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Effectiveness of microwave radiation, high temperatures and cooling degrees in control of dry wood termite, *Cryptotermes brevis* (Isoptrea: Kalotermitidae)

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Abstract:

Dry wood termite, *Cryptotermes brevis* Walker (Isoptrea: Kalotermitidae) is a serious pest attack the different kinds of hard and soft wood of wooden structures, standing trees, flooring, furniture, wooden works within buildings in different images and shapes , etc. Three different methods to control *C. brevis* termite within two kinds of wood (pine and beech) were used in this work; these are microwave radiation, high temperature and cooling degrees. The effects of these methods on the percentages of mortality are correlated with exposure times of infested wood (pine and beech) to each method. The least exposure time which gave 100% mortality differed according to used method. In microwave method, the shortest exposure time which gave 100% mortality recorded 20 sec. with power level 100 wattages for termite within pine wood while, required 80 wattages with beech wood, the longest exposure time which appeared100% mortality was 50 sec. for pine wood at 50wattages, while it was 60sec. at the power level 10 wattages for beech wood. In cooling method, the percentage of mortality recorded 100% at -27°C with 18Min.exposure time for pine wood and 20Min. for beech wood, while at -21°C the exposure time was 30 and 32Min. for pine and beech wood, respectively, whereas at -18°C the exposure time was 36 and 40Min. for pine and beech wood, respectively. In heating method, the shortest exposure time (for 100% mortality) recorded 28 Min. at 75°C for both pine and beech wood, while at 70°C the time was 34 Min. for both pine and beech wood, whereas the exposure times at 65 °C recorded 34 and 35Min.for pine and beech wood respectively. The longest exposure time reached 35Min at 60°C for two kind wood. The lethal time values (LT50 and LT95) were deterMined for the different treatments in different methods of control. The lost moisture content from infested wood exposure to both microwave irradiation and different temperature degrees was significant correlated with exposure time and showed changes in mortality percentages. Therefore, the combined effect of each temperature and lost moisture content play an important role beside exposure times and wood kind in effect on mortality of termite within infested wood.

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Introduction

Dry wood termites are social and cryptic insects which live entirely in the wood which cause significant damage to attacked wooden constructions. Previous studies by many investigators, such as, Light (1934); Coaton (1948); Edwards and Mill (1986); Myles *et al.*(2007) and Nunes *et al.*(2010) indicated that dry wood termites infest both hard wood and soft wood of wooden structures which cause a serious damage to furniture, painting, frames, poles, wooden works within buildings, standing trees of different wooden and ornamental trees, flooring and other wooden articles.

Cryptotermes brevis Walker (Isoptrea: Kalotermitidae) is one of most widespread pests in the world including, Africa, North Europe, Australia and most tropical islands (Scheffrahn *et al*., 2009). The same authors remember that the distribution of this pest is vast due to secondary introductions since it present in all continents except Antarctica, they added that *C. brevis* was introduced to Port Said, however this insect did not exist in Cairo, Egypt. While El-Hemaesy (1976) mentioned that this species is recently introduced to Egypt through Port Said Sea Port prior to 1965 by international trade.

Microwaves are radio waves with high frequency electromagnetic field which changed about 2 trillion times per second. These are unionized rays whose range of microwave frequency approximately ranges from 0.3 Ghz (Gigahertz) to 30 GHz with corresponding wavelength in vacuum from one meter to one millimeter. Microwave heating is heating inside the material and it is more effective than conventional methods of heating where the heat is generated outside the treated product and conveyed by conduction or convection. Materials containing free water, such as wood and organisms are capable of absorbing microwave energy with consequent increase in temperature. Water is an ideal material that absorbs radiation with wave length 12.25 Cm (corresponding to the frequency of 2.45GHz) (Merenda, 2006).

In this respect, Burdette *et al*. (1975) reported that microwave technology using for wood products to control borers infestations, while Lewis and Haverty (1996); Lewis *et al*. (2000); Peters and Creffield (2002) and Evans (2002) showed that microwave irradiation used to control for dry wood termite. Also, Fleming *et al.* , 2005 and Kisternaya and Kozlov, 2007 showed that the irradiation of microwave has been successfully used for many years for attacked wood treatment by wood borers. The heat treatment was used to control the infestations of dry wood termite *C. brevis* in timber and furniture (Horner and Bowe, 1934 and Forbes *et al*., 1988). The temperatures between 50 to 65 C° were used to control dry wood termites in infested timber < 5.1cm thick (Ehrhorn, 1934). The effects of low temperatures on termites have scarcely been investigated. Lund (1962) determined that workers of the eastern subterranean termite, *Reticulitermes flavipes* (Kollar) (Isoptera: Rhinotermitidae), succumbed after less than 5 Min exposure at -9.5 °C to -13.0° C. All *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) died when maintained at 10° C, whereas *R. flavipes* survived (Smythe and Williams, 1972). This work carried out to study the effectiveness of physical methods such as microwave irradiation, high temperature and cooling degrees to control dry wood termite, *C. brevis* within pine and beech wood.

Materials and methods

1.Culture of termite:

Infested wood samples with dry wood termite, *C. brevis* were collected from cumulated wooden combinations at

different places and coastal regions of Port Said town (Mediterranean sea port) during the summer season of 2018. These samples were transferred to wood borers and termite laboratory, Plant Protection Research Institute, Dokki, Giza Governorate, Egypt. The samples contained termite was kept in suitable containers under ordinary laboratory conditions.

2.Used laboratory apparatus:

2.1.Microwave device:

Apparatus radiating microwaves of the frequency 2.45 GHz (wave length 12.2Cm) was for Tornado kind (domestic microwave oven), Model TM-25 SD., Rated voltage 230V.

2.2.Standing deep freezer:

To cooling the tested samples on different degrees used Toshiba freezer, Model GF-22h.

2.3.Electric heat oven:

To generate thermal energy on the different thermal degrees used electric oven (Veb Mlw Medizinische; Type, 116 -0100).

3.Experiment equipments:

3.1.Kind of wood blocks:

Used wooden blocks were made from pine and beech wood. The prepared blocks were in small boxes shape sized 4x2x2 cm with walls and covers of the same thickness (5mm). Inside each block, tunnel measured 3cm long x 0.5cm width x 1cm depth (Figure,1).

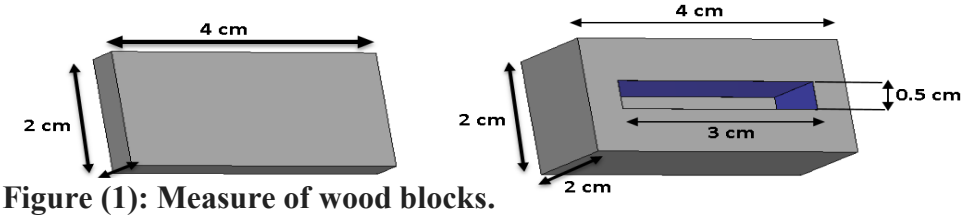

Figure (1): Measure of wood blocks.

4.Tested termite:

Extracted termite from infested wood samples for work the different experiments were distributed on manufactured tunnels inside wooden blocks, at rate 8 termite nymphs of each tunnel for 10 wooden blocks, these infested wooden blocks were applied for study the effect of microwave radiation, heating and cooling on mortality of termites at various exposure times. Microwave radiations were generated at power level of 10, 30, 50, 80 and 100 Wattage, while tested cooling degrees were -18,-21 and -27C°, whereas heating carried out heat at degrees 60,65,70 and 75 C°.

5.**Statistical analysis**:

The mortality percentages were calculated and corrected by using Aboott' Formula (Abbott, 1925) and the lethal time 50 and 95 was deterMined for established regression lines according to method of Finney (1971). Simple correlation and partial regression for obtained data were deterMined by SAS program (2001).

Results and discussion

The different effectiveness of each microwave radiation, cooling degrees and high temperature on mortality percentages of dry wood termite nymphs (*C. brevis*), introduced in two species of wooden blocks under different exposure time, obviously detected the following results:

1. Influence of microwave radiation:

1.1. On mortality percentages of *Cryptotermes brevis* termite:

Data illustrated in Table (1) showed the mortality percentages of *C.brevis* termite in two kinds of wooden blocks and treated by microwave radiations generated from microwave system under various wattages at different exposure times.

1.1.1. Pine wood:

Pine wooden blocks infested by *C.brevis* nymphs showed that percentages of mortality varied

according to exposure times and power of microwave device. The mortality percentage at 10 wattage was 0 % for all exposure times. At 30 wattage, the mortality percentage recorded 2.5 23.8, 67.5, 83.8 and 100% mortality for 20, 30, 40, 50 and 60 Sec. of exposure time, respectively. At 50 wattage, the percentage recorded 37.5, 68.8 and 91.3% for 20, 30 and 40 Sec. of exposure time, respectively; while it was 100% mortality for the other exposure times (50-60 Sec.). At 80 wattage, the mortality percentages were 22.5, 76.3 and 95%, for 10, 20 and 30 Sec. respectively, while the exposure time for 40 Sec. and more gave 100% mortality. While, at 100 wattage, the mortality percentage was 41.3% of exposure time 10 Sec., whereas all other exposure times recorded 100% mortality.

1.1.2. Beech wood:

Beech wood was more influence with microwave radiation, where the mortality percentages recorded 7.5, 31.3, 77.5, 96.3 and 100% for 20, 30, 40, 50 and 60 Sec. of exposure time, respectively, at 10 wattages. While, at 30 wattage the parentages of mortality were 25, 73.8, 93.8 and 100% for 20, 30, 40 and 50 Sec. of exposure time, respectively. At 50 wattage, mortality percentage reached 48.8, 86.3 and 100% for 20, 30 and 40 Sec. of exposure time, respectively. At 80 and 100wattages the all mortality percentages recorded 100% for all exposure times of more than 10 Sec. Previous results indicated that the mortality percentages for termite nymphs (exposing to microwave radiation) in beech wooden blocks were higher than pin wooden blocks at same measurements. These results revealed that wood kind play an important role in tolerance or protection of the internal stages of insect against the opposite external factors (circumstances).

The data presented in Table (2) showed that the lethal time (LT50 and LT95) values of the drywood termite*, C. brevis* in both pine and beech wood under power levels. Whereas, the lethal time values (LT50) for pine wood under power levels 30,50 and 80 wattage were 36.27, 23.3 and 14.43 Sec., while the lethal time values (LT95) recorded 59.29, 47.24 and 33.05 sec. respectively under same power levels. For beach wood the lethal times (LT50) were 32.4 and 25sec. while, the lethal time values (LT95) recorded 51.7 and 45.5 Sec., under power level 10 and 30 wattage, respectively.

Table (1): Effect of microwave irradiation on mortality rate of dry wood termite, *Cryptotermes brevis* in both pine and beech wood at different percentage exposure times.

Power level (Wattage)	Kind of wood	Mortality percentage at different exposure times (Sec.)					
		10	20	30	40	50	60
		M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE
10	Pine	0 ±0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ±0.0	0 ±0.0
	Beech	0± 0.0	7.5 ±2.03	31.3 ± 2.08	77.5 ±1.67	96.3 ±1.81	100 ± 0.0
30	Pine	0± 0.0	2.5 ± 1.67	23.8±2.64	67.5±2.41	83.8 ±1.91	100 ± 0.0
	Beech	0± 0.0	25 +1.86	73.8 ±2.23	93.8 ±2.08	100 ± 0.0	100 ± 0.0
50	Pine	0± 0.0	37.5± 3.23	68.8 ± 2.80	91.3 ±3.75	100 ± 0.0	100 ± 0.0
	Beech	0± 0.0	48.8 +1.25	86.3 ±2.89	100 ± 0.0	100 ± 0.0	100 ± 0.0
80	Pine	22.5 ±1.67	76.3 ± 2.22	95+ 2.04	100 ± 0.0	100 ± 0.0	100 ± 0.0
	Beech	0± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0
100	Pine	41.3 ±1.91	100 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0
	Beech	0± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0

Table (2): Values of Lt50 and Lt95 for *Cryptotermes brevis* termite within pine and beach wood exposed to different power levels of microwave irradiation.

Power level (wattage)	LT50	LT95	Slop	P.value
Pine wood				
30	36.27	59.29	7.7 ± 0.68	0.45
50	23.3	47.24	5.36 ±0.68	0.33
80	14.43	33.05	4.57±0.47	0.48
Beach wood				
10	32.4	51.7	8.12 ±0.63	0.06
30	25	45.5	6.34 ± 0.75	0.16

1.2. On percentage of lost moisture content :

Date illustrated in Table (3) appear the percentages of lost moisture content for two kinds of wood blocks treated by microwave irradiation generated from microwave device under varies wattages at different exposure times.

1.2.1. Pine wood:

Obtained results on lost moisture content percentages indicated that the increase of power level (Wattage) led to increase of lost moisture content percentage at different exposure times. The minimum percentages of lost moisture content recorded 0.38, 0.41, 0.57, 0.64 and 0.67% at 10 Sec. under all wattages values, while, the maximum percentages of lost moisture recorded 7.12% and 7.26% at 60 Sec.under 80 and 100 wattages, respectively. Also, the lost moisture recorded 6.05%, and 6.17%, at 60 Sec. under 30 and 50 wattages, respectively. While, it recorded 6.07 and 6.9 0% at 50 Sec. under 80 and 100 wattages.

1.2.2. Beech wood:

The lost moisture content percentages increased with the increase exposure time at values of oven power level. At time exposure 10 Sec., the least percentages recorded 0.14%, 0.20%, 0.50%, 052% and 0.59% under tested wattages values, respectively. Also, the least percentages at time exposure 20 Sec recorded 0.31%, 0.48% and 0.95% under 10, 30 and 50 wattage respectively. At exposure time 30 and 40 Sec. the least percentage was 0.58% and 0.94% under10 wattage. While, the maximum percentage of lost moisture was 4.56% and 4.73% under 80 and 100 wattages, respectively at time exposure 50 Sec. As at exposure time 60 Sec. the percentage of lost moisture recorded 4.25, 4.56, 4.89, 5.07 and 5.53 under tested wattages values (Table, 3). Highly significant correlations were clear obviously between percentages of lost moisture content of both pine and beech wood with different exposure time to microwave irradiation at different power levels (Table, 4).

Table (3) : **Effect of microwave irradiation on percentages of lost moisture content of both pine and beech wood at different exposure times.**

Power level (wattage)	Kind of wood	Percentages of lost moisture content at different exposure times (Sec.)					
		10	20	30	40	50	60
		M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE
10	Pine	0.38±0.008	1.29±0.014	1.76±0.019	3.33±0.028	5.08±0.035	5.27±0.038
	Beech	0.14±0.015	0.31±0.020	0.58±0.026	0.94±0.018	1.87±0.015	4.25±0.024
30	Pine	0.41±0.012	1.36±0.013	2.31±0.018	3.43±0.016	5.41±0.020	6.05±0.028
	Beech	0.20±0.013	0.48±0.021	1.39±0.015	2.15±0.021	2.79±0.019	4.56±0.024
50	Pine	0.57±0.014	1.44±0.022	3.07±0.042	3.88±0.021	5.73±0.036	6.17±0.032
	Beech	0.50±0.018	0.95±0.033	1.55±0.025	2.78±0.030	3.31±0.023	4.89±0.031
80	Pine	0.64±0.023	1.48±0.028	3.31±0.032	4.65±0.021	6.07±0.043	7.12±0.051
	Beech	0.52±0.024	1.16±0.028	1.91±0.040	3.28±0.034	4.56±0.030	5.07±0.039
100	Pine	0.67±0.031	1.66±0.033	3.63±0.047	4.93±0.072	6.90±0.031	7.26±0.021
	Beech	0.59±0.025	1.61±0.040	1.94±0.036	3.60±0.081	4.73±0.042	5.53±0.066

Table (4): Simple correlation and regression values between different power levels and percentages of lost moisture content of both pine and beech wood at different exposure times.

Power level (wattage)	Kind of wood	Percentages of lost moisture content	
		Simple correlation (r)	simple Regression (b)
10	Pine	0.980	0.11
	Beech	0.883	0.73
30	Pine	0.991	0.12
	Beech	0.974	0.08
50	Pine	0.989	0.12
	Beech	0.987	0.08
80	Pine	0.997	0.14
	Beech	0.991	0.10
100	Pine	0.989	0.14
	Beech	0.989	0.10

2. Influence of the cooling on mortality percentages of *Cryptotermes brevis* termite:

The mortality percentages of dry wood termite *C.brevis*, resulting from three cooling degrees, for two kinds of infested wood by exposing to different periods were showed in Table (5). The obtained results indicated that the percentages of mortality differed with differences of each cooling degrees, exposure time and attacked wood kinds.

2.1. Pine wood:

The effect of tested cooling degrees (-18, -21 and -27°C) on mortality of termite nymphs showed that the mortality percentages increased with increase in cooling degrees at different exposure times. At -18°C, the percentages of mortality ranged between 5 % mortality at 26 Min. exposure time to 100% mortality at exposure time 36 Min. at -21°C, the least mortality percentage was 11.3% at 20 Min., while the highest percentage recorded 100% at 30Min exposure time, whereas at -27°C, the mortality percentage recorded 100% on all exposure times.

2.2. Beech wood :

The mortality percentages of termite nymphs increased with the increase of exposure time to different cooling degrees. The exposure time which gave 100% mortality was 20 Min. recorded at -27°C, while the longest exposure time to obtain 100%mortaiilty was 40 Min. at-18°C exposure time. The obtained data in Table (5) showed that the mortality percentages of termite nymphs were affected according to infested wood kind. The mortality percentages of termite nymphs existent enter pine wooden blocks were higher than the others enter beech wooden blocks through different exposure times to the three cooling degrees (-18,-21,-27°C). The highest percentage of mortality (100%) was nearly similar in each pine and beech wood on -18°C degree at exposure time of 40 Min.at -21°C degree, pine wood recoded 100% mortality on 30-40 Min., while beech wood showed 100% mortality on 32-40 Min. exposure time. At -27°C degree, the highest mortality percentages were 100% enter pine wooden blocks at exposure time of 18Min. and more, whereas beech wooden blocks showed 100% mortality at exposure time of 20 Min. and more.

The primary experiments carried out by Forbes and Ebeling (1986) detected that termite workers killed within 5 Min. at temperatures between -18.5 to -19.4 °C (-1.3 to 2.9 °F), whereas Rust *et al.* (1997) corroborated the previous experiences and found that exposure of workers (sic) in wooden blocks to temperatures below -21.4° C resulted in 100 percent mortality. Abd-El Malak (2002), in Egypt found that the mortality percentages of *C. brevis* increased with increasing exposure time

for cooling degree, whereas, the exposure at -18°C gave 26.67, 46.67, 60, 83.33 and 100 % mortality under exposure time 30,31,32,33, and 34 Min., respectively. The data in Table 6 appeared that the lethal time (LT50 and LT95) values of both pine and beech wood were as following: for pine wood the LT50 and LT95 recorded 30.83 and 36.29 Min. at -18°C, respectively. While the lethal time (LT50 and LT95) values were 23.36 and 29.06 Min. at -21°C, respectively. The beech wood give lethal time (LT50 and LT95) values 32.28 and 38.81Min. under -18 °C, receptively, whereas lethal time (LT50 and LT95) values were 24.16 and 30.46 Min. under -21 °C, respectively (Table,6).

Table (5): Effect of cooling degrees on mortality percentages of drywood termite *Cryptotermes brevis* in both pine and beech wood at different exposure times.

Cooling degree	Kind of wood	Mortality percentages affected by cooling degrees											
		Time (Minutes)											
		18	20	22	24	26	28	30	32	34	36	38	40
		M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE	M.±SE
-18 °C	P	0± 0.0	0± 0.0	0± 0.0	0± 0.0	5± 2.04	17.5± 2.76	36.3± 1.25	62.5± 1.86	86.3± 1.25	100± 0.0	100± 0.0	100± 0.0
	B	0± 0.0	0± 0.0	0± 0.0	0± 0.0	0± 0.0	8.8± 1.90	22.5± 2.5	56.3± 2.79	66.3± 2.67	81.3± 2.08	92.5± 2.76	100± 0.0
-21 °C	P	0± 0.0	11.3± 2.24	35± 1.67	56.3± 1.88	77.5± 2.5	92.5± 2.76	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0
	B	0± 0.0	6.3± 2.79	27.5± 2.5	43.8± 2.08	60± 1.66	82.5± 2.04	98.8± 1.25	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0
-27 °C	P	100± 0.0	100±0. 0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0
	B	28.8± 1.91	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0

Table (6): Values of LT50 and LT95 for *Cryptotermes brevis* termite within pine and beach wood exposed to different cooling degrees.

Cooling Degrees	LT50	LT95	Slop	P. value
Pine wood				
-18°C	30.83	36.29	23.2±1.87	0.76
-21°C	23.36	29.06	17.36±1.39	0.86
Beach wood				
-18°C	32.28	38.81	20.53±1.48	0.30
-21°C	24.16	30.46	17.11±1.15	0.06

3.Effect of high temperature degrees:

3.1. On mortality percentages of *Cryptotermes brevis* termite:

Data illustrated in Table (7) detected the effect of four temperature degrees (60, 65,70 and 75 °C) on mortality percentages of *C. brevis* termite inside two kinds of wood (pine and beech) which subjected to different times.

3.1.1. On pine wood:

At 60 °C, 65°C and 70°C the lowest percentages of mortality recorded on different exposure times of 28, 29 and 30 Min., while the highest mortality percentages recorded at 33,34 and 35Min. At75 °C, the percentages of mortality were 100% at all exposure times.

3.1.2. On beech wood:

The same trend of mortality percentages on each 60 °C, 65 °C and 70°C for pine wood recorded also for beach wood. Previous results indicated that the infested wood with *C. brevis* termite required temperature degrees 60-70°C for exposure times 34-35 Min. to obtain 100% mortality except pine and beech wood for 60°C at 34 Min. gave 96.3% and 93.8% mortality, respectively. While, at 75°C the exposure time 28 Min. was enough to obtain 100% mortailty

In Florida, Scheffrahn *et al*. (1997) estimated that the temperature and heating time requirements to control *Cryptotermes brevis* in structural infestations. Furthermore, they found that exposure time 54.4°C for 60 Min., was suitable to control of dry wood termite. While, Forbes and Ebeling (1987), showed that the heat treatment was applied to control dry wood termite incicitermes minor at 49ºC under exposure time 30Min. Ebeling (1997), reported that temperature of 55ºC for 60 Min. was used in many applications. While, the exposure time 30 Minutes to 49ºC was suitable to controlled drywood termite *C. brevis* in wood (Woodrow and Grace, 1998 a, b). In Egypt, Abd-El Malak (2002) showed that the percentage of mortality of *C.brevis* termite increased by increasing the temperature degree of heating and exposure time, furthermore, he found mortality percentage was recorded 100% under exposure time 34 Minutes for 50, 60 and 70°C. The obtained data in Table (8) elucidated that the lethal time (LT50) values of the *C. brevis* termite, recorded 31.18, 30.79 and 30.27 Min. at 60° C, 65C° and70C°, respectively, while lethal time values (LT95) were 34.75, 34.70 and 34.34 Min. at 60° C, 65C° and70C° ,respectively for pine wood. Whereas, beech wood exposed to 60° C, 65C° and 70C° gave (LT50) values equal 31.74, 31.18 and 30.76 Min., respectively, also, (LT95) values were 35.57, 34.82 and 34.71 Min. respectively at same temperature degrees.

Table (7): Effect of high temperature degrees on mortality percentages of dry wood termite *Cryptotermes brevis* in both pine and beech wood at different exposure times.

Temperature degree	Kind of wood	Mortality percentages affected by heat degrees							
		Time (Minutes)							
		28	29	30	31	32	33	34	35
		M.+SE	M.+SE	M.+SE	M.+SE	M.+SE	M.+SE	M.+SE	M.+SE
60°C	Pine	6.3± 2.08	18.8 ± 2.79	27.5 ± 2.5	38.8 ± 2.42	56.3± 3.36	83.8± 2.66	96.3 ± 1.90	100± 0.0
	Beech	3.8 ± 1.91	12.5± 2.64	21.3± 3.3	30 ± 2.04	48.8± 3.46	78.8± 1.91	93.8± 2.08	100± 0.0
65°C	Pine	15± 1.67	21.3± 3.3	32.5± 2.76	41.3± 3.25	66.3± 3.09	93.8± 2.65	100± 0.0	100± 0.0
	Beech	8.8± 1.90	18.8± 2.08	26.3± 2.24	35± 1.67	57.5± 2.76	82.5± 2.04	97.5± 1.66	100± 0.0
70°C	Pine	23.8± 1.25	28.8± 1.91	37.5± 1.86	48.8± 2.92	77.5± 2.35	96.3± 1.91	100± 0.0	100± 0.0
	Beech	15± 1.67	22.5± 2.5	31.3± 2.08	43.8± 2.79	67.5± 2.04	92.5± 2.67	100± 0.0	100± 0.0
75°C	Pine	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0
	Beech	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0	100± 0.0

Table (8): Values of LT50 and LT95 for *Cryptotermes brevis* termite within pine and beach wood exposed to different temperature degrees.

Temperature degree	LT50	LT95	Slop	P. Value
Pine wood				
60°C	**31.18**	**34.75**	**34.92±2.30**	**0.02***
65°C	**30.79**	**34.70**	**31.69±2.55**	**0.0007****
70°C	**30.27**	**34.34**	**30.04±2.49**	**0.0001****
Beach wood				
60°C	**31.74**	**35.57**	**33.27±2.81**	**0.133**
65°C	**31.18**	**34.82**	**34.27±2.27**	**0.002****
70°C	**30.76**	**34.71**	**31.04±2.54**	**0.004****

**: highly significant * : significant

3.2. On percentages of lost moisture content :

The percentages of lost moisture content from pine and beech wood exposed to high temperature degrees for different times are clarified in Table (9). Obtained data detected that the percentages of lost moisture content increased with the increase of temperature degrees and also with the increase of exposure times of both pine and beech wood.

3.2.1. Pine wood:

The percentages of lost moisture content was 1.63% at 60°C with 28 Min. exposure time, reached to 2.81% at 75°C with same exposure time, while it recorded 3.47% at 60 °C with 35 Min.exposure time, whereas it reached 3.94% at 75°C with 35 Min.

3.2.2 Beech wood:

The data showed that the lost moisture content percentages at 60°C and 28 Min. exposure time was1.32%, reached 2.38% at 75°C with same exposure time. Whereas, the percentages of lost moisture content at 60°C with 35 Min., exposure time recorded 2.30%, increased to 3.53% at 75°C with same exposure time.Highly significant correlations were clear between exposure time and percentages of lost moisture content from pine and beech wood at different temperature degrees, also highly significant correlations were determined between temperature degrees (60-75°C) and percentages of lost moisture content at different exposure times (Table,10).

3.3. Combined effect of temperature and moisture content of wood:

Previous results in Tables (9 and 10) revealed that the temperature showed changes on moisture content of wood with the changes in percentages of mortality, it means that the moisture content play an important role with temperature beside exposure time and wood kind in the effect on mortality of termite inside the infested wood.

Table (9): Effect of high temperature degrees on percentages of lost moisture content of drywood termite *Cryptotermes brevis* in both pine and beech wood at different exposure times.

Temperature degree	Kind Of Wood	Percentages of lost moisture content at different exposure times (Min.)							
		28	29	30	31	32	33	34	35
		M±SE	M±SE	M±SE	M±SE	M±SE	M±SE	M±SE	M±SE
60°C	Pine	1.63± 0.029	1.82± 0.020	2.19± 0.022	2.39± 0.027	2.70± 0.035	2.93± 0.037	3.21± 0.034	3.47± 0.027
	Beech	1.32± 0.028	1.47± 0.017	1.60± 0.025	1.73± 0.023	1.89± 0.013	2.04± 0.044	2.18± 0.023	2.30± 0.011
65°C	Pine	1.79± 0.024	1.99± 0.022	2.21± 0.037	2.48± 0.015	2.86± 0.018	3.10± 0.017	3.38± 0.30	3.71± 0.027
	Beech	1.49± 0.032	1.68± 0.015	1.81± 0.026	1.99± 0.017	2.13± 0.023	2.27± 0.042	2.33± 0.022	2.49± 0.017
70°C	Pine	2.26± 0.026	2.46± 0.025	2.60± 0.015	2.78± 0.030	3.02± 0.027	3.29± 0.023	3.53± 0.28	3.80± 0.018
	Beech	1.76± 0.012	1.89± 0.011	1.98± 0.017	2.15± 0.017	2.28± 0.012	2.40± 0.011	2.63± 0.013	2.75±0 .026
75°C	Pine	2.81± 0.030	3.08± 0.044	3.29±00. 016	3.40± 0.050	3.55± 0.033	3.64± 0.036	3.76± 0.035	3.94± 0.061
	Beech	2.38± 0.021	2.50± 0.024	2.63± 0.027	2.82± 0.020	3.09± 0.040	3.21± 0.033	3.34± 0.023	3.53± 0.027

Table (10): Simple correlation and regression values between different temperature degrees and percentages of lost moisture content of both pine and beech wood at different exposure time.

Temperature degree)	Kind of wood	Percentages of lost moisture content	
		Simple correlation (r)	Simple Regression (b)
60°C	Pine	0.999	0.27
	Beech	0.999	0.14
65°C	Pine	0.997	0.28
	Beech	0.995	0.14
70°C	Pine	0.995	0.22
	Beech	0.859	0.24
75°C	Pine	0.988	0.15
	Beech	0.996	0.17

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