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Effects of Yeast Culture Additives on Growth Performance, Blood Metabolites and Puberty Age of Cows' Heifers

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ABSTRACT

The investigation aimed to assess the impact of yeast culture (YC) additives on growth performance, blood components, and puberty in cows' heifers. The study involved fifteen cows, heifers six months old, with average body weight 141.84 ± 2.55 kg, divided into three equal groups, with five heifers for each. The control group (C) received basal diet without any additives; while the other two groups (T1 and T2) received basal diet supplemented with 10 g and 20 g of YC per heifer daily, respectively. The experiment took place over 7 months, from July 2023 to January 2024. Throughout this period, changes in body weight were monitored, and blood samples were collected monthly. The findings indicated that the inclusion of YC in the diets led to a significant increase ($P < 0.01$) in total gain (TG), average daily gain (ADG), body weight changes percentage (BWC%), and a noteworthy improvement in feed conversion ratio (FCR). Moreover, there was a notable rise ($P<0.01$) in certain blood metabolic parameters; total protein, globulin, and trace elements (iron and zinc) in the yeast groups as compared to the control group. Additionally, the yeast groups exhibited a substantial increase ($P<0.01$) in the levels of estrogen and progesterone hormones. Consequently, it can be inferred that the addition of yeast culture enhances the growth performance, blood metabolites in cows' heifers, and could potentially have a positive effect on the early onset of puberty.

KEYWORDS: Yeast Culture, Growth Performance, Blood Metabolites, Puberty, Cows' Heifers.

1. INTRODUCTION

In Egypt, cows play a crucial role in meeting dietary requirements and providing essential nutrients (Shoukry, 2021; Ashour and Abdel-Rahman, 2022). The inclusion of yeast additives in livestock feed has been demonstrated to support the growth and welfare of juvenile cattle, ultimately leading to improved calf performance. (Amin & Mao, 2021; Mahasneh et al., 2023).

The onset of sexual puberty in bovine heifers usually occurs between 9 and 15 months, with some variation (Estill, 2021; Steele et al., 2023). Research has demonstrated that adding

yeast to the diet of ruminants can lead to increased feed consumption, growth rate, milk yield, and milk fat (Baijan et al., 2021). Furthermore, adding the diet with yeast has been found to improve growth performance, digestibility, rumen fermentation, and reduce methane production in animals (Phesatch et al., 2021). Additionally, the use of yeast can compete with toxins produced by pathogenic bacteria, thereby promoting animal growth (Broadway et al., 2015).

Probiotics have been shown to have a positive impact on the microbial community in both the rumen and intestines, serving as a potential alternative to antibiotics (El-Beltagy et al., 2013 ; Jia et al., 2018; Nayel et al., 2019). Furthermore, dry yeast can act as a cost-effective alternative to high-priced protein sources and enhance nutrient digestion (Lima et al., 2011; Sharif et al., 2018 Kewan et al., 2021; Ali et al., 2023). Anjum et al. (2018) discovered that including yeast in the diet of Holstein cows led to reduced BUN levels, increased blood glucose, improved protein utilization, and higher levels of cellulolytic bacteria. Conversely, Cherdthong et al. (2019) did not observe any impact on BUN levels in beef cattle when yeast was incorporated into their diet.

Probiotic additives was shown to enhance weight gain and hematological and serum blood constituents, as detailed by Farzana et al., 2021. Furthermore, the inclusion of yeast culture additives to calf feed increased body weight, as noted by Anand Laxmi et al. (2012). Single-cell protein has also been found to improve growth, rumen development, and immune competence in calves, according to Zhang et al. (2022).

For cows, heifers, achieving adequate growth speed to reach puberty and have successful yearling calving is essential. Utilizing yeast culture additives plays a critical role in preserving rumen health. The significance of yeast culture additives for rumen health cannot be overstated. There is still a lack of complete understanding regarding the impact of yeast culture additives on puberty. Consequently, this research aims to investigate the influence of yeast culture additives on growth performance, blood parameters, and onset of puberty in growing cows, heifers, with the intention of offering beneficial knowledge to ranchers for achieving enhanced growth rates and earlier puberty in cows, heifers.

2. MATERIALS AND METHODS

2.1.Study location

The current study took place at a privately owned cattle farm situated in the city of Al-Fashn, in the Beni Suef Governorate of Egypt. This area is classified as a semi-arid region geographically. All experimental procedures for Animal Experiments were approved by the Local Ethics Committee.

2.2.Animals and feeding Management

Commercial yeast culture (YC) products (BGY-35, Manufactured by F. L. Emert., Co. USA) were used. The yeast culture product used was evaluated, and live cells of *Saccharomyces cerevisiae* were counted according to the method of the American Society of Brewing Chemists (1988). Viable yeast cell concentration was 2.35 × 1011 CFU/g yeast product. A total of fifteen cross-breeding (Friesian & Balady) cows' heifers, were found to be in good health following a comprehensive clinical assessment. These animals, at six months of age (born in January), weighed an average of 141.84 ± 2.52 kg. They were then randomly distributed into three experimental groups, each consisting of five heifers. The first group served as the control and was given a basal diet without any additives. The second group (T1) received the basal diet supplemented with 10 g YC/ heifer /day, while the third group (T2) received the basal diet supplemented with 20 g YC/heifer/day. Clean, fresh water was available all times throughout the duration of the experiment, which took place from July 2023 to the end of January 2024, following a one-month adaptation period.

The animals were provided with two meals per day at 08:00 and 14:00 hours, consisting of a combination of Berseem hay and concentrate feed mixture at 40:60% roughage concentrate ratio to fulfill their dietary requirements over the course of a seven-month experimental period, as outlined by NRC (2001). The concentrate feed mixture was formulated as follows: yellow corn 50%, soy bean meal 10% cotton seed meal 15.0%,

wheat bran 22.0%, limestone 1.6%, common salt 1.0%, mineral and vitamin mixture 0.4%. The chemical compositions of the feed ingredients were analyzed in accordance with AOAC (2000) guidelines. Additionally, a portion of the ground concentrate feed mixture was supplemented with Yeast culture (YC). The chemical composition of both the standard rations and the YC additives can be found in Tables 1 and 2, respectively.

Table 1. Chemical composition (%) of experimental feeds on DM (%, Basis).

Ingredients	DM	OM	CP	EE	CF	NFE	Ash
Berseem hay	85.1	88.94	12.21	1.17	28.53	47.03	11.05
Concentrate feed mixture	91.42	89.67	13.60	2.53	15.66	57.88	10.29
Yeast culture	91.66	97.72	37.83	4.51	8.44	46.94	2.28

DM; dry matter, OM; organic matter, CP; crude protein, CF; crude fiber, EE; ether extract, NFE: Nitrogen free extract

Table 2. Contents of YC (BGY-35, Manufactured by F. L. Emert., Co. USA), as fed

Vitamin, TDN & NEM		Amino acid		Mineral	
Biotin	2.55 mg/kg	**Hist.**	0.86 %	**Ca**	0.23 %
Folic-acid	7.70 mg/kg	**Arg.**	1.85 %	**P**	0.61 %
Niacin	245.40 mg/kg	**Cyst.**	0.55 %	**Na**	0.16%
Cholin	3412.0 mg/kg	**Isoleuc.**	1.44 %	**K**	0.21%
Pantothenic acid	59.10 mg/kg	**Leuc.**	3.44 %	**Mg**	0.21%
Riboflavin	18.15 mg/kg	**Lys.**	1.62 %	**Mn**	21.29 ppm
Thiemine	46.30 mg/kg	**Phenyl.**	2.01 %	**Fe**	184.06 ppm
Pyridoxine	22.10 mg/kg	**Threon.**	1.35 %	**Cu**	4.99 ppm
E	36.70 IU/kg	**Trypt.**	0.36 %	**Zn**	74.90 ppm
TDN	71.00 %	**Meth.**	0.60 %	**Se**	1.01 ppm
NEM	1.70 mcal/kg	**Val.**	2.05%		

2.3.Climatic conditions

The predominant weather in the area is characterized by extended periods of warm temperatures during summer, brief periods of cooler temperatures in winter, minimal precipitation, and high rates of evaporation. Data on the climatic conditions in the city of Al-Fashn, Beni-Suef Governorate are obtained from the central agricultural laboratory.

Throughout the duration of the experiment, a hygro-thermometer was utilized to consistently record the average air temperature ($AT^{O}C$) and relative humidity (RH %). Subsequently, the temperature-humidity index (THI) was determined using the equation developed by Mader *et al.* (2006).

$$THI = 0.8 \times AT + [(RH\ \%/\ 100) \times (AT - 14.4)] + 46.4$$

Figure (1) depicts the environmental conditions both inside and surrounding the heifer enclosures for both the control and treatment groups during the experimental period.

2.4.Experimental procedures

The experiment involved periodic weighing of all cows, heifers to measure their growth. This was done in the morning before feeding, with weights rounded to the nearest 10 grams. The changes in body weight was calculated by subtracting the initial weight from the final weight, and the average daily gain was determined by dividing the difference in weights by the trial period. Additionally, measurements were taken for average daily dry matter intake and feed conversion ratio. Blood samples were collected monthly after the heifers had been fed and given water. Approximately 10 ml of blood was drawn from the jugular vein and stored at -20°C until analysis. The plasma was then analyzed for total protein, albumin, iron, and zinc. The total globulin was calculated by subtracting the albumin value from the total protein value.

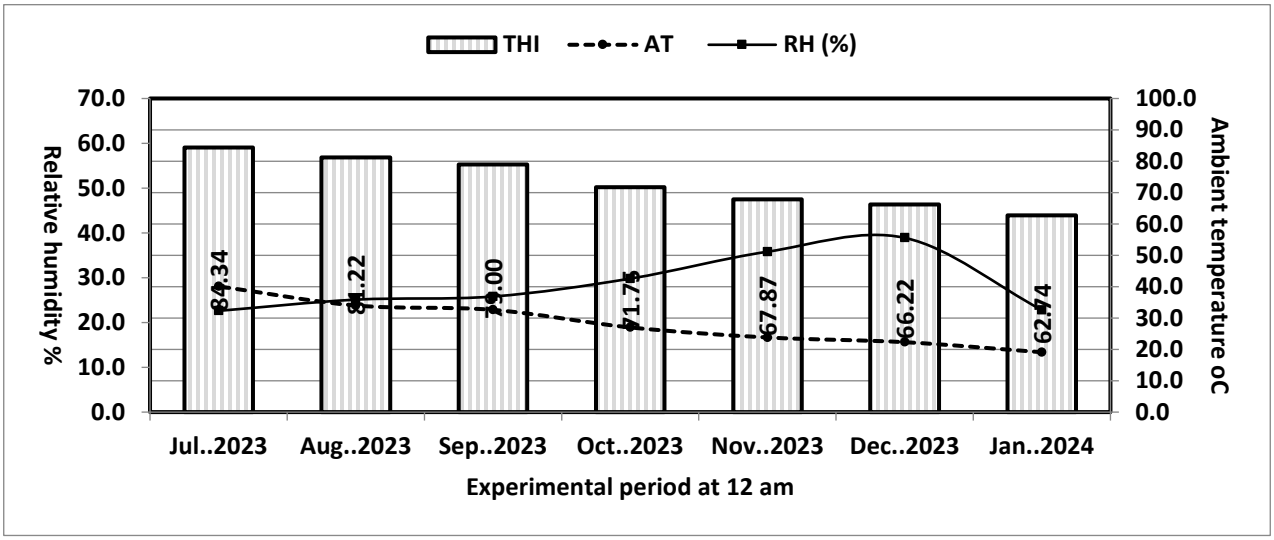

Figure 1. Graphical representation of the ambient temperature (°C), temperature humidity index (THI) (expressed in °C), and relative humidity (%), recorded during the days when blood samples are drawn at noon.

Finally, the plasma total estradiol and total progesterone levels were determined using an ELISA system.

2.5.Statistical Analysis

The statistical analysis was conducted using General Linear Model (GLM) procedures in SAS (2004) through simple one way analysis of variance repeated measurements. Duncan's New Multiple Range Test (Duncan, 1955) was used to distinguish differences among treatment means.

The mathematical model used was: $Yij = \mu + Ti + eij$

In this model, Yij represents the parameter being analyzed, μ: is the overall mean; Ti is the treatment effect, and eij is the experimental error.

3. RESULTS AND DISCUSSION

3.1.Growth parameters

The findings presented in Table (3) unambiguously demonstrate that the addition of yeast culture to the diet had a statistically significant ($P < 0.01$) positive impact on the growth performance of cows, heifers. The results suggested that incorporating yeast into the diets of developing heifers led to an increase in the total weight gain (TG) by 8.96 and 16.96%, average daily gain (ADG) by 8.96 and 16.96%, percentage body weight change (BWC %) by 11.12 and 15.71%, average daily dry matter intake (ADI) by 2.01 and 6.21%, which was reflected in a significant improvement in the feed conversion ratio (FCR), which decreased by 6.42% and 9.14% for the groups to which yeast culture was added at a rate of 10 and 20 grams, respectively, compared to control group.

The results were in line with a study by Fiems (1993) that indicated including Saccharomyces cerevisiae in the diet led to a 9.5% rise in calf body weight gain and a 7.8% increase in weight gain for adult cows. Ghazanfar et al. (2015) as well as Farzana et al. (2021) noted increased growth rates in developing dairy heifers who were provided with a probiotic incorporating Saccharomyces cerevisiae. Furthermore, Krehbiel et al. (2003) discovered that the group receiving supplements exhibited notably greater ($P < 0.05$) total gain, average daily gain, and feed conversion efficiency.

The study found that feed conversion ratio (FCR) varied between treatments and was better in animals treated with yeast culture. This improvement is believed to be due to yeast promoting growth and establishing a healthy gut microbiota, which affects nutrient digestion and energy metabolism. Yeast's probiotic effect also improves growth performance by increasing

Table 3. Impact of adding yeast culture on the growth performance of calves during the experimental period.

Items	Experimental Treatment			± Standard error
	Control (0 gm YC)	T1 (10 gm YC)	T2 (20 gm YC)	
Initial Body weight, Kg	141.58	140.80	143.16	2.55^{NS}
Final Body weight, Kg	242.64^{B}	250.90^{B}	261.38^{A}	3.34^{**}
Total Gain, Kg	101.06^{C}	110.12^{B}	118.20^{A}	1.12^{**}
Average Daily Gain, gm	481.20^{C}	524.30^{B}	562.92^{A}	6.25^{**}
Percentage of body weight change, %	71.40^{C}	79.34^{B}	82.62^{A}	1.19^{**}
Average daily dry matter intake, kg	5.47^{B}	5.58^{B}	5.81^{A}	0.8^{*}
Feed conversion ratio	11.37^{A}	10.64^{B}	10.33^{B}	0.11^{**}

Experimental period: 210 days

Values with distinct letters in the same row, such as A, B, and C, exhibit significant differences (P< 0.05).

NS: non-significant, *: (P<0.05); **: (P<0.01).

energy and essential nutrient availability (Zhang et al., 2022; Elghandour et al., 2024).

Zhang et al. (2020) and Salah et al. (2024) attributed improved feed conversion rate in cows, heifers to yeast culture. Yeast culture may reduce pH in the cecum and colon, improving fermentation pattern. Erasmus et al. (1992) found probiotics might increase cellulolytic activity, leading to improved fiber degradation and increased amino acid supply post-ruminally. Additionally, animals fed with probiotics may experience better body weight gain due to increased feed intake and efficient feed utilization, as suggested by Antunović et al. (2005).

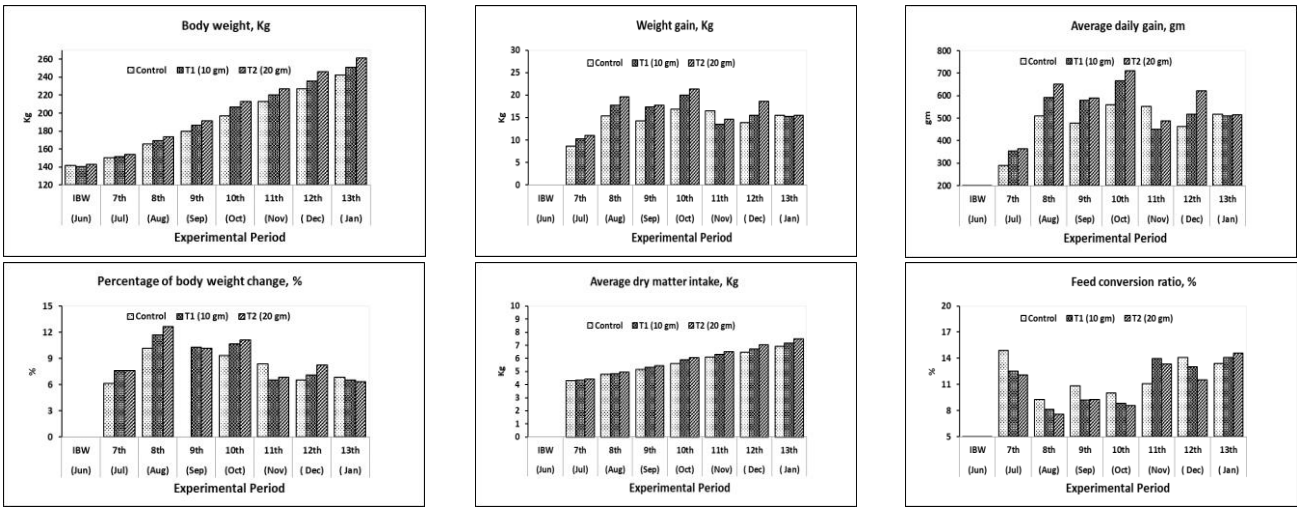

Figure 2. Effect of yeast culture additives on growth performance in cows, heifers during experimental months.

These results shown in Figure (2) demonstrate that the fluctuations in the weights of growing cows, heifers varied in all groups, whether the control group or the two yeast supplementation groups, during the study period. It is worth noting that the lowest values for total gain, average daily gain, percentage of body weight change, and daily dry matter intake were recorded in July. This is consistent with the marked rise in temperatures, which led to a decrease in thyroid hormone secretion, and thus a decrease in metabolic efficiency (Perdomo et al., 2020). In addition, as the heifers matured, an increase in body weight was observed, as shown

by the feed conversion ratio in all experimental groups.

3.2.Biochemical Measurements

Protein parameters:

The results of this research study, as depicted in Table (4) and figure (3), demonstrated a noteworthy increase in the concentrations of total protein and its components such as albumin and globulin, particularly with the addition of 20 grams of yeast per day in the diets of cows, heifers. The additional use of yeast culture at various levels (10 and 20 grams per day) positively impacted the nutritional content of heifers' diets, consistent with findings from Amin & Mao (2021) and Jach et al. (2022). The increase in albumin levels due to the addition of yeast culture to the diet has the potential to improve the general well-being and productivity of the animals (Pang et al., 2022). Serum globulins encompass a diverse array of proteins with varied functions, known for their role in immunity, coagulation, and the prevention of bleeding (Shah et al., 2024).

Table 4. Impact of adding yeast culture on blood protein parameters of cows, heifers.

Items	Experimental Treatment			± Standard error
	Control (0 gm YC)	T1 (10 gm YC)	T2 (20 gm YC)	
Total proteins (g/l)	5.76^{B}	5.78^{B}	6.07^{A}	0.08 **
Albumin (g/l)	3.35^{A}	3.14^{B}	3.36^{A}	0.06 **
Globulin (g/l)	2.40^{B}	2.64^{A}	2.71^{A}	0.05 **
AL/GL ratio	1.44^{A}	1.21^{B}	1.24^{B}	0.04 **

Values with distinct letters in the same row, such as A and B exhibit significant differences (P< 0.01).
*: P< 0.05; **: P< 0.01.

Fluctuations in serum globulin levels may arise in heifers due to factors such as high temperatures (as illustrated in Figure 3, which outlines discrepancies in globulin levels between warm and cold seasons), stress, inadequate protein intake, liver or kidney conditions, or immunodeficiency. The elevation in serum globulin levels observed in this current investigation among yeast-fed heifer suggests an improvement in their immune response (Gauly & Ammer, 2020; Wang et al., 2020).

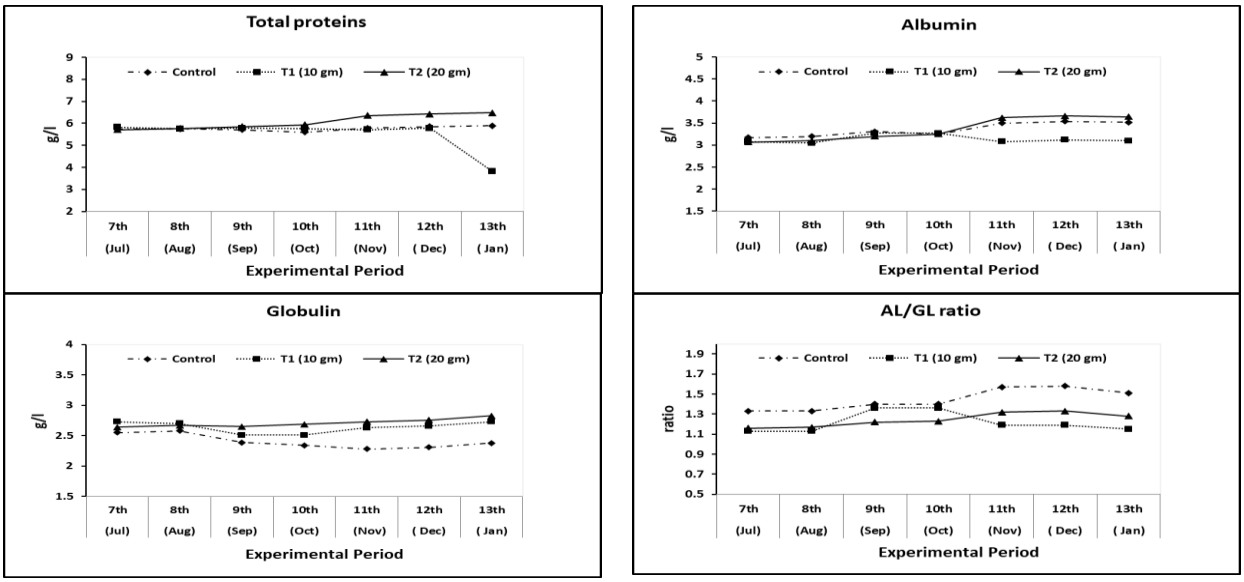

Figure 3. Effect of yeast culture additives on blood proteins parameters in cows, heifers during the experimental months.

Plasma minerals:

The levels of zinc and iron (Table 5) recorded during the experimental period demonstrated a notable rise in the calf groups that were administered either 10 or 20 g of yeast culture, in comparison to the control group. Specifically, the iron levels saw an increase of 11.39% and 10.20%, while the zinc levels increased by 3.85% and 2.81% for T1 and T2, respectively.

The significant increase (P<0.01) in zinc and selenium levels in cows, heifers given varying amounts of yeast culture is of great importance. Minerals play an essential role in the biological and physiological processes of the body and significantly impact the development of cows, heifers in meeting the needs of different body systems (Zhang et al., 2020; Arshad et al., 2021; Shareef et al., 2021; Jamali et al., 2022; Alwardy et al., 2023; Li et al., 2023). Zinc, an essential micronutrient, is integral to the metabolism of carbohydrates, lipids, proteins, and nucleic acids. It also influences various metabolic processes, such as bone development, maintenance, repair, and immune response. Furthermore, zinc serves as a coenzyme for multiple antioxidant enzymes and supports immune system function (Wessels et al., 2021; Kanwar & Sharma, 2022; Pandey et al., 2023).

Table 5. Effect of yeast culture additives on plasma minerals in growing cows, heifers

Items	Experimental Treatment			± Standard error
	Control (0 gm YC)	T1 (10 gm YC)	T2 (20 gm YC)	
Iron, µg/dl	215.56^{B}	240.09^{A}	237.56^{A}	8.63 *
Zinc, µg/dl	158.07^{B}	164.16^{A}	162.51^{A}	1.09 **

Values with distinct letters in the same row, such as A and B exhibit significant differences (P< 0.05).
*: (P<0.05); **: (P<0.01).

Figure (4) depicted a remarkably steady and unwavering upsurge in the concentration of iron and zinc in the plasma of the maturing heifers as they progressed in age in both the 10 and 20 g yeast groups, in stark opposition to the control group. This gradual and notable ascendancy in the presence of these crucial elements aptly implies a resoundingly optimistic correlation between the advancing age of the heifers and the commendable accumulation of iron and zinc within their system (Qu et al., 2020; Piacenza et al., 2021).

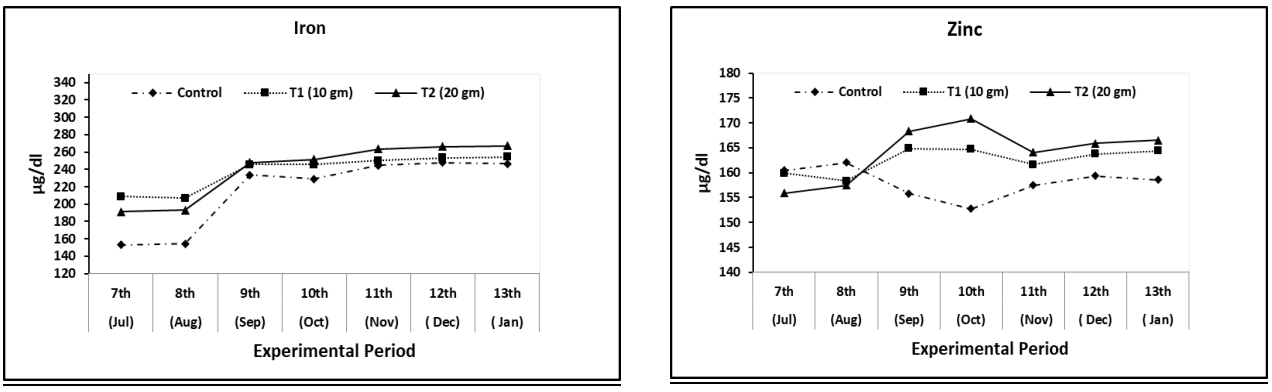

Figure 4. Effect of yeast culture additives on plasma minerals in growing cows, heifers during experimental months.

3.3.Estradiol and progesterone hormones:

Estradiol and progesterone, the primary sex hormones, are essential for the development of crossbred cow heifers and are critical in determining the onset of puberty and reproductive potential in the animals (Sueapheng &

Sorachakula, 2021; Shaarawy et al., 2024; Shemesh & Shore, 1994).

Our ongoing research focuses on the effect of adding different levels of yeast culture to the diets of growing cows, heifers on hormonal fluctuations and their impact on the onset of puberty.

Data from our research (Table 6) showed that supplementing the diet of heifers with yeast culture can increase the body's hormone levels by stimulating the production of estrogen, which may lead to early puberty (Kitilit, 2022). The addition of 20 g of yeast per day significantly impacted the elevation of estrogen and progesterone levels. Hormones act as messengers and chemical regulators of bodily functions such as growth, tissue development, and cell metabolism. It is clear that the positive effects are associated with the presence of live yeast supplements, which leads to early maturation. As a result, it can be concluded that the maturation of the cow is directly related to estrogen, which is a major reproductive hormone (Kelly et al., 2020; Evans et al., 2022; Wu et al., 2022).

Table 6. Effect of yeast culture additives on estradiol and progesterone hormones in growing cows, heifers

Items	Experimental Treatment			± Standard error
	Control (0 gm YC)	T1 (10 gm YC)	T2 (20 gm YC)	
Estradiol, pg/ml	14.32^{B}	15.80^{AB}	17.71^{A}	0.89 *
Progesterone, ng/ml	0.53^{B}	0.98^{AB}	1.35^{A}	0.19 **

Values with distinct letters in the same row, such as A and B exhibit significant differences (P< 0.05).
*: (P<0.05); **: (P<0.01).

The results (shown in Figure 5) demonstrated a significant. increase in the levels of estradiol and progesterone in growing cows, heifers that were given a daily diet supplemented with 20 grams of yeast culture. The figure also depicts a rise in estradiol levels for group T2 at 11th month of age, followed by group T1 at 12th month and finally the control group at 13th month. This pattern suggests that group T2 reached early puberty first, followed by T1, and then the control group. These levels also corresponded to the levels of progesterone associated with puberty and the rupture of Graafian follicles. The study findings were consistent with those of Shareef et al. (2021) on goats, Getabalew et al. (2020) on beef cattle, and Garcia (2021) on pigs.

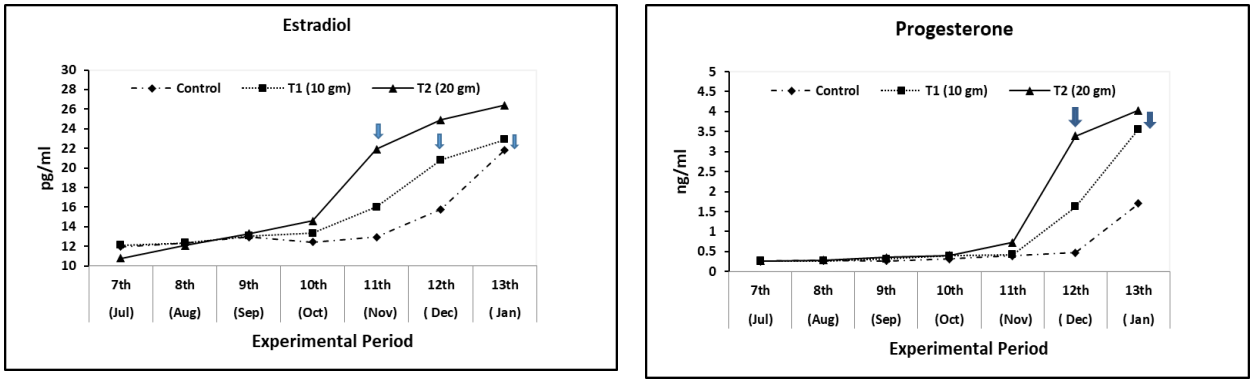

Figure 5. Effect of yeast culture additives on estradiol and progesterone hormones in growing cows, heifers during experimental months.

4. GONCLUSION

In conclusion, adding yeast culture to the diet of cow, heifers resulted in enhanced growth performance. Additionally, including yeast culture in their diet also had positive effects on their blood constituents. Therefore, incorporating yeast as a supplement could be

advantageous for promoting growth and overall health in developing heifers. Our study also indicates that introducing yeast culture to the diet of cow, heifers has a positive impact on the age at which they reach puberty. However, our study also found that 10 g of yeast culture may not be effective in improving the efficiency of commercial feed.

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Author's contributions

Each of the referenced authors played a significant role in the conceptualization, analysis, and interpretation of data, as well as in drafting the paper. They all conducted a thorough review of the content and provided approval for the final version to be submitted for publication.

Conflicts of interest

The authors affirm that no conflicts of interest exist.

Ethical Approval

This research was carried out in accordance with the regulations for the treatment and handling of laboratory animals established by Beni-Suef University (BSU-IACUC). Approval was granted under number (***-***).

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الملخص العربي

تأثير إضافة الخميرة على أداء النمو وبعض مكونات الدم وعمر البلوغ الجنسي في عجلات الأبقار

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هدفت هذه الدراسة إلى تقييم تأثير إضافة الخميرة خلال مرحلة النمو على أداء النمو ومكونات الجسم وعمر البلوغ الجنسي في عجلات الأبقار. أجريت التجربة الحالية في مزرعة أبقار خاصة تقع في مدينة الفشن، محافظة بني سويف، مصر. اشتملت التجربة على خمسة عشر عجلة خليطة عمرها ستة أشهر بأوزان ١٤١.٨٤ ± ٢.٥٥ كجم، مقسمة إلى ثلاث مجموعات متساوية (خمسة عجلات لكل مجموعة). ولم تتلق المجموعة الضابطة (C) أي إضافات، بينما أعطيت المجموعتان الأخريان T1) و 10 (T2 جم و٢٠ جم من الخميرة لكل عجلة يوميًا على التوالي. وامتدت التجربة على مدى ٧ أشهر من يوليو ٢٠٢٣ إلى نهاية يناير ٢٠٢٤، وتم رصد التغيرات في وزن الجسم الحي، وجمع عينات الدم وتحليلها على فترات شهرية. وأشارت النتائج إلى أن اضافة الخميرة في غذاء العجلات أدى إلى زيادة معنوية ($P<0.01$) في الزيادة الكلية في وزن الجسم (TG) ومتوسط الزيادة اليومية (ADG) ونسبة التغير في وزن الجسم BWC) (%وتحسين الكفاءة الغذائية التحويلية .(FCR) كما أظهرت النتائج أن إضافة الخميرة إلى النظام الغذائي للعجلات النامية بشكل منتظم أدى إلى زيادة معنوية ($P<0.01$) في بعض معايير الدم الأيضية مثل البروتين الكلي والجلوبيولين والعناصر المعدنية النادرة (الحديد والزنك) مقارنة بالدلائل الأيضية الأخرى. بالإضافة إلى ذلك، أظهرت النتائج زيادة معنوية ($P<0.01$) في مستويات هرموني الاستراديول والبروجسترون بعد إضافة الخميرة إلى النظام الغذائي المنتظم للعجلات.

ومن هذه النتائج، يمكن الاستنتاج أن إستخدام الخميرة كإضافات غذائية تساهم في تحسين أداء النمو وقياسات الدم الكيميائية والحيوية، وقد تؤثر إيجابًا على بداية البلوغ الجنسي في عجلات الأبقار الخليطة.

الكلمات المفتاحية: الخميرة، أداء النمو، مكونات الدم، البلوغ الجنسي، عجلات الأبقار