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COMPARISON IN BIODEGRADABLE FILMS FORMULATED FROM TWO RED SEAWEEDS OF KARACHI COAST

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ABSTRACT: In this research a comparative study was made between biodegradable films obtained from two different indigenous red seaweeds collected from Karachi coast. *Gracilaria corticata* and *Melanothamnus afaqhussainii* were collected from the Buleji coast of Karachi, Pakistan (24^{o}50′N, 66^{o}48′E). Agar extracted from both the seaweeds was used and incorporated as raw material for the formulation of biodegradable films. Sorbitol was used as plasticizer to increase the tensile strength and elasticity of the films. The results showed that the solubility of *M. afaqhussainii* was higher than *G. corticata*. The soil burial test showed that the biodegradability percent of *M. afaqhussainii* (60%) was higher as compared to *G. corticata* (40%). The tensile strength and elongation break of *G. corticata* (9.79±1.21 MPa and 28.72±5.13%) was stronger than the *M. afaqhussainii* (3.98±1.08 MPa and 16.32±3.80). Results of current study showed that the *G. corticata* has stronger gelling property as compared to *M. afaqhussainii*.

KEYWORDS: Red seaweed, *Melanothamnus afaqhussainii*, *Gracilaria corticata*, Agar, Biodegradable films.

INTRODUCTION

Seaweeds are one of the most important living resources (Gade *et al.*, 2013) known for their richness in polysaccharides, vitamins, minerals, fibres and some other bioactive compounds such as proteins, lipids and polyphenols (Matanjun and chan, 2017). Some species of brown and red seaweeds have also been used to extract hydrocolloids such as: Alginates, Agar and Carrageenan (Armisen and Galatas, 1987; Matanjun and Chan, 2017). The agar from red seaweed is a biologically active compound due to its gelling, emulsifying and elasticity which is widely used as phycocolloidal extracts (Yu *et al.*, 2009).

Many of the researchers are focusing on development of different biodegradable packaging materials by using natural polymers as an alternative to synthetic ones (Leceta *et al.*, 2014). Since the synthetic packaging are derived from petroleum-based materials and natural gas they are highly carcinogenic and toxic in nature (Yu *et al.*, 2009; Fakhoury *et al.*, 2012; Gade *et al.*, 2013; Jalil *et al.*, 2013; Ginting *et al.*, 2017). The synthetic plastic is also resistant to microbial degradation and deposit in the form of solid waste on earth, which is a big threat to environment and livestock (Rajendran *et al.*, 2012). To overcome these environmental problems some reports on seaweeds are evident that use of agar from red seaweeds as biopolymer for preparation of biofilms can reduce plastic pollution (Machmud *et al.*, 2013; Guerrero *et al.*, 2014; Ismail *et al.*, 2015). The use of agar with compatible plasticizer increases the flexibility and extensibility of film by reducing the brittleness of polymer (Karim *et al.*, 2011; Bressler *et al.*, 2013). The most commonly used plasticizers are polyols (glycerol, sorobitol, xylitol, maltitol and sugar) in hydrocolloid film production (Beppu *et al.*, 2011; Bressler *et al.*, 2013; Farhan and Hani, 2017). Scientists have worked on agar-based films mostly from *Gracilaria* and *Gelidium* species of red seaweeds (Sousa *et al.* 2010). Detailed study has been done on physiology, taxonomy and element analysis of red seaweed from Karachi coast (Rizvi *et al.* 2001; Rizvi and Shameel, 2005). Recently a rare attempt was made to produce bioplastic from *Gelidium pusillum* collected from Karachi coast (Tabassum, 2016), which served as a baseline research for bioplastic production in Pakistan. The objective of this study was to compare biodegradable films obtained from *M. afaqhussainii* and *G. corticata* collected from Buleji coast of Karachi, Pakistan which will help to eliminate plastic disposal problem in future.

MATERIALS AND METHOD

Collection of seaweeds: The collection and storage process was same as described by (Tabassum, 2016). Red seaweeds *M. afaqhussainii was* collected in the month of August 2014 and *G. corticata* was collected in the month of January 2017 from rocky ledges of Karachi coast.

Preparation of Agar: Agar extraction was done by Traditional Hot Water Extraction Method (TWE) as described by (Armisen and Galatas, 1987 and Tabassum, 2016).

Preparation of Films: Casting method was used for film fabrication (Guerrero *et al.*, 2014 and Tabassum, 2016) for both the species. Three replicates of respective species were used for the formation of films for further testing.

Soil burial test: Biodegradability of biofilms was examined by soil burial test. 2 cm pieces of plastics were buried in loamy soil and left for a week. The initial weight (M_o) and the final weight (M_1) were recorded. The percentage of weight loss after a week was calculated (Wong *et al.*, 2016).

$$\text{Weight loss (\%)} \quad \frac{M_0 - M_1}{M_o} \; = \; \text{x } 100\%$$

Solubility test: The 2cm pieces of bioplastics from the species were placed in acidic (1M HCL) and basic (1M NaOH) solutions and rate of solubility was observed with time. This test was conducted to determine the solubility of *M. afaqhussainii* and *G. corticata*.

Mechanical properties: The tensile properties of films were evaluated using universal testing machine (zwick/Roell, GmbH &co, D-89079 μml), equipped with a 1 KN load cell. The obtained stress strain graph was analyzed by test Xpert ® software. Rectangular strips of dimension (40 x 100) mm were cut from each film and clamped between vertical grip of machine (lower grip was fixed to platform while upper grip stretched the film). The grip to grip separation was kept at 50 mm and the speed of deformation was kept at 100 mm/min. The parameters analyzed were tensile strength (Ts, MPa) and elongation at break (EAB, %).

RESULTS AND DISCUSSION

Soil burial test: The soil burial test was carried out to determine the biodegradability of biofilms from *M. afaqhussainii* and *G. corticata*. The biodegradability of films depends upon structural alteration and the scission of polymeric chain that are affected by environmental factors and microorganism activity (Wong *et al.*, 2016). Results showed that the percentage of weight loss of *G. corticata* film was lower as compared to the *M. afaqhussainii* (Table. 1). This might be due to packed structure of *G. corticata* as compared to *M. afaqhussainii* or due to the hydrophilic property of agar. The agar having higher sulphated bonds in extended side chains have high hydrophilicity which subsequently promotes microorganism activity (Wong *et al.*, 2016).

Table 1. Soil burial test.

S. No.	Name of sample	Bio degradation weight (gm)		Weight loss (%)
		Initial wt.	Final wt.	
1	*Melanothamnus afaqhussainii*	0.05	0.02	60
2	*Gracilaria corticata*	0.05	0.03	40

Solubility test: In this study both species showed different rate of solubility on testing (Table 2 & 3). It was observed that the gel strength of agar depends on side chains of sulphated bonds (Ho *et al.*, 2017). Present study showed that the *M. afaqhussainii* has low gel strength as compared to *G. corticata*. It was observed that *M. afaqhussainii* immediately started to dissolve when placed in acidic or basic medium whereas the *G. corticata* films took longer time to dissolve. It can also be concluded that the *G. corticata* film is good for commercial purpose as compared to the *M. afaqhussainii*.

Mechanical properties

The factors that affect the tensile strength and percent elongation of biofilms are molecular weight, chemical structure, hydration behaviour, temperature and relative humidity (Wong *et al.*, 2016).

In present research sorbitol was added for the production of biofilms because sorbitol interacts with the polysaccharide chain of agar and disrupted the inter or intra molecular hydrogen bonds, so the plasticized films can form in a continuous phase structure (Yu *et al.*, 2009).

Table 2. Solubility in acidic medium.

S. No.	Specimen	Concentration of acid M	Solubility time mins			Mean mins
1	*Melanothamnus afaqhussainii*	1	6	5	4	5
2	*Gracilaria corticata*		60	57	60	59

Table 3. Solubility in basic medium.

S. No.	Specimen	Concentration of base M	Solubility time mins			Mean mins
1	*Melanothamnus afaqhussainii*	1	7	4	5	5
2	*Gracilaria corticata*		60	59	57	59

Results revealed that the *G. corticata* exhibited higher tensile strength and elongation at break as compared to *M. afaqhussainii* (Table 4) which showed stronger chemical interaction between agar and sorbitol in *G. corticata* films.

Table 4. Comparison between mechanical properties of bio films.

Parameters	**Samples**	
	Gracilaria corticata	***Melanothamnus afaqhussainii***
F-max (Mpa)	9.79 ± 1.21^{1}	3.98 ± 1.08^{2}
F-break (N/mm^2)	8.11 ± 0.96^{1}	3.21 ± 0.19^{2}
E-break (mm)	18.86 ± 3.22^{1}	11.25 ± 2.97^{2}
E-Fmax (%)	28.72 ± 5.13^{1}	16.32 ± 3.80^{2}

CONCLUSION

The increased use of synthetic plastics causes the gradual changes in earth's environment and biodiversity, which attracted scientist to developed alternative, sustainable and eco-friendly plastic. The availability of *M. afaqhussainii* and *G. corticata* in bulk amount on Karachi coast will play a vital role in formation of seaweed bioplastic as a substitute to synthetic plastic. The results showed that two species of red seaweeds *M. afaqhussainii* and *G. corticata* differed in their biodegradability, solubility and mechanical properties. Comparison of both the films showed that in *G. corticata* film lumps of agar were observed whereas the films of *M. afaqhussainii* were smooth. Similar smooth appearance was evident from the films obtained from *Gelidium pusillum* (Tabassum, 2016). The solubility test of both films showed marked differences in solubility time in acidic and basic mediums (Table 2&3). It was observed that *M. afaqhussainii* dissolved at a faster rate than *G. corticata*. This may be due to difference in gel strength and side chain sulphate bonding of agar (Ho *et al.*, 2017). Similarly, the biodegradability of agar by soil burial test of both the films showed that *M. afaqhussainii* degraded earlier as compared to *G. corticata* (Table 1). It may be due to weak gel strength of *M. afaqhussainii*.

Mechanical test results showed that the tensile strength (MPa) and elongation at break (%) of *G. corticata* was stronger than *M. afaqhussainii* (Table 4). This may be due to the gel strength and bonding of plasticizer used with polymer and other environmental factors which also affect the tensile strength and elongation at break (Yu *et al.*, 2009; Wong *et al.*, 2016). Present research work is the extension of research of Tabassum, 2016 for bioplastic production from red seaweed collected from Pakistan coastline.

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