Is a Dry Period Really Necessary?

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Take Home Message

- Most studies evaluating length of dry period are retrospective analyses of data with significant bias possible.
- New studies have shown that cows given dry periods of less than 40 d are capable of producing similar milk yields in the next lactation.
- Cows can produce substantial amounts of milk right up to calving.
- A lack of a dry period does not alter milk production after calving in cows entering their 3rd or greater lactation.
- Use of bST improves milk yield in late and early lactation in continuously milked mature cows.

Introduction

A dry period of approximately 60 d has been considered the optimal length since the early 1900s (Bachman and Schairer, 2003). The standard of a 305-d lactation and 60-d dry period was adopted during World War II in the United Kingdom and later in the U.S. (Knight, 1998). This management strategy provided the best balance for optimizing milk yield and genetic progress. Today more than 70% of U.S. dairies are managing for a 60-d dry period (NAHMS, 1996). However, several changes have occurred since the adoption of the 60-d dry period. They include improved milk production of 5,000 kg per lactation per cow, greater emphasis on profit, use of artificial insemination and embryo transfer, total mixed rations (TMR), increased milking frequency, altered photoperiod, and bovine somatotropin (bST). Despite these changes, research on a dry period requirement has received little attention.

Controlled studies examining dry period requirements have demonstrated production losses of 18 to 29% in continuously milked (CM) cows (Rémond et al., 1997). The cows used in these experiments had peak milk yields of 25 kg/d or less compared to today's dairy cow capable of reaching peak milk yields in excess of 50 kg/d. Others reported a dry period less than 40 d resulted in a reduction in subsequent milk yields and an 8 wk dry period provided the best balance between optimal milk production and lost milk income from shorter dry periods (Sørensen and Enevoldsen, 1991). However, many of these data were collected in retrospect from dairy records and may be biased by the fact that these herds were managing for a 60-d dry period. Mismanagement, health status, multiple births, gestation length, and/or inaccurate breeding records may have resulted in shortened or omitted dry periods. Studies on today's high-producing cow have demonstated no production losses by reducing the dry period to 30 d (Bachman, 2002; Gulay et al., 2003; Rastani et al., 2003). Complete omission of the dry period has not been reinvestigated in high-producing cows.

Research on effects of shortened and omitted dry periods on subsequent milk yields have focused on four hypotheses: 1) replenishment of body reserves (nutrition), 2) endocrine differences, 3) reduced mammary cell number, and 4) reduced mammary funtionality. Swanson (1965) evaluated the nutritional hypothesis in a study using identical twins. The CM (continuously milked) twins produced 72 and 62% as much as the controls in the second and third lactations, respectively. The CM twins maintained a higher body weight than the control twins for the duration of the study, suggesting that nutrition was not limiting milk yield in CM twins. After the third lactation, all twins were given a 60-d dry period. During the fourth lactation, milk yields were similar between CM and control twins, suggesting no residual effect of CM. The endocrine and nutritional hypotheses were examined by Smith et al. (1967) using a half-udder model. Half of the udder (two quarters) were continuously milked while the other 2 quarters were given a dry period. The CM quarters produced 77% of the control quarters in the next lactation despite an equal supply of endocrine factors and nutrients. Hormonal factors with autocrine or paracrine actions may play a role in production losses in CM glands, but have not been investigated. Further, nutrients were supplied equally to control and CM glands in this study adding further support to the hypothesis that nutrition is not limiting subsequent milk yields. Reduced mammary cell numbers in CM cows or glands has not been demonstrated in cows (Swanson et al., 1967; Capuco et al., 1997), but has been shown in rats (Paape and Tucker, 1969) and suggested in goats (Fowler et al., 1991). The theory of reduced mammary functionality was first examined by Swanson et al. (1967) using a half-udder model. A 6-wk difference in dry period length did not affect mammary DNA content or alveolar concentration. The authors concluded that impact of CM was on functionality of mammary tissue rather than structure. It has been proposed that reduced mammary functionality in CM cows is the result of changes in mammary cell turnover during late gestation that result in more old mammary cells in the subsequent lactation (Capuco et al., 1997). This hypothesis assumes older mammary cells have less secretory activity and reduced proliferative capacity (Capuco and Akers, 1999).

Management technologies introduced since the adoption of the 60-d dry period have further increased milk production and lactation persistency, and may improve mammary functionality in CM cows. Bovine somatotropin (bST) is particularly interesting because it increases milk yield by 10 to 15% and impacts mammary cells by improved synthetic activity per cell, less secretory cells in a resting state, reduced mammary cell loss, and/or any combination of these bST-mediated effects (Bauman and Vernon, 1993). We hypothesized that use of bST across the last 60 d of gestation and early lactation could negate any negative effects of a shortened or no dry period on the subsequent lactation.

Therefore, the objective of the following study was to determine effects of a shortened or omitted dry period and concomitant use of bST on subsequent milk yield and composition in today's genetically superior cow.

■ Materials And Methods

University of Arizona and Idaho Institutional Animal Care and Use Committees approved all procedures involving animals. The study utilized three herds, two Idaho dairies (Herds 1 and 2) and one Arizona dairy (Herd 3). All cows had ad libitum access to feed and water. Herds 1 and 2 were milked 3X/d and herd 3 2X/d. At each milking, yield was determined by milk meters, recorded in Dairy Comp 305, and stored for 7 d. Weekly back-up files were taken and milk yield data were transferred to a spreadsheet. Milk samples from one milking were taken monthly and analyzed for fat percent, true protein percent, and SCC. Daily milk production and monthly milk composition were collected for the last 17 wk of gestation and first 17 wk of the subsequent lactation. Weekly means of daily milk data were used for statistical analysis.

Herds 1 and 2 used all Holsteins while Herd 3 utilized both Holstein and Brown Swiss. Treatment groups in herd 3 were balanced for breed. Selection criteria for cows on the study were: 1) 305ME greater that 12,000 kg, 2) supplemented with bST (POSILAC®, Monsanto Company) according to label, and 3) SCC less than 200,000. Within each herd 40 cows were selected from eligible cows and assigned randomly to treatment. The study included four treatment groups: (1) 60-d dry (60DD), label bST, (2) 30-d dry, label bST (30DD), (3) no dry period, label bST (CMLST) and (4) no dry period, continuous bST (CMCST). The off-label use of POSILAC® (continuous bST) was conducted under a FDA INAD. Each treatment group contained 5 primiparous and multiparous cows in each herd. Primiparous cows were in their first lactation and multiparous cows were in their second or greater lactation at the start of the study.

Cows in 60DD and 30DD groups were dried 58 ± 1.5 d and 31 ± 1.4 d, respectively, before parturition. Cows were dried by abrupt cessation of milking and administered intramammary antibiotics. Cows without a dry period (CMLST and CMCST) were considered dry if production dropped below a level preset by each of the herds (Herd 1=14 kg/d; Herds 2 and 3=9 kg/d) for 7 consecutive d not due to illness. Cows from CMLST and CMCST were dried according to the procedures used for 60DD and 30DD. After parturition, all cows were tested for antibiotic residues in milk and milk was discarded until clean.

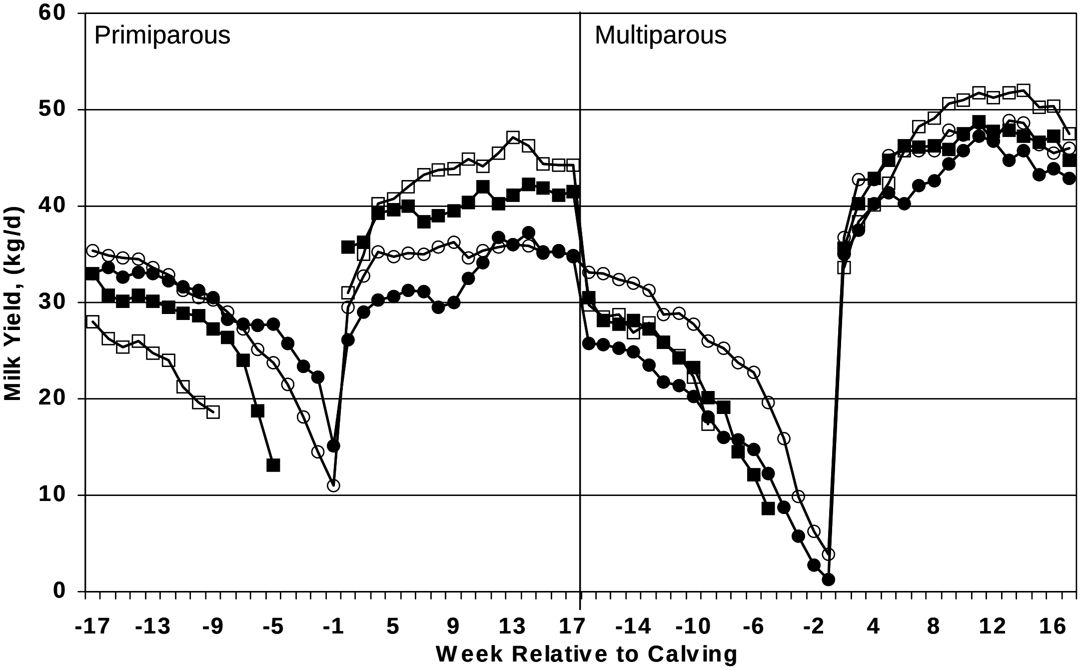
All cows were fed a TMR formulated to meet or exceed nutrient requirements for their given production level and/or stage of gestation. Cows assigned to 60DD and 30DD treatments were fed a lactation ration until dry-off. At dry-off, cows were moved to a far-off dry pen and fed a far-off dry cow ration until 21 d prior to their expected calving date. Cows were then moved to the close-up dry pen and fed a close-up ration. At parturition they were moved into lactating pens and fed a lactation ration. Cows assigned to CMLST and CMCST were fed a lactation ration throughout the study, unless they dried spontaneously. Cows that were dried more than 21 d prior to their expected calving date were removed from the study. These animals were removed because the objective of the study was to examine the biology in omitted dry periods or very short dry periods. Leaving cows that dried spontaneously prior to 21 d prepartum in the data confounded that objective. Cows dried less than 21 d prior to their expected calving date were moved to the close-up dry pen and fed a close-up ration. At parturition they were moved into lactating pen and fed a lactation ration.

Colostrum samples were collected at Herds 2 and 3. Colostrum samples were collected for the first 4 milkings after parturition. Samples were pooled and analyzed for IgG content according to procedures described by Richards et al. (1999) with modifications by Duff et al. (2000).

All statistical analyses were performed using Proc Mixed procedure in SAS (v.8.2; SAS). The level of significance was set at $P \leq 0.05$ for main effects and interactions. Milk yield data collected from 17 to 8 wk prepartum were used as a covariate. Means for wk 1 postpartum were omitted due to missing data. Milk yield from primiparous and multiparous cows were analyzed separately. Weekly milk yield analysis included prepartum milk from the last 8 wk of gestation through 17 wk postpartum. Independent variables in the model were treatment , week relative to calving, herd, breed, covariate, and their potential interactions. Milk composition data were analyzed with the parities combined because the treatment*parity interaction was not significant. Analysis of IgG content in colostrum used average IgG concentration.

■ Results And Discussion

Cows without a dry period lactated for nearly the entire prepartum period. The short d dry in CM cows (2.9 and 1.8 d; CMLST and CMCST, respectively), and the fact that only 2 cows were removed due to dry periods greater than 21 d suggest that most cows are able to sustain a profitable production level throughout the last 8 wk of gestation. The study objective of evaluating shortened and omitted dry periods in high-producing cows was also met as primiparous control cows reached peak milk yields greater than 45 kg/d and multiparous controls reached peak milk yields greater than 50 kg/d (Figure 1). The data analysis included 95 out of the 120 cows originally assigned to



treatment. Each treatment group had a similar number of cows removed and no patterns existed in reasons for removing cows.

Figure 1. Milk production during late gestation and 17 wk of the next lactation in cows subjected to a shortened or omitted dry period and bST supplementation. Key to figure is ((open squares) 60 days dry, ((closed squares) 30 days dry, ((closed circles) continuously milked with label use of bST, and o (open circles) continuously milked with continuous supplementation with bST.

The temporal pattern of milk production during the last 17 wk of gestation and first 17 wk of the subsequent lactation are presented in Figure 1 for both primiparous and multiparous cows. Primiparous cows in CMLST and CMCST groups averaged 21.0 ± 1.1 kg/d and 18.9 ± 1.1 kg/d during the last 8 wk of gestation. Further, both treatments averaged more than 10 kg/d the last wk of gestation. Primiparous cows in 30DD averaged 5.1 ± 1.2 kg/d during the additional 8 wk of lactation, but were only lactating for 4 additional wks. After parturition, all treatments demonstrated similar temporal patterns in milk yield (Figure 1); however, CM cows reached a lower plateau than 60DD and 30DD cows. The CMLST cows increased milk yield by approximately 5 kg/d between wk 9 and 12, which corresponds with the initiation of postpartum bST supplementation. Throughout the first 17 wk of the subsequent lactation, primiparous cows in 30DD, CMLST, and CMCST groups produced 7, 25 and 20% less than 60DD cows (Table 1). Reduced milk yield in primiparous CM cows may be the result of impeded mammary growth, reduced mammary functionality, or a combination of both. This hypothesis was further supported by data from a half-udder study examining the effects of CM and bST on postpartum milk yield and mammary cell proliferation. Regardless of bST treatment, milk yield was dramatically reduced (48 to 56%) in CM halves and CM glands were visibly smaller than control (60-d dry) glands (E.L. Annen, R.J. Collier, and A.C. Fitzgerald, unpublished data). Prepartum milk yields were much lower in multiparous than in primiparous cows (Table 1). Average daily milk yield during the last 8 wk of gestation by multiparous cows in 30DD, CMLST, and CMCST groups was 63, 80, and 66% of the milk produced by primiparous cows. The temporal pattern of milk production in multiparous cows during the last 17 wk of gestation was similar to that observed in primiparous cows, but they were less persistent (Figure 1). The production decline during the last 3 wk of gestation was dramatic in multiparous cows, but the increase in daily milk yield was rapid during the first 2 wk after parturition. All treatments had similar lactation curves and production levels during the first 17 wk postpartum (Figure 1). Similar to primiparous cows, CMLST cows produced less milk until the 9th wk of the subsequent lactation when label bST treatment began. Throughout the first 17 wk of the subsequent lactation average daily milk yield in multiparous cows was similar among all treatments (Table 1). The largest difference of 5 kg/d existed between 60DD and CMLST; however, this difference was not significant. There have not been other studies evaluating CM and bST supplementation and few studies evaluating a shortened or omitted dry period discuss parity differences. Similar milk yield in CM, multiparous cows (CMLST and CMCST) and controls (60DD) in this study has not been observed previously.

Table 1. Least-squares means and standard errors for daily milk (kg/d) produced during the last 8 wk of gestation and weeks 2 through 17 of the subsequent lactation.

	Daily milk from last 8 wk of gestation (kg/d)	Daily milk from weeks 2-17 of the subsequent lactation (kg/d)
Primiparous		
60DD	$0.0^{c} \pm 1.4$	$43.1^{a} \pm 2.1$
30DD	$5.1^{b} \pm 1.2$	$40.1^{ab} \pm 1.8$
CMLST	$21.0^{a} \pm 1.1$	$32.2^{c} \pm 1.8$
CMCST	$18.9^{a} \pm 1.1$	$34.5^{bc} \pm 1.6$
Multiparous		
60DD	$0.0^{b} \pm 2.1$	$47.3^{a} \pm 3.0$
30DD	$3.2^{b} \pm 2.3$	$45.6^{a} \pm 3.3$
CMLST	$16.8^{a} \pm 3.0$	$41.9^{a} \pm 4.5$
CMCST	$12.5^{a} \pm 2.9$	$45.5^{a} \pm 4.4$

Identification of treatments: 60 DD = 60 days dry; 30DD = 30 days dry, CMLST = continuously milked with label use of bST, and CMCST = continuously milked with continuous supplementation with bST.

Values within a column that do not share a superscript (^{abc}) are different ($P<0.05$).

This is the first study to investigate CM in high-producing, bST-supplemented cows. We hypothesize that bST-mediated effects on mammary epithelial cells may have improved functionality of mammary epithelial cells. This hypothesis is supported by improved milk yields in early lactation (wk 2 to 8), regardless of parity, in CMCST compared to CMLST cows (Figure 1). Rastani et al. (2003) recently examined the effects of CM in high-producing cows without bST supplementation. In contrast to the current study, results demonstrated a 14% reduction in milk yield during the succeeding lactation when compared to 56-d dry cows. Parity differences were not reported for this study. Collectively, these two experiments suggest a role for bST in reducing the dry period requirement in multiparous cows.

A shortened dry period (less than 40 d) has been evaluated with (Gulay et al., 2003) and without (Coppock et al., 1974; Lotan and Alder, 1976; Bachman, 2002; Rastani et al., 2003) the use of bST during late gestation and early lactation. A majority of these studies showed no difference in 305-d milk yield (Lotan and Alder, 1976; Bachman, 2002) or daily milk yield (Gulay et al., 2003) in cows dry 30 d compared to 60 d. The current study also demonstrated no difference in milk yield in both primiparous and multiparous cows dry for 30 d.

Coppock et al. (1974) observed production losses of 10% or less in cows dry 40, 30, or 20 d.

Similar to other studies (Rémond et al., 1992; 1997; Gulay et al., 2003), milk fat content in the current study was unaffected by treatment. Milk protein content has been shown to be greater (Rémond et al., 1992; 1997) or unchanged (Smith et al., 1967, Gulay et al., 2003) in CM or shortened dry period cows. Rémond et al. (1997) reviewed several studies and reported a consistent increase in milk protein content after a shortened or omitted dry period and attributed it to lower milk yields and therefore a lower dilution effect. This study resulted in increased milk protein content in 30DD, CMLST, and CMCST (Table 2). It is possible that cows in these groups improved DMI as a result of fewer and less dramatic ration changes during late gestation, and better energy balance than 60DD cows, thus enabling enhanced milk protein production. However, since milk protein remained elevated through the first 4 mo of the succeeding lactation, it is unlikely that energy balance was limiting milk protein synthesis in 60DD cows.

Table 2. Summary of milk composition and colostrum IgG content in the subsequent lactation of cows subjected to a shortened or omitted dry period.

Milk Composition	60DD	30DD	CMLST	CMCST
Milk Fat, %	3.7 ± 0.3	3.9 ± 0.3	3.6 ± 0.4	4.4 ± 0.4
Milk True Protein, %	2.7 ± 0.1[a]	3.0 ± 0.1[b]	3.0 ± 0.1[b]	3.1 ± 0.1[b]
SCC Linear Score	0.05 ± 0.80[a]	1.09 ± 0.87[ab]	2.89 ± 1.13[b]	4.85 ± 1.17[b]
Colostrum IgG, mg/ml	6.84 ± 1.13	6.35 ± 1.03	6.61 ± 1.08	6.26 ± 1.14

Identification of treatments: 60 DD = 60 days dry; 30DD = 30 days dry, CMLST = continuously milked with label use of bST, and CMCST = continuously milked with continuous supplementation with bST.

Values within a row that do not share a superscript ([ab]) are different ($P<0.05$).

The impact of shortened and omitted dry periods on udder health and milk quality is an important factor to dairy producers. Rémond et al. (1997) observed a tendency for SCC to increase in cows having received a shortened or omitted dry period. This increase in SCC was not accompanied by an increase in clinical mastitis cases. The current study demonstrated increased somatic cell linear score (SCLS) without an increase in incidence of clinical mastitis in CMLST and CMCST cows compared to 60DD cows. There was a tendency for increased SCLS in 30DD cows. Groups 60DD and 30DD both received intramammary antibiotics; however, SCLS was still elevated in 30DD cows suggesting a full 8-wk dry period is required for optimal dry-cow antibiotic therapy or the additional period of lactation caused increased SCLS. High variability in SCC among and between cows makes interpretation difficult for this number of cows.

Immunoglobulins in colostrum from CM cows have been shown to be only 46% of the concentrations of colostrum from cows dry 2 mo (Rémond et al., 1997). Enhanced protein and Ig concentrations in colostrum are believed to be the result of an accumulation of secretion in the udder prior to calving (Wheelock et al., 1967; Rémond et al., 1997). Continuously milked cows may have reduced colostrum quality due to the lack of a secretion accumulation period. The current study did not demonstrate a difference in colostral IgG due to any treatment (Table 3).

Table 3. Summary of reproductive parameters in cows subjected to a shortened or omitted dry period and bST supplementation

Treatment	n	Heats After VWP*	Breedings	Number Pregnant	S/C**	DIM at 1st Heat	DIM at Conception
60DD	24	54	54	16 of 24 (67%)	3.4	47 ± 5	74 ± 3
30DD	23	42	42	19 of 23 (83%)	2.2	39 ± 5	71 ± 4
CMLST	22	47	47	15 of 22 (68%)	3.1	42 ± 5	83 ± 4
CMCST	26	39	39	21 of 26 (81%)	1.9	53 (5	76 (4

*Voluntary wait period

**Services per conception

Other aspects of shortened and omitted dry periods combined with bST supplementation that are important to the dairy producer are reproductive performance, economics, and management of late-gestation, lactating cows. The cow numbers used in this study are far too small for a statistical analysis of reproductive parameters, but a summary for percent of cows pregnant, services per conception, DIM at first heat, and DIM at conception for each of the treatment groups is provided (Table 3). Due to the lack of statistical power, no conclusions can be made, but similar reproductive performance occurred across all treatments.

The economics of 30DD, CMLST, and CMCST groups were analyzed by evaluating the cumulative net margin (CNM) for each treatment compared to the 60DD group. The CNM began to accumulate at 8 wk prior to parturition when 60DD cows were dry, but the other treatments were beginning periods of additional milk income in late gestation. These margins account for the estimated ration and bST costs. In primiparous cows, the CNM for CMLST and CMCST cows over 60DD cows increased sharply from 8 wk prepartum to a peak value at 1 wk prepartum. After parturition the substantial production losses in CM treatments resulted in a rapid reduction of CNM to a negative value by wk 17 of the subsequent lactation. The 30DD cows, also had a rapid increase in CNM over the controls from 8 to 4 wk prepartum, when they were dried. Similar to the other treatments, production losses in the succeeding lactation diminished CNM to zero. Multiparous cows were not as persistent in the last 8 wk of gestation and subsequent milk yields were similar for all treatments resulting in a lower peak CNM value, but maintenance of peak CNM from 1 wk prepartum to 5 wk postpartum. The CMCST cows produced less milk in late lactation than the CMLST cows, but averaged 3.5 kg/d more milk after parturition than CMLST cows. This resulted in a lower peak CNM, and a slower decline for CMCST. In multiparous cows, all treatments maintained a positive CNM over 60DD, with CMLST and CMCST cows ending the study with the highest CNM, $50/cow.

Management of late-gestation, lactating cows proved to be challenging with parturition taking place in lactating pens, as well as colostrum production and mammary secretions immediately prior to calving being misidentified as mastitis. If future management practices entail continuously milking cows, facilities should be built or remodeled to accommodate a lactating pen for cows in the final 4 wk of gestation. This pen should provide a comfortable place for parturition to occur and prevent calves from being born in high-risk areas, such as flush lanes. Further, cows would be calving in an area focusing on fresh cow and calf management where herd managers and other employees are trained to assist with dystocias, administer colostrum to calves, and evaluate the health status of fresh cows.

Very low milk yields in the last 2 wk of gestation and leaky tight junctions allowing extracellular fluid into alveolar lumens may result in a transudate of plasma becoming the primary secretion rather than milk (Wheelock et al., 1965; Linzell and Peaker, 1974). Further, colostrum production and secretion begins prior to parturition in some continuously milked cows. These changes alter the appearance and consistency of milk and result in these cows being identified as having mastitis. Milkers should be educated on potential changes in mammary secretions in CM cows and be able to identify (colored leg bands) CM cows in the final weeks of gestation to ensure proper handling of milk and execution of treatment protocols. Further research needs to be conducted to better understand the composition and physical properties of late-gestation, mammary secretions.

■ Summary

A reduced or omitted dry period combined with bST resulted in no differences in average daily milk yield during the first 17 wk of the succeeding lactation for multiparous cows. Additional milk income during the last 8 wk of gestation and

similar postpartum milk yields resulted in a $50 improvement in cumulative net margin for CM over 60DD cows. Primiparous cows were more sensitive to a reduction in the length of dry period, resulting in significant production losses in CM heifers in the subsequent lactation. The 30DD primiparous cows had non-significant production losses intermediate to those resulting from omitting the dry period. More substantial production losses during the first 17 wk of the subsequent lactation nullified any economic gains from additional milk income during late gestation.

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