing products commercialised in Germany were marked with an intense ochre sign with the explicit labeling as “compostable” (Fig. 3). The compostability is proved by a multi-stage examination according the German standard DIN V 54 900 (1998). A market and recovery test was carried out in Kassel, Germany (Klauss et al. 2003).

Fig. 1: Bag for fruits

Fig. 2: Tray

kompostierbar

Fig. 3: Compostability Label

This label certificates these products for general compostability, though it was only tested in technical composting plants with optimized conditions, i.e. optimum moisture contents, mesophilic to thermophilic temperature range etc. It is very complicated to convey to consumers the fact, that they must not depose signed and certified biopolymer packing at their backyard composting site if it is marked explicitly as "compostable", because its biodegradability is only tested in industrial composting sites.
Most of the German and North European cities have an area-wide municipal collection system for organic residues, the so called "biowaste bin", "bio bin" or "composting bin." Area-wide means in Germany that approx. 70% of the households use that collection system (Kehres 2001), since not all citizens want to do so. The remaining percentage consists of households in problematic municipal areas, i.e. mostly with low social standards, from these the bio bins were withdrawn due to an high amount of impurities and the larger part of households that operate backyard or home composting on their own properties (Thomé-Kozmiensky 1995). The number of the last mentioned increased considerably in the last years. Particularly, home composting was and is strongly promoted in many German, European and North American cities as a very relevant way to recycle organic waste. That was caused by intense promotions and substantial discount rates on the fees for the waste collection, granted by the local waste management companies after application for. The financial support is given directly by a discount on the waste fees or indirectly by offering cost-free or very cheep compost makers (Bidlingmaier 2000). Especially in rural areas, home composting is very well established as a recycling procedure for organics (Wiegel 1990).

3. AIMS AND OBJECTIVES

To realize the recovery and the recycling via the backyard composting, it must be clarified whether and how these different types of biopolymers degrade under the special conditions of domestic composting systems. Actually, investigations exist almost exclusively concerning the aerobic degradation of biopolymers under laboratory conditions or in technical composting facilities as the standards are fixed for that way of recycling. Since the input material of backyard composting can differ considerably from this of a large plant, i.e. composition, amount, moisture etc., it must be examined how the composting process is influenced by inserting biopolymers into the input material. Furthermore, the conditions of domestic composting can differ considerably from those in an industrial system. In home composting processes the high temperature levels are partly not achieved, the material does not have optimum moisture contents and very wet biosolids with a bad structure can provoke anaerobic conditions. The objective of this work is to examine the degradability of BDP packing in two commercially available home or backyard composting systems thus providing data about the BDP degradation and to give recommendations concerning their treatment resp. recycling in these systems under their special conditions. To investigate this topic, emphases were set on the following points:

Indoor Pilot-Scale Testing Rig: Composting of BDP products with kitchen and garden wastes in two selected home composting systems in a indoor pilot-scale testing rig under defined environmental conditions as temperature, moisture and input conditions. Results, that characterize the biodegradation of BDP products without the influence of extreme climatic conditions, such as the variation of temperature, rain etc., were obtained from these trials.

Outdoor Pilot-Scale Testing Rig: Composting of BDP products with kitchen and garden waste in two selected home composting systems in a outdoor pilot-scale testing rig under real environmental conditions occurring during one year in middle European climate. The results characterize the biodegradation of BDP products under real European environmental conditions.

Investigations concerning the quality and quantity of BP reduction in one cubic meter windrows in a commercial composting facility with inserted specimen and without further treatment and in existing home composting systems were carried out as comparative studies. These investigations are not subject of this paper. Furthermore, only degradation data of three selected tested BDP items are provided here as this work is an investigation in process.

4. MATERIALS AND METHODS

Two different types of home composting systems were chosen for the in- and outdoor trials: a simple wooden construction (LR) and an isolated system (TK). Fig. 4 provides a view at the test facility and Fig. 5 a scheme of the layer composition..

Fig. 4: Indoor Pilot-Scale Tests (TK and LR)

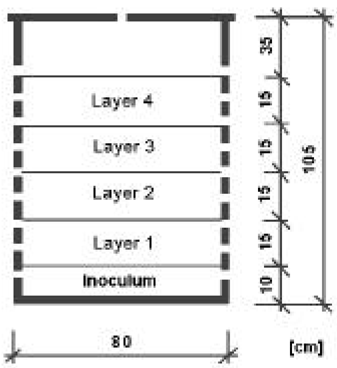

Fig. 5: Layers of the insulated system (TK)

Testing material was kitchen and garden waste mixed with 30% (w/w) of shredded wood in order to achieve an optimum structure. 1% (w/w) weighted and classified BP product mix was added to that material. Used BDP items were: trays type AP 70 consisting of thermoplastic starch with a layer of EastarBio® copolymer (TPSS) delivered by the APACK AG, test cups for dairy products made from poly lactic acid EcoPLA 1 (PLA), received by AUTOBAR Group and a starch-based film made from the commercial grade Mater-Bi® NF01U, a, produced by Novamont s.p.a. (Fig. 6, 7 and 8).

Fig.6: Tray AP 70 - "TPSS"

Fig. 7: Mater-Bi® film - "MBF"

Fig. 8: PLA cups - "PLA"

Characterizing input parameters like moisture content, C/N ratio, pH, VS contents etc. were determined. Each compost maker was filled to its capacity on a monthly basis within for months. Approx. 50 kg of organic waste mixed with 1% (w/w) BDP were added each charging campaign, starting Sep. 2001. 50 kg are estimated average amount of organic waste produced by a four-person-household per month in summertime. This amount of organic waste was calculated by literature research (Behling 1999b, BLFU 1994, Fischer and Jauch 2001etc.). Each individual filling was covered with a gaze net in order to divide the compost makers in layers. Each layer represents one of the four charging campaigns.

The duration of these trials was set to 12 months as one year is the recommended time for a home composting process. Every three months a disassembly was planned and carried out, thus needing principally four compost makers of each type. To secure the results statistically, fourfold trials were carried out, thus obtaining for each BDP fourfold degradation data under identical conditions. 16 compost makers for each of the two used types were used in the indoor testing rig, the outdoor trials were carried out with eight compost makers both types of employed home composting system.

The temperatures were regularly measured in core and edge zones of the newest layer of each compost maker, i.e. with the freshest material, covering the intensive stages of the process directly after each charging. A disassembly of four compost makers of each type (wooden and isolated) of the indoor tests and two of each type in the outdoor testing rig was carried out in tree-months intervals, starting three months after the first charging and proceeding each 90 days. The characterizing parameters of each layer (moisture, VS etc.) were determined separately. The materials located in each of the four layers of each compost maker was dried, classified and the BDP residues were extracted. Remaining BDP particles found in the respective layers and fractions were classified and weighted.

5. RESULTS AND DISCUSSION

This paper presents a part of an investigation in process thus data obtained should be seen as interim results. The results indicate that different types of biopolymer packing have varying degradation behavior in home composting systems. Each of the used biopolymer items degrades in a technical composting facilities within a 90 day interval. Three selected products are discussed here as an example for their respective material group.
Tables showing the results of the trials for the degradation rates are designed as follows: The tables show in the left column the compost maker type and name. “TK” characterizes an insulated compost maker and “LR” a wooden one. The letter “X” stands for the respective disassembly campaign and the layer (“S”). “TK 1.4-S1”, for example, means the bottom layer of the insulated compost maker No. 1.4 (4th disassembly). The values of the degradation rates are provided for each compost maker and layer separately. Average values achieved by the two different systems employed are given. The first disassembly yielded only values for three layers as the last charging was not conducted at the first disassembly campaign.

5.1 Indoor Pilot-Scale Trials

Assessment of the Composting Process: Starting the experiments, the organics used had high moisture contents, a lumpy structure and strong odor emissions. After a processing time of three months the output material had lost most of its smell and had an improved structure. The composts obtained after 6 months from the middle layers had an earthy structure and smell. Composts discharged at the end of the trials had almost no smell and an earthy structure. Particles sizes decreased during the process. Bottom layers were found principally relatively wet, apparently caused by inadequate draining through the perforated plastic plane covering of the bottom of the compost makers. Top layers were found generally very dry containing rough-structured material. Irrigating had no or less effect on top layers as the water was drained almost immediately into the next layers. The moisture contents were obviously different between edges and core of the material. The dry areas were observed in all compost makers, the corresponding ones in the insulated compost makers had slightly smaller extensions. Temperature levels of above 60ºC were achieved for some days in insulated systems and approx. 45ºC in open systems, respectively. Heavy insect attacks were observed after each charging, mostly mayflies. These populations died after a period of two to three weeks in summertime, in case of low temperatures even faster. Mice affections were detected in 5 compost makers. The composting process resulted after 12 months in a good compost free of odor that had the aspect of soil indicating that the composting process worked well in this systems. The maturity of the compost was proved by self heating capacity values measured.

Degradation Rates of Employed BDP in the indoor experiments: Coated starch trays (TPSS) degraded relatively fast during the initial stages of composting. Within three month of composting mass losses between 70 and 80% average (Table 1) were achieved in both systems. Final average degradation rates after 12 months of processing were measured up to 98%. 100% degradation rates were not achieved as in all disassembly campaigns small particles of TPSS were found in the edges of the layers. After 90 days residues found consisted mostly of the copolymer layer or pieces found at the edges of the layers.

Table 1. Degradation of TPSS - Indoor Trials

disass.	1st disassembly			2nd disassembly				3rd disassembly				4th disassembly			
No.=X	1-S3	1-S2	1-S1	2-S4	2-S3	2-S2	2-S1	3-S4	3-S3	3-S2	3-S1	4-S4	4-S3	4-S2	4-S1
duration [d]	60	90	120	60	120	150	180	150	210	240	270	240	300	330	360
TK 1.X	61.6	82.4	78.5	66.2	70.8	82.9	89.4	92.2	85.8	85.3	96.1	88.7	97.2	98.3	95.4
TK 2.X	44.3	58.5	81.6	70.4	73.8	78.1	87.3	88.9	92.2	94.7	92.6	99.0	89.0	97.3	96.1
TK 3.X	53.2	68.8	75.8	71.2	72.2	80.4	87.7	86.9	80.4	86.7	95.6	94.0	97.6	96.9	97.6
TK 4.X	67.0	73.0	82.2	78.4	73.9	87.1	87.9	67.0	95.3	92.4	95.8	89.3	94.6	99.2	99.1
Æ TK	**56.5**	**70.7**	**79.5**	**71.5**	**72.7**	**82.1**	**88.1**	**83.8**	**88.4**	**89.8**	**95.0**	**92.7**	**94.6**	**97.9**	**97.0**
LR 1.X	53.6	56.9	68.2	87.1	86.1	86.9	77.0	14.7	87.9	84.7	93.9	97.9	94.2	97.0	92.3
LR 2.X	59.1	71.1	75.3	83.4	79.5	56.9	80.7	38.0	87.0	91.1	80.4	78.3	93.6	91.1	95.3
LR 3.X	61.4	78.9	78.0	43.3	83.1	75.7	86.7	78.8	89.3	84.7	86.2	80.3	96.6	97.4	96.1
LR 4.X	66.2	72.2	70.0	37.5	65.7	83.0	77.3	85.3	90.0	79.3	95.3	93.7	97.3	97.3	94.5
Æ LR	**60.1**	**69.8**	**72.9**	**62.8**	**78.6**	**75.6**	**80.4**	**54.2**	**88.6**	**84.9**	**89.0**	**87.5**	**95.4**	**95.7**	**94.6**

A-PLA cups were only inserted into the organic waste of the first charging, resp. layer 1 (bottom), all other charging campaigns were carried out with material including C-PLA cups. A-PLA and C-PLA is principally the same material with slight differences in its structure and properties. It was done due to two main reasons. The development of a PLA cup for dairy products for the Kassel test market was in process starting these experiments. First material employed in the development of a marketable cup was A-PLA. It was changed to C-PLA that has a higher resistance to thermal stress. These changes were made in the product development and adapting the test rigs of this investigation both materials were employed.

Table 2. Degradation of A-PLA (S1 layers) and C-PLA cups (S2, S3 and S4 layers) - Indoor Trials

disass.			APLA				APLA				APLA				APLA
disass.	1st disassembly			2nd disassembly				3rd disassembly				4th disassembly			
No.=X	1-S3	1-S2	1-S1	2-S4	2-S3	2-S2	2-S1	3-S4	3-S3	3-S2	3-S1	4-S4	4-S3	4-S2	4-S1
duration [d]	60	90	120	60	120	150	180	150	210	240	270	240	300	330	360
TK 1.X	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.0	0.6	0.0	0.3	2.0
TK 2.X	0.0	0.0	0.0	0.0	0.0	0.1	1.7	0.0	1.0	0.0	8.3	0.0	0.0	0.0	4.2
TK 3.X	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.2	0.3	0.0	3.5	0.0	1.0
TK 4.X	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.7	1.4	0.0	0.0	0.0	0.0	0.1	1.3
Æ TK	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.8**	**0.2**	**0.6**	**0.3**	**2.4**	**0.1**	**0.9**	**0.1**	**2.1**
LR 1.X	0.0	0.0	0.0	0.0	0.3	0.0	0.7	0.7	1.4	0.0	0.7	0.0	0.1	0.0	0.7
LR 2.X	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.6
LR 3.X	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	1.2
LR 4.X	0.0	0.0	0.0	0.0	0.0	0.1	0.0	n.v.	0.0	0.0	0.3	0.0	0.0	0.2	1.0
Æ LR	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.2**	**0.2**	**0.3**	**0.0**	**1.2**	**0.0**	**0.0**	**0.1**	**1.4**

PLA items (A-PLA, C-PLA) showed generally no evident degradation signs for a period of about nine months as indicated by values provided in Table 2. Some PLA cups showed a loss of structural stability after six months of composting, meaning that these materials cracked under low mechanical stress being brittle and having almost no elasticity. Most of the cups had undergone a certain loss of structural stability at the end of the experiments. Some PLA samples showed a certain deformation, mostly a shrinkage. The majority of the PLA items used showed no proof of degradation in terms of a detectable mass loss.
The mass losses indicated in Table 2 after approx. 6 months of processing were caused by the loss of some parts of the cups crumbling away during the discharging campaigns; the particles were very small thus passing the 4 mm sieve. Particles smaller than 4 mm were assessed as degraded since it was not possible to sort them out.

Mater-Bi® film sheets (MBF) had undergone a relatively fast degradation as shown in Table 3. After 90 days of composting almost 44 to 46% of the material were found degraded in the bottom layers. Final degradation values between 86 and 91% proved a good degradability in both types of home composting systems. MBF films degraded within the testing time into small and very small particles, loosing its form as film sheets completely. All particles found in the last disassembly campaigns had well reduced particle sizes.

Table 3. Degradation of MBF - Indoor Trials

disass.	1st disassembly			2nd disassembly				3rd disassembly				4th disassembly			
No.=X	1-S3	1-S2	1-S1	2-S4	2-S3	2-S2	2-S1	3-S4	3-S3	3-S2	3-S1	4-S4	4-S3	4-S2	4-S1
duration [d]	60	90	120	60	120	150	180	150	210	240	270	240	300	330	360
TK 1.X	4.2	11.9	34.8	26.4	26.8	46.8	75.3	46.4	46.4	45.0	84.2	92.7	83.2	57.5	95.1
TK 2.X	22.9	6.0	61.9	22.2	17.5	37.7	75.7	42.2	71.2	50.5	65.5	52.6	45.0	86.2	85.7
TK 3.X	9.4	16.3	39.6	20.4	43.1	36.1	71.6	57.8	40.1	67.7	55.0	34.3	79.1	92.7	85.9
TK 4.X	8.4	7.1	39.5	27.6	48.7	29.4	70.4	65.1	73.1	55.7	62.8	69.8	80.7	86.2	96.5
Æ **TK**	**11.2**	**10.3**	**43.9**	**24.2**	**34.0**	**37.5**	**73.2**	**52.9**	**57.7**	**54.7**	**66.9**	**62.3**	**72.0**	**80.7**	**90.8**
LR 1.X	7.1	13.1	39.9	19.1	41.0	49.8	80.4	40.3	85.9	77.3	80.1	56.8	98.3	87.3	73.3
LR 2.X	7.5	16.4	40.1	8.0	33.9	37.7	65.4	40.3	91.8	66.9	54.1	39.0	94.9	75.6	91.5
LR 3.X	1.3	12.5	51.8	6.4	38.7	53.2	68.4	10.1	68.1	80.9	56.8	41.3	60.6	81.8	93.1
LR 4.X	7.2	14.7	50.7	16.5	18.7	57.2	48.5	51.3	95.7	57.2	56.1	69.5	85.0	83.4	84.9
Æ **LR**	**5.8**	**14.2**	**45.6**	**12.5**	**33.1**	**49.5**	**65.7**	**35.5**	**85.4**	**70.6**	**61.8**	**51.6**	**84.7**	**82.0**	**85.7**

2.1 Outdoor Pilot-Scale Trials

Assessment of the Composting Process: General aspects of the outdoor composting trials were the same as mentioned for indoor test series. Bottom layers were found always being wet, apparently caused by inadequate draining through the perforated plastic plane covering of the bottom of the compost makers. Top layers of slatted frame (wooden) compost makers (LR) were covered with several plants (tomato, wheat, grass etc.) after a period of six months and generally less dry compared to their counterparts in the roofed testing facility. The moisture contents were obviously different between edges and core of the material.

No distinct insect attacks were observed the complete testing time. The composting process resulted after 12 months in a good compost free of odor that had an earthy structure indicating that the composting process worked well in this systems.
Highest temperatures levels were achieved within a time interval of approx. 12 hours after feeding. High temperatures could been maintained during a period of approx. one week after charging. Charging the organic residues in insulated systems caused temperatures up to 55ºC in the core of the composting matrix, open systems achieved smaller values with approx. 45ºC.

Degradation Rates of Employed BDP in the indoor experiments: Degradation occurred slightly slower in the initial phases than in the indoor trials due to the environmental conditions. Generally the same degradation behavior was calculated. Degradation rates of TPSS in outdoor composting trials were provided in Table 4.

Table 4. Degradation of TPSS - Outdoor Trials

disass.	1st disassembly			2nd disassembly				3rd disassembly				4th disassembly			
No.=X	1-S3	1-S2	1-S1	2-S4	2-S3	2-S2	2-S1	3-S4	3-S3	3-S2	3-S1	4-S4	4-S3	4-S2	4-S1
duration [d]	60	90	120	60	120	150	180	150	210	240	270	240	300	330	360
TKA 1.X	50.0	71.0	74.2	55.2	70.8	82.2	81.1	73.3	88.2	92.0	95.1	95.4	90.8	95.7	93.0
TKA 2.X	42.7	68.1	67.9	48.9	81.2	88.3	89.8	89.7	93.3	93.4	95.6	87.9	96.7	93.6	92.7
Æ **TKA**	**46.3**	**69.6**	**71.0**	**52.1**	**76.0**	**85.3**	**85.4**	**81.5**	**90.7**	**92.7**	**95.4**	**91.6**	**93.8**	**94.7**	**92.8**
LRA 1.X	30.6	60.4	63.5	62.1	70.5	67.1	80.3	83.9	89.6	88.9	86.6	90.1	88.8	89.3	91.2
LRA 2.X	29.5	69.0	69.3	55.2	69.2	79.3	82.7	85.8	83.8	87.7	88.5	84.9	91.8	87.5	89.2
Æ **LRA**	**30.0**	**64.7**	**66.4**	**58.7**	**69.8**	**73.2**	**81.5**	**84.9**	**86.7**	**88.3**	**87.6**	**87.5**	**90.3**	**88.4**	**90.2**

Same results as mentioned for the indoor results were obtained for the tested PLA cups (Table 5). Almost no degradations in terms of mass losses were recognized during the 12 months testing time.

Table 5. Degradation of A-PLA (S1 layers) and C-PLA cups (S2, S3 and S4 layers) - Outdoor Trials

disass.	APLA			APLA				APLA				APLA			
disass.	1st disassembly			2nd disassembly				3rd disassembly				4th disassembly			
No.=X	1-S3	1-S2	1-S1	2-S4	2-S3	2-S2	2-S1	3-S4	3-S3	3-S2	3-S1	4-S4	4-S3	4-S2	4-S1
duration [d]	60	90	120	60	120	150	180	150	210	240	270	240	300	330	360
TKA 1.X	0.0	0.0	0.0	n.v.	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.1	1.0	2.1
TKA 2.X	0.0	0.0	0.0	0.0	0.1	0.0	0.7	0.0	0.0	0.0	2.2	0.0	0.0	0.2	6.5
Æ **TKA**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**1.2**	**0.0**	**0.0**	**0.0**	**1.1**	**0.0**	**0.1**	**0.6**	**4.3**
LRA 1.X	0.0	0.0	0.0	0.0	0.0	0.1	1.5	n.v.	0.0	0.0	2.3	0.0	0.0	0.1	3.7
LRA 2.X	0.0	0.0	0.0	n.v.	0.1	0.1	0.7	n.v.	0.0	0.0	0.7	0.0	0.0	0.0	6.0
Æ **LRA**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**1.1**	**n.v.**	**0.0**	**0.0**	**1.5**	**0.0**	**0.0**	**0.1**	**4.8**

Starch based films achieved with 67 and 77% mass loss slightly slower degradation rates in the outdoor composting trials as indicated in table 6. The degradation seemed to work better in insulated system. achieving an average of 10% more mass loss compared to that one in open composting systems.

Table 6. Degradation of MBF - Outdoor Trials

disass.	1st disassembly			2nd disassembly				3rd disassembly				4th disassembly			
No.=X	1-S3	1-S2	1-S1	2-S4	2-S3	2-S2	2-S1	3-S4	3-S3	3-S2	3-S1	4-S4	4-S3	4-S2	4-S1
duration [d]	60	90	120	60	120	150	180	150	210	240	270	240	300	330	360
TKA 1.X	1.8	17.1	13.8	15.1	19.9	34.5	56.7	33.8	74.2	65.7	67.7	55.3	59.2	54.2	94.6
TKA 2.X	7.3	20.4	33.9	12.3	34.3	37.1	39.2	38.3	62.2	77.7	70.6	23.5	81.7	67.5	59.7
Æ TKA	**4.5**	**18.8**	**23.8**	**13.7**	**27.1**	**35.8**	**47.9**	**36.1**	**68.2**	**71.7**	**69.1**	**39.4**	**70.5**	**60.9**	**77.1**
LRA 1.X	3.2	4.9	27.8	7.3	35.5	26.5	22.5	12.1	47.4	37.1	54.3	44.3	57.6	81.0	54.8
LRA 2.X	5.7	15.5	23.4	4.7	16.3	15.8	24.7	22.0	10.7	64.2	45.2	54.1	74.7	71.5	79.5
Æ LRA	**4.5**	**10.2**	**25.6**	**6.0**	**25.9**	**21.2**	**23.6**	**17.1**	**29.1**	**50.7**	**49.8**	**49.2**	**66.1**	**76.2**	**67.2**

5. CONCLUSION

In general, the obtained data indicate that tested starch based, biodegradable packing items are compostable in home composting systems as well as in technical composting plants, with the exception of PLA-based products. Even starch based products with a copolymer coating made from fossil resources degraded almost completely. The process of the degradation in backyard composting systems occurred less intensive compared to that in a technical facility though considerable degradation rates of up to 97% mass loss could be achieved within the recommended composting time of 12 months, even under sometime non-optimal environmental conditions (winter, hard rainfall etc.).

Starch based blends as the commercial grade Mater-Bi achieved average degradation rates between 77 and 91% in insulated compost makers in in- and outdoor trials, and 67 and 86% in open compost makers, respectively. This can be seen as a proof that the material degrades in home composting system as well as in commercial composting facilities. Residues of the material were only found in the edges of the composting matrix, a complete degradation may be achieved by a frequent turning of the composting material within the treatment period.

Starch-based trays coated with a copolymer layer degraded even faster, these materials achieved degradation rates between 93 and 97% (w/w) in insulated systems and between 90 and 95% in open systems. These packing items degrade without complications in home composting systems almost completely.

Almost no degradation in home composting systems was achieved with PLA based products. Almost no loss of weight was measured, indicating that the PLA items do not degrade without a pre-treatment within 12 months of composting in small backyard systems. It may cause considerable difficulties trying to compost these items in backyard composting facilities without adequate pre-treatment.

Generally the results indicate that it is possible to recover starch based biodegradable polymer packing items, even with fossil based copolymer coating, via backyard composting without complications and changes of the composting method not the system. The degradation of PLA items in home composting systems seems to be a process needing longer time intervals thus being more sophisticated.

6. OUTLOOK

PLA based materials are widely employed for medical applications as biodegradable implants (Heidemann et al. 2001). Investigations reported the complete degradability of these PLA based materials in vitro as well in vivo. Conditions of the degradation in vivo do not seem so different to the conditions of home composting in terms of temperature and moisture. So certain possibilities might exist to enhance the biological degradation in backyard composting systems by physical, chemical or mechanical methods. Further investigations, concerning an appropriate pre-treatment method (thermal, chemical, physical) for PLA products, are planned as literature indicates that a certain enhancement is possible by several measurements as the addition of special nutrients and adapted micro-organisms (Li et al 2000, Jang et al. 2002).

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