XTRACT® and the effect on heat stress in dairy cows

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Introduction

One of the great challenges that the dairy industry faces, especially during the summer month, is heat stress. Increase in temperature, together with an increase in humidity, results in a decrease in milk production, feed intake, feed efficiency and even reduced growth rate in heifers (West, 1999). Reproduction and health are also negatively affected by heat stress (St Pierre et al., 2003). Different management systems are used to reduce the effect of heat stress on dairy cows, for example, fans with water sprayers or dairy cow housing (shading). However, not all dairies are able to implement these kind of management systems, and even with these, cows still experience a certain amount of heat stress, depending on the environment.

What is heat stress?

The thermal comfort range of lactating dairy cows was estimate to be from -0.5 to 25°C (Berman et al. 1985). Temperature, however, is not the only factor that plays a role in heat stress. Increase in relative humidity also increase heat stress in animals. Both temperature and humidity are therefore used to calculate Thermal Heat Index (THI). In the past, it was determined that cows start to experience heat stress from a THI of 72 and more. However, with today's high producing dairy cows, Burgos Zimbelman and Collier (2011) proposed a revised THI scale to assess the impact of heat stress in dairy cattle (Fig 1). According to their re-evaluation, it appears that a THI of 68 is low enough to have a negative effect on production. Studies indicated that there is a significant negative correlation between THI and DMI (Holter et al., 1997), and the effect of THI is probably mediated through the effects of increasing body temperature. According to Ravagnolo et al. (2000), milk yield can decline by 0.2 kg per unit increase in THI when THI exceeded 72.

The effect of heat stress on production will not necessarily be directly after cows experience heat stress. According to West et al. (2003), there may be a lag time between increase in THI and the full effects on production. They reported that during hot weather the mean THI two days earlier had the greatest effect on milk yield, while DMI was most sensitive to the mean air temperature two days earlier.

Lactating dairy cows produce a large quantity of metabolic heat and accumulate additional heat from the environment. Heat production and accumulation, coupled with compromised cooling capabilities causes heat load increase in the cow to the point that body temperature rises, intake decline and ultimately a decline in production (West, 2003). Ruminants decrease feed intake in an attempt to create less metabolic heat, as the heat increment of feeding is a large portion of whole body heat production (Kadzere et al., 2002). In addition to reduced nutrient intake, heat stressed cows have an increase in maintenance cost (> 30%; Fox and Tylutki, 1998) as maintaining body temperature has a large energy cost. Because of decreased energy availability and increased energy utilization, heat stress cows enter into a calculated negative energy balance (NEB) (Moore et al., 2005). Methods to counter act the NEB include increase energy density of the diet or improve digestibility of feed components. Inclusion of feed additives, like ionophores, yeast or plant extracts can be beneficial for improved nutrient digestibility (Schelling, 1984 ; Beauchemin et al., 2003).

Fig 1. University of Arizona revised heat stress scale (Burgos Zimbelman & Collier, 2011). Legend: Yellow = Stress Threshold; Orange = Mild-Moderate stress; Red = Moderate – Severe Stress; Purple = Severe stress.

Temp	% Relative Humidity																		
(°C)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
22	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71
23	65	65	66	66	66	67	67	68	68	68	69	69	70	70	71	71	71	72	72
23.5	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73
24	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74
24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
25	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76
25.5	67	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77
26	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78
26.5	68	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79
27	68	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	78	79	80
28	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81
28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82
29	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83
29.5	70	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84
30	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84
30.5	71	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85
31	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86
31.5	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87
32	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88
33	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89
33.5	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90
34	74	75	76	77	78	79	80	80	81	82	83	85	85	86	87	88	89	90	91
34.5	74	75	76	77	78	79	80	81	82	83	84	86	86	87	88	89	90	91	92
35	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
35.5	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94
36	76	77	78	79	80	81	72	83	84	85	86	87	88	89	91	92	93	94	95
36.5	76	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95
37	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	95	96
38	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	98
38.5	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	98	99
39	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100
39.5	78	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98	99	101
40	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101
40.5	80	80	82	83	84	86	87	88	89	91	92	93	95	96	97	99	100	101	102
41	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103
41.5	80	81	83	84	85	87	88	89	91	92	94	95	96	98	99	100	102	103	104

Breede and Collier (1986) identified three management strategies to minimize the effect of heat stress: 1) physical modification of environment, 2) genetic development of heat tolerant breeds, and 3) improved nutritional management practices. The rest of the article will focus on the third strategy.

XTRACT 7065 and XTRACT Caps XL

What is XTRACT?

XTRACT is the result of a long-term research program studying the effects of at least 50 different plant extracts and their active substances on rumen function and animal behavioural patterns. Three plant extracts, namely Eugenol (clove), Cinnamaldehyde (cinnamon) and Capsicum (chilli pepper), stood out from the rest in terms of its effect on improvement in ruminant performance. XTRACT® 7065 is a blend of three different natural identical / synthetic essential oils namely: Capsicum (3.5%), Cinnamaldehyde (5.5%) and Eugenol (9.5%). XTRACT® Caps XL, code X60-7035 is a single plant extract which consists of standardized Capsicum oleoresin (20%).

Both XTRACT® 7065 and XTRACT® Caps XL are manufactured in accordance with ISO Fusion Technology™ ensuring homogeneous distribution and flow-ability, stability, uniformity & analytical traceable and are thermally protected by a retention agent. XTRACT® 7065 and XTRACT® Caps XL are compliant with EU regulations, free of GMO and animal products and carries FAMI-QS certificate of analysis. Both products are registered in South Africa in accordance with Act 36 of 1947: **XTRACT® X60 - 7065 - V 21630; XTRACT X60 - 7035 – V 23802.**

XTRACT® 7065 and XTRACT® Caps XL are especially developed for the ruminant market. *In vitro*, *in vivo* as well as production studies have been conducted by several scientists to determine the effect of XTRACT® 7065 and XTRACT® Caps XL on different ruminant parameters. These effects, in relation to heat stress in dairy cows, will be discussed in more detail in the rest of the document.

Feed and water intake

Feed intake plays a significant role in milk production. Not only the total amount of feed being consumed per day, but also the feed intake pattern during the day. Uneven feed intake during the day can have a negative effect on the rumen environment by increasing the fluctuation of rumen pH. During heat stress cows will most probably experience a decrease in feed intake (West, 2003) and possible variation in feed intake during the day and night. Cows tend to increase feed intake during the night when the air temperature decrease.

Cardozo et al. (2006) observed a 9.2% increase in DMI when Capsicum was added to the diet. Fandiño et al. (2008) also reported a 13% increase in DMI and Rodriguez-Prado et al. (2012) reported a 14% increase in total daily DMI as well as a reduction in the size of the first meal. This lead to a reduction in variation in feed intake during the day when Capsicum was added to the diet. As dairy cows can experience increase variation in feed intake during heat stress, a decrease in feed intake variation can be beneficial. Rodrigues-Prado et al. (2006; unpublished) observed an increase in rumen pH at 3 and 6 hours post feeding when capsicum was added to the diet. This is supported by French and Kennelly (1990) who reported that an increase in feeding frequency results in higher and less variable rumen pH.

By improving DMI, decrease DMI variation and thereby increase rumen pH, one can have a positive effect on dairy cows during heat stress, where a decrease in DMI it normally observed (West, 2003).

Water is arguably the most important nutrient for dairy cows. Increases in water intake, especially during heat stress, can have a positive effect on the decrease in body temperature as well as an increase in milk production (West, 2003). Cardozo et al. (2006) observed a 25% increase in water intake when capsicum was added to the diet. This increase in water intake could play a positive role in reducing the effect of heat stress on dairy cows.

Saliva production

Dairy cows produce on average between 166 and 253 g saliva per minute (Beauchemin et al., 2003). Saliva production during eating is higher compare to resting salivation rate (Cassida and Stokes, 1986). As reported by Rodriguez-Prado et al. (2012) and others, capsicum increase DMI, and therefore increase time spend eating. Increase in time spent eating could therefore lead to an increase in salivation. This was observed by Rodriguez-Prado et al. (2006; unpublished) when capsicum was added to the diet. Saliva production was especially increased during the first half of the feed intake period. Saliva secretion plays the biggest role in rumen pH buffering and plays a significant role in reduce the incidence of rumen acidosis (Beauchemin et al., 2008). Cows are panting during heat stress and a significant amount of saliva is lost through open mouth panting (West 2003). By increasing the saliva production, a smaller percentage of produced saliva is therefore lost through panting and more to be utilized for buffering the rumen.

Oxidative stress

Oxidative stress resulting from increased production of free radicals and reactive oxygen species, and/or a decrease in antioxidant defence, leads to damage of molecules and disruption of normal metabolism and physiology (Trevisan et al., 2001). When reactive forms of oxygen are produced faster than they can be safely neutralized by antioxidant mechanisms, oxidative stress results (Sies, 1991). Harmon et al. (1997) reported a reduction of antioxidant activity of plasma and therefore an increase in oxidative stress in mid-lactating heat-stressed dairy cows. Bernabucci et al., 2002, also observed an increase in oxidative stress in transition cows experience heat stress during the summer months.

The Heterophil : Lymphocyte ratio has been proved to be a reliable indicator of oxidative stress and heat stress in animals (Davis et al., 2008). The Heterophil : Lymphocyte ratio are increased when animals experience heat stress. Capsicum proved to have a positive effect on oxidative stress by decreasing the Heterophil : Lymphocyte ratio (Prieto and Campo, 2010). In this way, the oxidative injury induced by high ambient temperatures (Lin et al., 2006) could be reduced by the actions of antioxidants, like Capsicum.

Volatile fatty acids and ammonia production

As mentioned earlier in the document, cows can experience a negative energy balance during heat stress. This is mainly due to the decrease in feed intake coupled with an increase in energy maintenance requirements (Fox and Tylutki, 1998). In addition, heat stress decreased total rumen VFA content (Schneider et al., 1988) and specifically propionate levels (Kelley at al, 1966). This finding is supported by Rhoads et al, 2009, who reported a decline in glucose concentrations during heat stress.

Cows generally experience a negative energy balance during early lactation and to counter act it, they mobilize body fat reserves, producing non-esterified fatty acids (NEFA) as energy source. However, Shwartz et al, 2009, reported that cows experience heat stress does not display the typical NEFA production. It appears that heat stress affects cellular physiology and systemic metabolism. Febbraio, 2001, reported that animals experience heat stress, rather prefer glucose, with propionate as precursor (Van Soest, 1982), as energy source instead of NEFA. This could be due to the fact that the ß-oxidation of NEFA may produce more metabolic heat that of carbohydrates (Baumgard and Rhoads, 2007).

Cardozo et al., 2006, added eugenol and cinnamaldehyde to a high concentrate diet and reported in increase in propionate and a decrease in acetate production in an *in vivo* trial. This could be positive for heat stress cows, as propionate can be used to produce more glucose (preferred energy source during heat stress), and less acetate (lower energy utilization efficiency for use of acetate compare to propionic acid ; Moe, 1981). Busquet et al, 2006, also observed an increase in propionate and decrease in acetate proportions when eugenol was added to the diet. Cardozo et et., 2005, also observed an increase in total VFA, decrease in acetate, increase in propionate when capsicum or cinnamaldehyde were added to the diet. Calsamiglia, 2009, added XTRACT® 7065 to diets fed to goats carrying twins during the transition period (used as a cow model) and observed a reduction in NEFA and beta-hydroxybutyrate in the blood. This helped with a reduction in body condition loss. Therefore, by increasing propionic acid production in the rumen, using eugenol, cinnamaldehyde and capsicum, could play a role in improving the energy balance of dairy cows during heat stress by providing more glucose precursors, i.e. propionate

Cows experience heat stress could display an increase in plasma urea nitrogen (PUN) (Wheelock et al., 2010). This could be due to inefficient rumen ammonia incorporation into microbial protein, or hepatic deamination of amino acids from skeletal muscle. Cardozo et al, 2005, observed a decrease in ammonia N concentration in the rumen with the addition of capsicum to the diet. Cardozo et al, 2006, also observed a decrease in ammonia N concentrations in the rumen when eugenol and cinnamaldehyde was added to the diet. Therefore, by decreasing the ammonia N concentrations, there could a possibility to decrease PUN in cows experience heat stress, and therefore, improve protein metabolism.

Commercial dairy trials, evaluating XTRACT® 7065 under heat stress conditions.

In the light of the results obtained by various researchers regarding the effect of capsicum, eugenol and cinnamaldehyde on animal production, commercial research trials were conducted at the same dairy farm to determine if XTRACT® 7065 could have a positive effect on the production of dairy cows during heat stress.

In the first trial (Pancosma TB 711) 92 high producing multiparous Holstein cows were randomly allocated to either Control (CON) or XTRACT® 7065 treatment (XT). XT cow group were supplemented with 1 gram XTRACT® 7065 per head per day. The trial was conducted during the summer in Israel for a period of 5 month (June to October). Cows were fed a concentrate diet (38.5% NDF, 60.3% DM and 15.1% CP). Days in milk for the both groups of cows were on average 190 days. Normal production parameters were measured during the trial.

The effect of XTRACT® 7065 compared to Control are reported in Table 1.

Table 1. The effect of XTRACT® 7065 compared to Control on the production parameters of Holstein dairy cows experience heat stress (June to October).

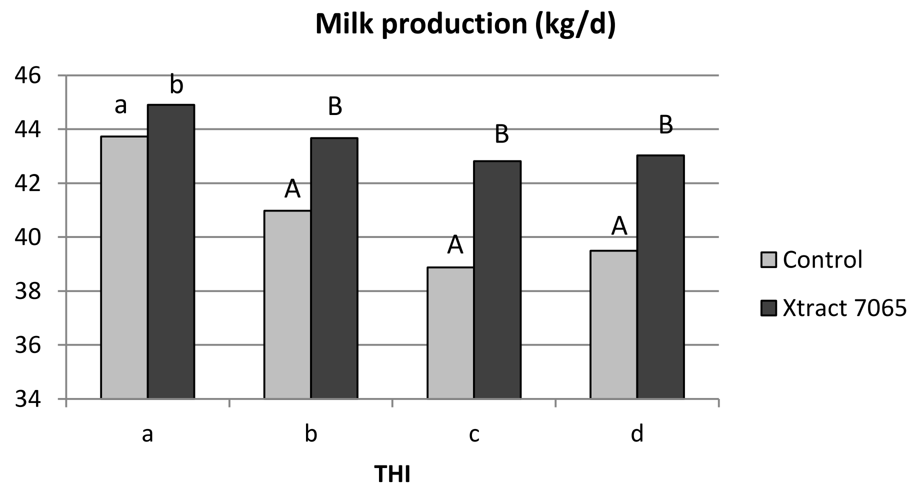
Parameter	Control	XTRACT® 7065
Milk (kg)	40.77[a]	43.60[b]
Body condition score	2.77[a]	2.92[b]
Milk Fat (%)	3.45	3.41
Milk Protein (%)	3.09	3.09
Fat Yield (g/kg)	1.34[a]	1.46[b]
Protein Yield (g/kg)	1.20[a]	1.33[b]
DM Intake (kg/d)	25.4[a]	26.2[b]
Feed efficiency (g/g)	1.60[a]	1.67[b]

Rows with different super script differ by P < 0.05

From the results reported in Table 1, is it clear that XTRACT® 7065 has a positive effect on animal performance. Milk production was increased by 6.9%, DMI improved by 3.1% and Feed efficiency by 4.4 %. Body condition score was significantly increase by XTRACT® 7065. This results also indicates that cows during heat stress minimizes body fat reserves mobilization as energy source, as indicated by the increase in body condition score in the XTRACT® 7065 group. There was no effect on milk fat or milk protein percentage.

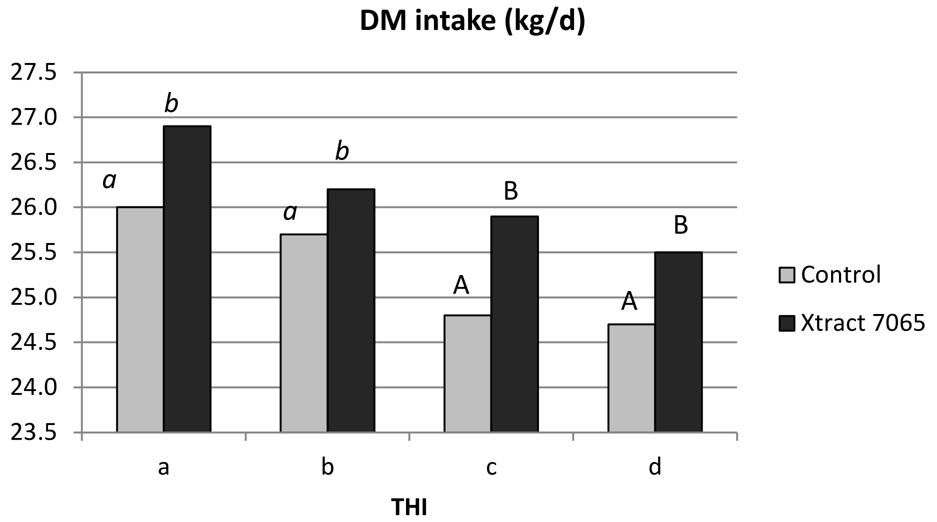
The same trial data were re-evaluated by allocating the results to differ THI classes (Fig 2 – 4). THI classes: Class a = medium heat stress, Class d = severe heat stress. The THI class significantly affected milk production, DM intake and feed efficiency. The increase of the level of heat stress (via an increase in THI class) reduced milk production, dry matter intake and feed efficiency. However, the effect of XTRACT® 7065 on milk production, DM intake and feed efficiency was increasing when level of heat stress increased. XTRACT® 7065 increased milk production by 2.68% in class A of THI (*P* = 0.027 – graph 1), by 6.56% in class B (*P* < 0.001), by 10.11% in class C (P < 0.001) and by 8.96% in class D (P < 0.001). Un-supplemented cows exhibited a reduced feed efficiency when heat stress was increasing. At the opposite, cows fed XTRACT® 7065 maintained their feed efficiency whatever the level of heat stress.

Fig 2. The effect of XTRACT® 7065 on milk production during different THI classes.



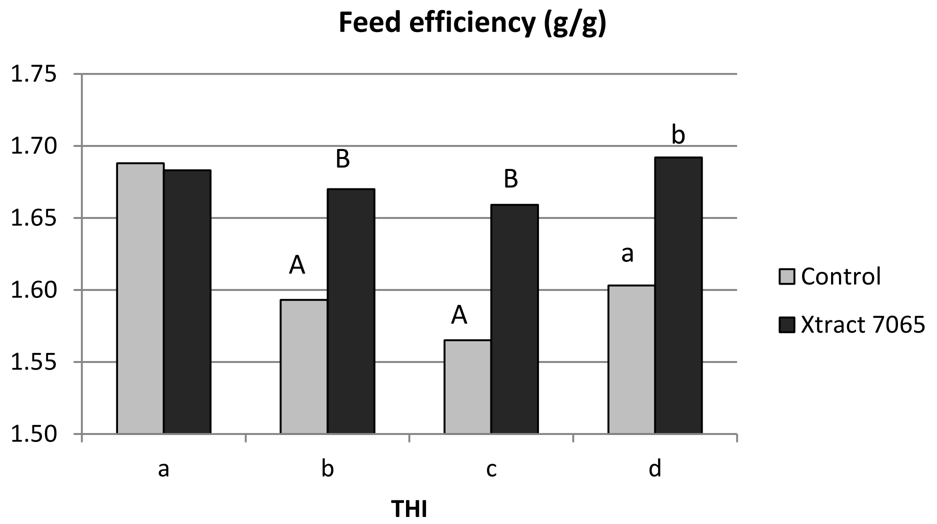
a, b = P < 0.05 ; A, B = P < 0.01

Fig 3. The effect of XTRACT® 7065 on DM intake during different THI classes.



a, b = P < 0.1 ; A, B = P < 0.01

Fig 4. The effect of XTRACT® 7065 on Feed efficiency during different THI classes.



a, b = P < 0.05 ; A, B = P < 0.01

In the second trial (Pancosma TB 725), 140 Holstein dairy cows (± 120 DIM, ± 3.3 lactations) were randomly allocated to either Control (CON) or XTRACT® 7065 treatment (XT). XT cow group was supplemented with 1 gram XTRACT® 7065 per head per day. The trial was conducted during the summer in Israel, from June to September. The average THI during this trial was 80.1 (THI of above 72 can be considered as heat stress for dairy cows). Different performance parameters were measured during the trial period (Table 2)

Table 2. The effect of XTRACT® 7065 compared to Control on the production parameters of Holstein dairy cows experience heat stress (June to September).

Parameter	Control	XTRACT® 7065	P-Value
Milk (kg)	36.9	38.6	0.001
DMI (kg)	19.9	18.8	0.11
Fat (%)	3.5	3.4	0.20
Protein (%)	3.2	3.1	< 0.001
Lactose (%)	4.8	4.7	0.07
ECM (kg/d)	36.8	38.1	0.01
SCC (x 1000 cells/ml)	342.5	222.5	0.001
BCS	3.0	2.9	0.20
FCR	1.85	2.05	*

From the results reported in Table 2, is it clear that XTRACT® 7065 has a positive effect on animal performance. Milk production was increased by 4.6%, but DMI was not significantly affected by XTRACT® 7065. Milk protein percentage was significantly decreased by XTRACT® 7065. ECM (energy corrected milk) and SCC (somatic cell count) were significantly improved by XTRACT® 7065 treatment. Although not statistically analysed, FCR was improved by 10.8%.

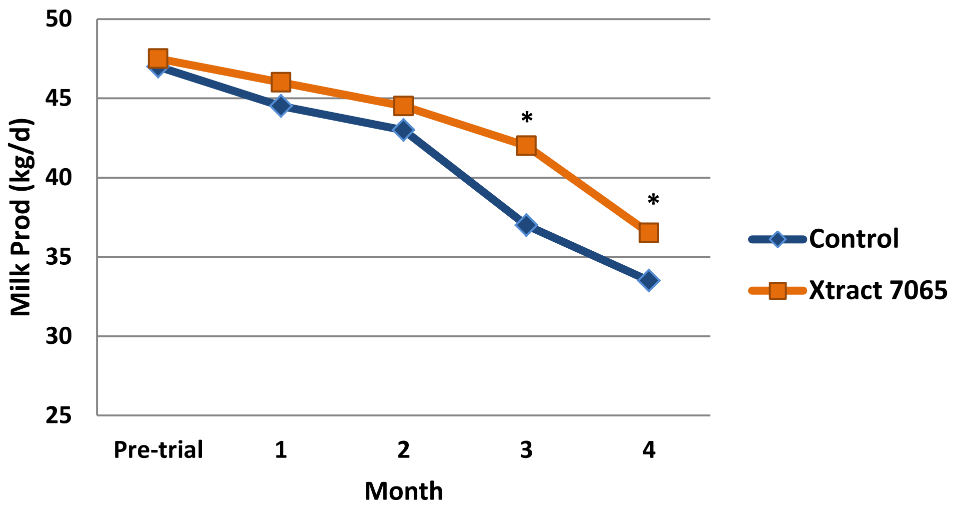
Data of both trials (Blanck et al, 2014) were also analysed together (Table 3; Fig 5).

Table 3. The effect of XTRACT® 7065 compared to Control on the production parameters of Holstein dairy cows experience heat stress (Trial 1 and 2 combined, June to September).

Parameter	Control	XTRACT® 7065	P-Value
Milk (kg)	39.4	42.2	0.01
DMI (kg)	22.6	22.5	0.70
Fat (%)	3.45	3.46	0.90
Protein (%)	3.17	3.14	0.30
ECM (kg/d)	40.1	42.2	0.01
SCC (x 1000 cells/ml)	306.1	242.3	0.03
FCR	1.74	1.89	< 0.001
BCS	2.8	2.9	0.20

The results in Table 3 give a clear indication of the effect of XTRACT® 7065 on animal performance. Milk production (7.1%), ECM (5.2%), SCC (20.8%) and FCR (8.6%) were significantly improved. In Fig 5 one sees the effect of heat stress in correlation with the addition of XTRACT® 7065 to milk production. Milk production drop in both the Control and XTRACT® 7065 treatment, but as time progress, drop in milk production was less severe when cows were fed XTRACT® 7065.

Fig 5. The effect of XTRACT® 7065 compared to Control on milk production over time of Holstein dairy cows experience heat stress (Trial 1 and 2 combined).



* P < 0.05

Conclusion

It can be concluded that plant extracts, especially XTRACT® 7065 can have a positive effect on production in cows experience heat stress.

Reference

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